UHASSELT

KNOWLEDGE IN ACTION

Faculty of Business Economics

Master of Management

Master's thesis

Sustainability Initiatives in Innovation Districts: A Comparative Analysis of Tech Lane Ghent and High Tech Campus Eindhoven

Pamir Momand

Thesis presented in fulfillment of the requirements for the degree of Master of Management, specialization Strategy and Innovation Management

SUPERVISOR :

Prof. dr. Jean-Pierre SEGERS

UHASSELT

KNOWLEDGE IN ACTION

www.uhasselt.be
Universiteit Hasselt
Campus Hasselt:
Martelarenlaan 42 | 3500 Hasselt
Campus Diepenbeek:
Agoralaan Gebouw D | 3590 Diepenbeek

2024
2025

UHASSELT

KNOWLEDGE IN ACTION

Faculty of Business Economics

Master of Management

Master's thesis

Sustainability Initiatives in Innovation Districts: A Comparative Analysis of Tech Lane Ghent and High Tech Campus Eindhoven

Pamir Momand

Thesis presented in fulfillment of the requirements for the degree of Master of Management, specialization Strategy and Innovation Management

SUPERVISOR :

Prof. dr. Jean-Pierre SEGERS

Acknowledgement

First and foremost, I am grateful to the Almighty God for providing me with the strength, perseverance, and patience to finish this incredible journey.

I am sincerely thankful to My supervisor, Prof. Dr. Jean-Pierre Segers, who has been a tremendous support to me during this journey. His guidance, supportive attitude, and encouragement gave me the motivation to proceed.

I am deeply grateful to my parents, who have always stood by me and kept me in their prayers. Furthermore, I am especially thankful to my wife, whose unwavering patience and support carried me through even the busiest and most stressful times. I also extend my gratitude to my siblings, who have been part of this journey in their own meaningful ways. Finally, I would like to thank my colleagues at work, who have supported me.

This thesis reflects something I care deeply about: sustainability and innovation. It is the result of many hours of learning, reflecting, and writing. But more than that, it reflects the people who believed in me, supported me, and walked this path with me. For that, I am genuinely thankful.

Summary

Innovation districts today are more than just clusters of science and business; they're increasingly seen as testbeds for sustainable urban living. Yet, while many policy documents and master plans mention sustainability, how it's implemented on the ground can vary significantly. This thesis asks:

What sustainability initiatives are in place at Tech Lane Ghent, and how do they compare to those at High Tech Campus Eindhoven (HTCE) in terms of waste reduction, energy efficiency, CO_2 emissions, and mixed-use development?

Beyond the main comparison, the study also looks at how the mix of homes, offices, and recreational spaces shapes sustainability in each district. It also examines who is accountable for making sustainability happen and how the governance is done. Besides, the study also considers how companies, employees and communities view and address sustainability activities expounding the level of participation, awareness and feedback mechanisms in place.

To explore these questions, the comparative case study approach consists of qualitative and quantitative approaches.

- 9 semi-structured interviews were conducted with relevant stakeholders, with operations managers of both districts, sustainability experts, and ecosystem leaders.
- Additionally, an online survey was distributed to professionals working in both districts, gathering 41 responses (14 from Tech Lane Ghent and 27 from HTCE).

The survey addressed awareness, involvement in sustainable practices, and perceptions of campus sustainability efforts. All data was analyzed using thematic coding, which helped identify recurring patterns and emerging insights across both datasets. While some themes like governance or stakeholder engagement were expected, others, such as grassroots innovation and low-tech ecological solutions, surfaced more organically.

The results show that both districts are serious about sustainability, but they go about it in very different ways.

HTCE employs a centralized, strategy-driven model, supported by a clear roadmap, measurable targets, and digital tools such as Power BI dashboards for tracking progress. Its ambition to achieve CO_2 neutrality by 2030 is backed by large-scale infrastructure projects, including expanding solar panel capacity from 11,000 to 30,000 units, implementing Aquifer Thermal Energy Storage (ATES), and adopting smart building technologies.

Tech Lane Ghent reflects a more grassroots and community-driven approach, gradually transitioning toward a hybrid governance model. Individual companies take the lead through recycling initiatives, workshops, and energy-monitoring pilots. Notably, 79% of survey participants at Tech Lane reported regular recycling participation, with many also engaged in informal actions like volunteer clean-up efforts.

Several signs point to a shift toward greater coordination at Tech Lane, such as using BEN (Nearly Energy Neutral) building standards, an ongoing energy master plan, and three sustainability-focused committees (Mobility, Durability, Events) facilitated by VZW Ardoyen.

Governance and Stakeholder Involvement

One of the most apparent differences between the two districts lies in their governance structures. At HTCE, a professional management team leads with centralized control, data-driven planning, and clear communication. One of the most apparent differences between the two districts lies in their governance structures.

At HTCE, a professional management team leads with centralized control, data-driven planning, and clear communication.

In contrast, Tech Lane Ghent has a more fragmented structure involving UGent, VZW Ardoyen, and POM Oost-Vlaanderen, making coordination more complex and inclusive. Interviews with experts validated this finding. As Laura Biancuzzo of the Global Institute on Innovation Districts states:

"Governance should be place-based and flexible, evolving with local needs. Furthermore, community involvement is essential"

Differences were also found in stakeholder engagement: only 15% of HTCE respondents felt their feedback had been sought, compared to 36% at Tech Lane, where interviewees described a culture of collaboration and shared ownership.

Mixed-Use environment

HTCE stands out for its mature mixed-use environment. The campus includes gyms, cafés, childcare, and even sheep for eco-friendly lawn mowing. These amenities help reduce car dependency and make everyday life more engaging.

In contrast, Tech Lane Ghent is still building its infrastructure. Although it has food trucks and a few cafés, survey respondents indicated that they would prefer additional amenities such as more bike lanes, green spaces, and communal areas to facilitate interaction.

Conclusions

This study finds value in both approaches:

- HTCE's top-down model is effective for implementing large-scale, coordinated infrastructure projects.
- Tech Lane's bottom-up approach, now evolving into a hybrid, encourages participation, ownership, and adaptive innovation.

Rather than choosing between the two, the research suggests a blended model that combines strategic direction with community-driven action offers the most significant promise for sustainable innovation.

Limitations and Future Directions

Like any research, this study has its limits.

- The survey sample size was relatively small, especially from Tech Lane Ghent, limiting broader generalization.
- The focus was primarily on environmental and participatory dimensions of sustainability, leaving economic or regulatory aspects for future work.
- Long-term evaluation was challenging for some initiatives, like Tech Lane's new sustainability committee, because data collection was still in its early phases.

Despite these limitations, the findings are highly relevant to policymakers, urban planners, and campus developers seeking to build more sustainable innovation ecosystems. Future research could explore more districts, evaluate the influence of local policy, or design tools for tracking Scope 3 emissions and circular economy progress.

Table of Contents

List of Figures:

List of Tables:

Chapter 1: Introduction

Innovation districts have emerged as key engines for economic development, technological advancement, and urban regeneration. As Katz and Wagner (2014) describe, these districts integrate economic, physical, and social networking assets to create environments where innovation can flourish. Alongside economic goals, sustainability has become an increasingly important focus in the development of innovation districts, reflecting a broader shift towards greener and more resilient urban spaces (OECD, 2015). This dual focus on innovation and sustainability forms the core of this study, which explores how these themes are being implemented in two prominent European districts: Tech Lane Ghent Science Park and High-Tech Campus Eindhoven.

1.1 Background and problem statement:

These districts represent new models of urban development where research institutions, companies, startups, and community spaces come together. These districts are often seen not only as engines of economic growth but also as opportunities to implement sustainable urban practices. As cities seek ways to reduce carbon emissions, increase energy efficiency, and create vibrant, livable communities, innovation districts are becoming critical testing grounds for new approaches.

However, while sustainability is frequently highlighted in strategic plans and visions for innovation districts, there is often a gap between ambition and real-world implementation. Understanding how sustainability initiatives are actually developed and managed on the ground is key to evaluating their success and identifying best practices.

This research focuses on the implementation of sustainability initiatives in two leading European innovation districts: Tech Lane Ghent Science Park (Belgium) and High-Tech Campus Eindhoven (Netherlands).

Although innovation districts are frequently promoted as sustainable, little comparative research has been conducted to examine how different governance models, stakeholder participation, and spatial planning approaches influence the actual sustainability performance of such districts. A closer examination of how different districts operate in practice is needed to understand the factors that support or hinder sustainability.

1.2 Research Objectives and research questions:

To address the problem outlined above, this research pursues the following objectives:

- Identify and compare the sustainability initiatives at Tech Lane Ghent and High-Tech Campus Eindhoven.
- Examine the role of governance structures in facilitating or hindering sustainability goals.
- Explore how the integration of mixed-use development supports environmental, social, and economic sustainability.
- Assess how stakeholders perceive and contribute to sustainability efforts in both districts.

The primary research question guiding this study is:

What sustainability initiatives are in place at Tech Lane Ghent, and how do they compare to those at High Tech Campus Eindhoven in terms of waste reduction, energy efficiency, CO_2 emissions, and mixed-used development?

Sub-questions:

- How does integrating residential, commercial, and recreational spaces at Tech Lane Ghent and High-Tech Campus Eindhoven contribute to sustainability?
- What governance structures are in place to oversee sustainability initiatives at Tech Lane Ghent and High-Tech Campus Eindhoven?
- How do stakeholders (e.g., businesses, employees, local communities) perceive the sustainability efforts at both campuses?

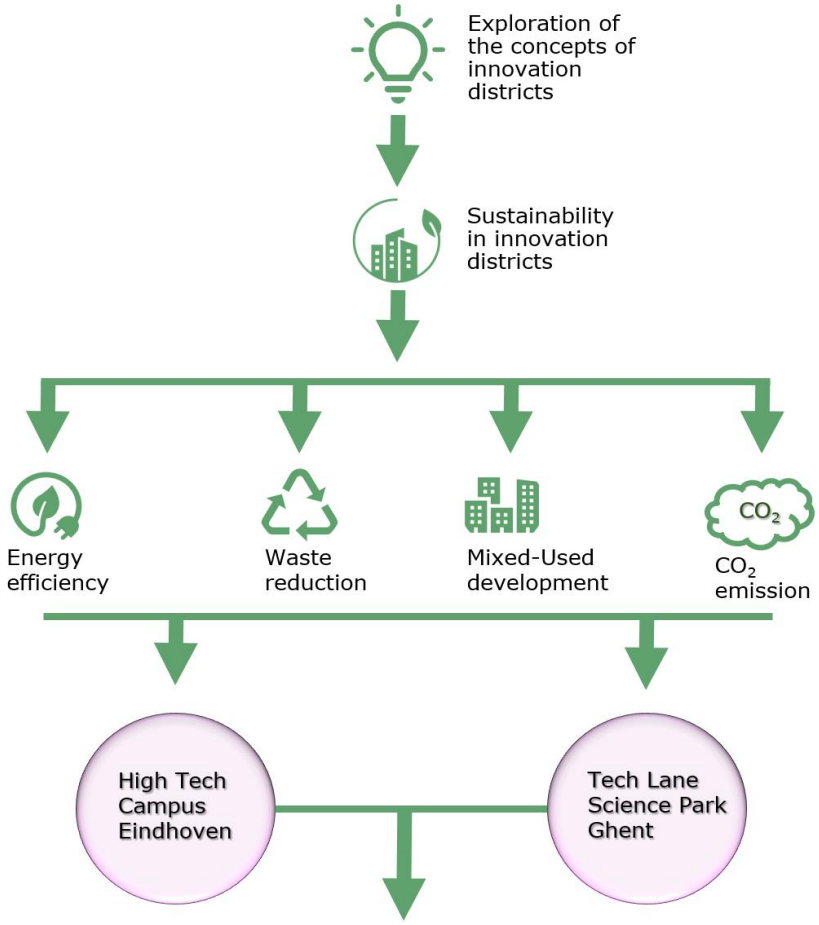

Figure 1. Formation of the Research Question

Adapted and created by the author.

1.3 Relevance of the Study

This research contributes to the growing field of sustainable urban development and innovation management by offering a practical comparison of two districts with different approaches to sustainability. It provides insights for policymakers, planners, and campus managers seeking to design or improve innovation districts with environmental and social sustainability in mind. By comparing two distinct governance and engagement models, the study highlights practical lessons and strategic insights that can guide the development of future innovation districts across Europe and globally, contributing to more sustainable, resilient urban ecosystems.

Chapter 2: Literature Review

2.1 Understanding Innovation:

Innovation is about coming up with new ideas, products, or ways of doing things that bring value to both the economy and society. It helps businesses, governments, and communities respond to change, whether that means tackling challenges or seizing new opportunities. In doing so, innovation plays a powerful role in shaping economic growth and driving forward more dynamic, adaptable cities. The Organization for Economic Co-operation and Development (OECD) emphasizes that innovation is crucial for productivity growth and competitiveness.

2.1.1 Types of Innovation

Innovation can take many forms. Below are a few key types commonly discussed in the literature:

- *Incremental Innovation:* This form of innovation involves continuous improvements to existing products or processes. For example, due to advancements in smartphone technology, a smartphone company releasing a new model with a better camera capability in successive models (Tidd & Pavitt, 2011).

- *Open innovation:* Chesbrough (2003) coined the term open innovation as a model where companies do not rely solely on internal R&D but engage in partnerships with other firms, research institutions, and users to co-create value. This approach is particularly prevalent in tech hubs and innovation districts, where diverse stakeholders collaborate to co-create solutions and accelerate technological advancements (West, Salter, Vanhaverbeke, & Chesbrough, 2014).

- *Disruptive Innovation:* According to (Christensen, Raynor, & McDonald, 2015), disruptive innovation involves radical changes that create entirely new markets or disrupt existing ones. The authors further emphasize that disruptive innovation often begins at the lower end of the market but eventually displaces established players. A well-known example is Netflix, which changed the way people watch TV by making it easier to stream shows and movies anytime, without needing traditional cable.

- *Radical Innovation:* Not all innovations are bold. While companies and governments invest heavily in research and development, much of today's innovation focuses on minor upgrades, like making apps faster or adding features to a phone. But what we really need more are radical innovations, the kind that change entire industries or solve major problems like climate change or global health. (Ramge & Laguna de la Vera, 2023) argue that despite the technological possibilities, risk aversion, tight regulations, and short-term thinking limit our ability to innovate boldly. Radical innovation demands long-term vision, government support, and a culture willing to invest in uncertain but transformative ideas. For example, developing lab-grown meat isn't just about improving food; it's about reimagining agriculture to reduce carbon emissions and animal suffering. That's the kind of radical thinking innovation ecosystems need more of today.

- *Mission-Oriented Innovation:* This type of innovation aims to solve large-scale societal challenges such as climate change, digitalization, and social equity. (Mazzucato, 2018) stresses that such innovations often emerge from public-private partnerships and are guided by clear missions that create both public and business value. For example, the European Union's Green Deal is a mission-oriented innovation. It brings together different sectors and partners with a clear goal: making Europe climate-neutral by 2050 (European Commission, 2019). This kind of innovation isn't just about new technology, it's about using innovation to achieve a meaningful and measurable social goal.

- *Responsible Innovation:* This model encourages innovation practices that anticipate societal impacts and actively involve stakeholders in shaping technology development. Stilgoe et al. (2013) define responsible innovation as a governance framework rooted in inclusion, anticipation, reflexivity, and responsiveness. For example, if a company is designing facial recognition software, responsible innovation would mean thinking ahead about privacy issues, inviting feedback from users, and adjusting the technology to prevent misuse or bias.

- *Sustainable Innovation:* As described by Boyd (2023), this form involves intentional efforts to redesign products, services, or processes to deliver environmental and social benefits alongside economic gain. Firms adopting sustainable innovation often embed these goals into their culture and decision-making systems. For instance, if an outdoor clothing company, designs its products using recycled materials and offers repair services to extend product life, reducing waste while still maintaining profitability and strong brand loyalty.

Furthermore, Innovation is not only about developing new technologies, but it also plays a vital role in shaping smarter, more inclusive, and sustainable urban systems. As Florida (2014) explains, innovation ecosystems are essential to building thriving, future-ready cities. These ideas form the basis for understanding how innovation is embedded in broader social, economic, and spatial environments.

Eco system: Before diving into innovation ecosystems, it's useful to first understand what an ecosystem means in this context. In simple terms, an ecosystem is a connected environment where different people, organizations, and resources work together and grow over time. As Autio and Thomas (2014) put it, it's not just about individual players, it's about how they interact and create value together. This idea helps us better understand how innovation ecosystems function as spaces where ideas can develop, take shape, and spread through collaboration.

2.1.2 Innovation Ecosystems

Autio & Thomas (2014) define innovation ecosystem as a network of organizations, people, and institutions that collaborate to create new ideas and technologies. This network comprises businesses, universities, research centers, governments, and startups. By sharing knowledge and resources, these entities help drive innovation.

One of the most essential features of an innovation ecosystem is collaboration, where different groups work together and share their expertise and resources. According to Katz and Wagner (2014), the success of these ecosystems frequently depends on solid collaborations between businesses, educational institutions, and governments, which allow for the sharing of ideas and the combining of resources to accomplish shared objectives.

Diversity is another critical aspect of innovation ecosystems. According to Autio and Thomas (2014), a variety of industries, specialties, and viewpoints foster innovation and help generate original solutions. When stakeholders from different backgrounds collaborate, they bring unique perspectives that can lead to breakthrough innovations.

(Tõnurist, Kattel, & Lember, 2017) argues that the success of innovation ecosystems also depends on a supportive infrastructure. This covers both digital infrastructure, such as cloud computing platforms and high-speed internet, and physical locations, such as labs and co-working hubs.

In addition, access to a skilled workforce is essential, as talented individuals and researchers form the backbone of thriving innovation ecosystems (Autio & Thomas, 2014).

To further understand how innovation ecosystems are structured, it’s helpful to explore the key models that describe the interaction between different societal actors. The Triple, Quadruple, and Quintuple Helix models offer theoretical frameworks that explain how innovation emerges through the collaboration of academia, government, industry, civil society, and the environment.

2.1.3 Triple, Quadruple, and Quintuple Helix Models

To better understand how innovation works in real life, it's helpful to look at a few models that show how different groups contribute to it. One of the most well-known is the *Triple Helix Model*. This model, developed by Etzkowitz and Leydesdorff (2000), explains how universities, businesses, and governments work together to drive innovation. Each group brings something important to the table: universities offer research and skilled people, businesses bring practical tools and funding, and governments set rules and provide support. When these three collaborate, they can create powerful environments for new ideas to grow.

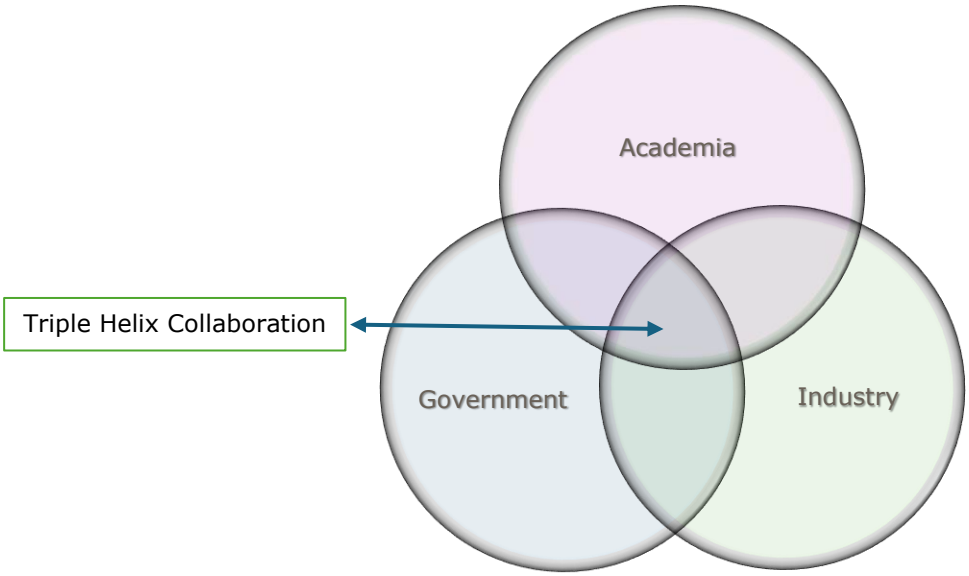

Figure 2. The Triple Helix Mode
Integration of Academia, Industry, and Government.
Source: Author's own elaboration based on Etzkowitz & Leydesdorff (2000).

The Quadruple Helix Model takes this a step further by including a fourth key player, civil society. This means that people, citizens, users, and communities are also part of the innovation process. Carayannis and Campbell (2009) point out that when the public is involved, innovation becomes more relevant and inclusive. Examples of this include co-creation workshops, open innovation platforms, or living labs where people help shape new solutions.

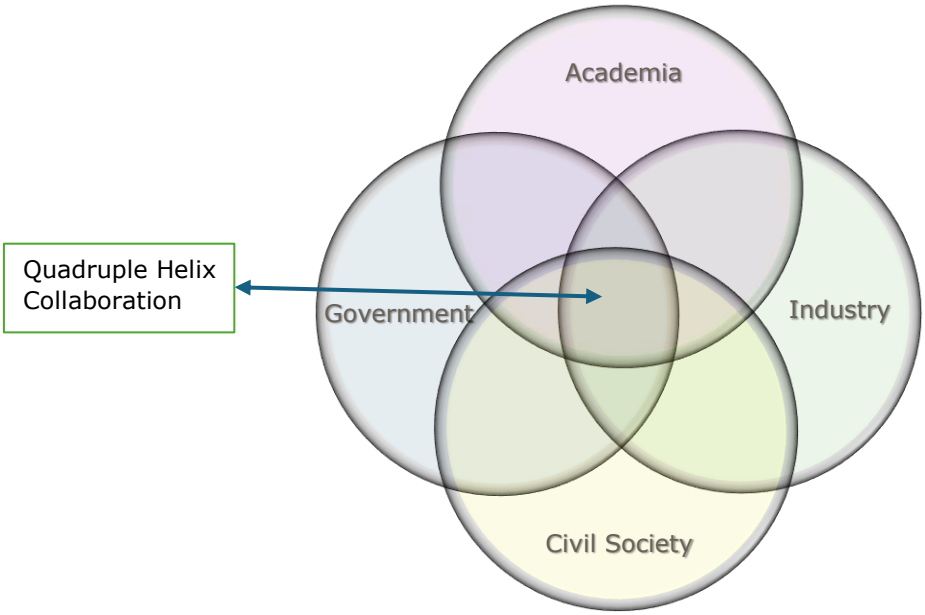

Figure 3. The Quadruple Helix Model
Integration of Academia, Industry, Government and Civil Society.
Source: Author's own elaboration based on Carayannis and Campbell (2009).

The Quintuple Helix Model adds a fifth important layer, the natural environment. In this version, innovation isn't just about economic or social value; it's also about sustainability. As Carayannis et al. (2012) argue, the environment needs to be part of our thinking if we want long-term progress. This means making sure new ideas and technologies also protect the planet.

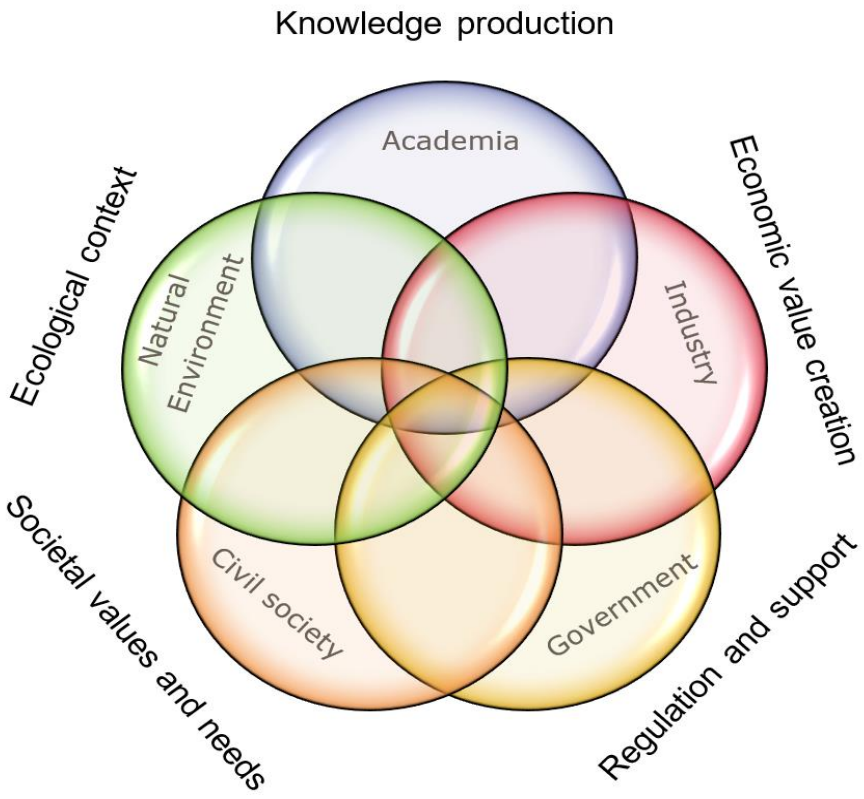

Figure 4. The Quintuple Helix Model
Integration of Academia, Industry, Government, Civil Society, and the Natural environment.
Source: Author's own elaboration based on Carayannis, Barth & Campbell (2012).

Together, these models show that innovation is a team effort involving many different actors, all contributing from their own perspectives. These ideas are especially visible in innovation districts, where universities, companies, governments, citizens, and environmental goals often come together in the same space. The next section looks at how this works in practice.

Innovation ecosystems take on a spatial dimension in innovation districts, purpose-built areas designed to stimulate technological advancement and industry growth. These districts often bring the helix models to life: combining universities, companies, governments, and civil society within one physical space. For example, at High Tech Campus Eindhoven, collaboration between Philips, Eindhoven University of Technology, and government institutions exemplifies a Triple Helix approach in action. Similarly, Tech Lane Ghent thrives through close ties between Ghent University, innovative startups, and regional policymakers. The next section explores the concept of innovation districts and their importance in more detail.

2.2 Innovation Districts: Definitions, governance, and Land Use

This section explores the key characteristics, governance structures, and land-use strategies that define innovation districts, providing the foundation for the comparative case studies.

2.2.1 Definition and Key Traits

Innovation Districts, as described by Katz and Wagner (2014), are the most recent term for the geography of innovation. It is where cutting-edge anchor institutions and businesses gather and establish connections with start-ups, business incubators, and accelerators described as innovation districts. They provide mixed-use housing, office, and retail spaces and are technically wired, transit-accessible, and physically compact. Innovation districts, as opposed to traditional scientific parks or corridors, capitalize on proximity and density to promote strong social networks and cooperative, "open" innovation. Closeness helps with information sharing and creativity for employees, investors, and entrepreneurs (Katz, Wagner, & Osha, 2019).

According to Katz, Wagner, and Osha (2019), Innovation districts differ from traditional models by integrating three main assets: economic assets, physical assets, and social networking assets. Economic assets include businesses, organizations, and institutions that drive innovation, such as universities collaborating with local startups to develop new products. Physical Assets refer to infrastructure, open spaces, and buildings that facilitate collaboration and knowledge exchange, for example, co-working spaces and public parks. Social networking assets refer to networks and relationships among the public, companies, and institutions that accelerate the spread of ideas, for instance, networking events connecting researchers, entrepreneurs, and investors. As shown in Figure 5, these assets work together to foster innovation and collaboration (Adapted from Katz, Wagner, & Osha, 2019).

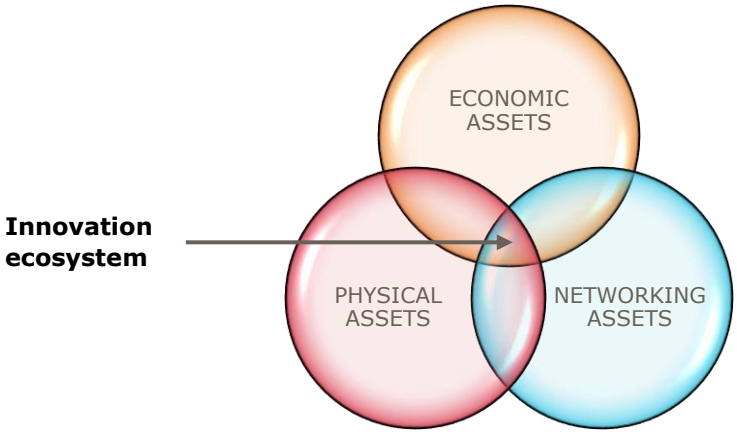

Figure 5. Three Assets of Innovation Districts
The center point shows the Overlap as an Innovation Ecosystem.
Source: Adapted from Katz, Wagner, & Osha, (2019).

Building on this foundation, Katz, Wagner, and Osha (2019) further highlight several essential components that arise from the interaction of these assets, namely proximity, collaboration, and knowledge sharing, all of which are crucial for fostering innovation ecosystems.

Furthermore, there are several essential components of innovation districts, as highlighted by Katz, Wagner, and Osha (2019). These component, Proximity, collaboration and Knowledge sharing, work together to create an environment favorable to innovation and economic growth.

- *Proximity:* The physical clustering of economic actors, including businesses, start-ups, and research institutes, in a small geographic area makes innovation districts effective. Knowledge communication is strengthened by this proximity, especially when it comes to complicated, implicit information (Katz, Wagner, & Osha, 2019). The importance of physical proximity in fostering innovation is highlighted in the research by Carlino et al. (2012), which examined the location of over 1000 R&D labs in the US northeast corridor. According to their study, Colocation at less than a quarter-mile distance benefits R&D labs in over one-third of manufacturing industries.

- *Collaboration*: Innovation districts encourage cooperation between many stakeholders, such as communities, businesses, governments, and universities. To tackle complicated problems, this "collaborate to compete" paradigm makes it possible to combine resources, exchange knowledge, and create cooperative methods (Katz & Wagner, 2014).

- *Knowledge-sharing:* An environment where actors can freely share information is produced when research and innovation activities are concentrated in certain innovation districts. This leads to the development of new ideas, products, and processes that advance technological advancement and economic growth (Katz, Wagner, & Osha, 2019).

Additionally, Katz and Wagner (2014) highlighted, innovation districts strongly emphasize integrating residential areas, workspaces, and recreational facilities to establish a live-work-play atmosphere. This strategy improves productivity and quality of life by creating a successful community where people may live, work, and play within the same geographic region.

2.2.2 Significance of Innovation Districts

By drawing companies, talent, and investment, innovation districts have a big impact on local economies, boosting economic expansion and producing high-quality jobs. For instance, when businesses and startups work closely, they can share knowledge and resources, which saves lots of time when coming up with new products or services. According to a study by Storper and Venables (2004), being close to people makes it easy to collaborate and share expertise, which helps businesses develop and flourish. Additionally, this will make it possible for troubled areas to grow into thriving, prosperous communities.

Benefits for Businesses, Universities, and Government: Innovation districts are helpful for businesses, universities, and governments. For businesses, being in an innovation district makes it easier to find talent and access fresh research when they are located in an innovation area. This keeps them competitive and helps them generate new ideas. Universities gain the ability to collaborate with companies on research, provide students with practical experience, and secure money for new initiatives. Governments see innovation districts as improving residents' quality of life, generating employment, and stimulating the economy. Governments promote innovation and new enterprises by aiding these regions. Etzkowitz and Leydesdorff (1995) introduce the Triple Helix model, which describes how governments, corporations, and academic institutions collaborate to promote innovation and regional growth. Their study illustrates how universities are increasingly engaging in economic development by collaborating with businesses and policymakers, providing education, and conducting research. As a result of this synergy, hybrid institutions that act as venues for cooperative innovation are created, such as scientific parks and technology transfer offices. The Triple Helix approach emphasizes how crucial these changing connections are to creating creative ecosystems that support regional economies, promote entrepreneurship, and develop cutting-edge technology. (Etzkowitz & Leydesdorff, 1995).

Adapting to Globalization and Digital Transformation: Innovation districts are calculated reactions to the problems brought on by the fast development of technology and globalization. These districts increase competitiveness for people and investment by combining local strengths with global prospects through the close partnership of firms, educational institutions, and entrepreneurs. Through the facilitation of the creation and testing of breakthrough technologies, these settings assist firms in staying ahead of the continuously changing technological world. In addition to encouraging innovation, this cooperative strategy promotes community prosperity in the contemporary economy. Cities with strong innovation districts are better positioned to sustain their global competitiveness, according to research (Yigitcanlar, O'Connor, & Westerman, 2008)

For instance, the 22@Barcelona project transformed a former industrial area into a dynamic innovation hub, attracting tech companies, research institutions, and startups. This initiative has significantly boosted the city's economic growth and global standing. Similarly, the Kendall Square district in Cambridge, Massachusetts, has become a leading center for biotechnology and information technology, benefiting from its proximity to MIT and fostering a vibrant ecosystem of innovation (Katz & Wagner, 2014).

2.2.3 Governance structure and Land use strategies

Innovation districts don’t just grow on their own, they need thoughtful planning and support. For these areas to thrive, it's important to have the right mix of rules, partnerships, and space planning that encourages new ideas while also being fair and sustainable. Based on insights from the Global Institute on Innovation Districts (GIID), expert research, and practical examples from real cities, this section explores four key building blocks that help shape successful innovation districts:

- Government Incentives, Policies, and Regulations
- The Role of Public-Private Partnerships and Innovation Labs
- International and Regional Sustainability Policies
- Land Use and Mixed-Use Development

Government Incentives, Policies, and Regulations:

Governments play a foundational role in shaping innovation districts through financial incentives, policy frameworks, and regulatory structures. These tools align private-sector activity with broader public goals particularly around sustainability, inclusion, and equitable growth.

The Global Institute on Innovation Districts (GIID, 2023) stresses that governance in innovation districts should be place-based, adaptive, and collaborative, evolving alongside district needs (Wagner, 2023). Rather than relying on static or generic models, governance must reflect the unique dynamics of each ecosystem.

Mazzucato (2024) underscores the importance of mission-oriented policy, where governments define bold societal goals, such as decarbonization or health equity, and use public investment to catalyze innovation in those directions. This approach moves government beyond market fixing to market shaping.

However, innovation must be inclusive. As Boschma et al. (2025) caution, unchecked innovation can intensify regional inequality when benefits concentrate in affluent areas while less-advantaged regions bear the environmental and social costs. This highlights the importance of redistributive mechanisms and policies that explicitly tackle socio-spatial disparities.

A case in point is Brainport Eindhoven, where regional policies enabled a transition from a Triple Helix model (university-industry-government) to a Quadruple Helix model by embedding sustainability and citizen engagement into governance (Bronneberg, Pieterse, & Post, 2023)

Enabling tools include zoning regulations that promote mixed-use development, tax incentives for green technologies, and mandates for carbon-neutral infrastructure, all of which accelerate sustainable transformation.

The Role of Public-Private Partnerships and Innovation Labs:

Public-private partnerships (PPPs) are at the heart of many successful innovation districts. They bring together governments, private companies, universities, and communities to invest in shared goals—especially around sustainability and inclusive growth.

A great example of this is High Tech Campus Eindhoven, where Philips, TU/e, and local authorities worked hand-in-hand to develop one of Europe's most advanced green innovation hubs. Similarly, the World Economic Forum (2025) highlights Detroit's mobility innovation hub, where corporate R&D, digital infrastructure, and public transit planning are coordinated—while also involving citizens in shaping decisions.

According to Mazzucato (2024), governments should do more than regulate—they should help shape markets by setting bold, long-term missions that guide private-sector innovation. But these partnerships must be accountable. As Boschma et al. (2025) caution, without strong safeguards, PPPs risk prioritizing corporate interests over public good or displacing vulnerable communities.

This is where innovation labs come in. These are collaborative spaces where different stakeholders, governments, researchers, companies, and citizens, can experiment with new ideas, co-create solutions, and test them before scaling up. These labs increase local trust, encourage innovation, and help ensure solutions reflect real needs.

Public Innovation Labs focus specifically on solving challenges in areas like healthcare, education, or urban planning. They use methods like design thinking, co-creation, and rapid prototyping to bring diverse voices into public decision-making (Tõnurist, Kattel, & Lember, 2017). For example, a lab might bring together city planners, tech companies, and residents to redesign a more inclusive public transit system.

Successful labs like MindLab in Denmark and Nesta's Innovation Lab in the UK show how governments can become more agile and people-centered (McGann, Blomkamp, & Lewis, 2018). These labs do more than solve one problem, they help foster a public sector culture that's open to creativity and learning.

They also have a long-term impact. As Voorberg, Bekkers, & Tummers (2015) point out, innovation labs help governments experiment with bold new ideas, like improving education in underserved areas or testing smart city tools to cut energy use. This mindset shift is essential for building urban systems that are more resilient and responsive to future challenges.

In short, public-private partnerships and innovation labs are not just project tools, they're core parts of how modern innovation ecosystems function (Autio & Thomas, 2014). They build trust, enable experimentation, and help districts move from ambition to action.

International and Regional Sustainability Policies:

Innovation districts are also influenced by transnational sustainability frameworks. The United Nations Sustainable Development Goals (SDGs) serve as a global agenda, with SDG 10 (Reduced Inequalities) and SDG 12 (Responsible Consumption and Production) especially relevant for innovation ecosystems (GIID, 2023).

At the regional level, the European Green Deal mandates sustainability-oriented planning through incentives for circular economy practices, carbon neutrality, and inclusive economic development.

The Quintuple Helix model, which incorporates environmental sustainability and civil society into innovation planning is a powerful tool for aligning local development with planetary boundaries and global justice (Carayannis, Campbell , & Grigoroudis , 2021)

Finally, Boschma et al. (2025) call for place-sensitive policy transfer, meaning that policies adapted from global frameworks should be tailored to local social and economic realities rather than applied wholesale. Without this sensitivity, even well-intentioned policies risk worsening inequality.

Land Use and Mixed-Use Development:

Land-use planning is a powerful lever for enabling innovation, connectivity, and sustainability. It determines how people interact, collaborate, and live in the district.

Wagner (2024) highlights that effective land use in innovation districts prioritizes proximity, accessibility, and flexibility co-locating businesses, research centers, and community infrastructure in walkable, green, and adaptable spaces.

Mixed-use development is central to this approach. Blending housing, workplaces, labs, cultural venues, and green spaces creates vibrant environments where people can live, work, create, and socialize. This integration reduces car dependency, improves quality of life, and encourages informal interaction—an essential ingredient for knowledge exchange and innovation.

In summary, Innovation districts thrive when their governance structures and land use plans are flexible, inclusive, and sustainability focused. From policy design and public-private partnerships to global sustainability alignment and local land planning, a layered governance approach is essential. When local, regional, and international actors collaborate strategically, innovation districts become engines not only for economic growth, but also for equity, community wellbeing, and environmental resilience.

2.2.4 Examples of innovation districts

Innovation districts have expanded globally, each using distinct assets and capabilities. Here are a few examples that stand out, as highlighted by Katz, Wagner, & Osha (2019).

The Cortex Innovation Community in St. Louis, Missouri: This 200-acre innovation district has grown into a technology, life sciences, and business hub. Saint Louis University, Washington University, and several other key universities partnered to create it. As evidence of the effectiveness of multi-stakeholder collaboration, Cortex has produced $550 million in investment and over 4,200 tech-related jobs (Katz, Wagner, & Osha, 2019).

Figure 6. Map of the Cortex Innovation Community, St. Louis, Missouri (Source: Google Maps, accessed March 2025).

22@Barcelona innovation district, Spain: Former industrial regions have been transformed into a thriving innovation hub in this district, which perfectly illustrates urban change. The development was spearheaded by the municipal government, which established a variety of corporate R&D facilities, start-ups, and research institutes (Katz, Wagner, & Osha, 2019).

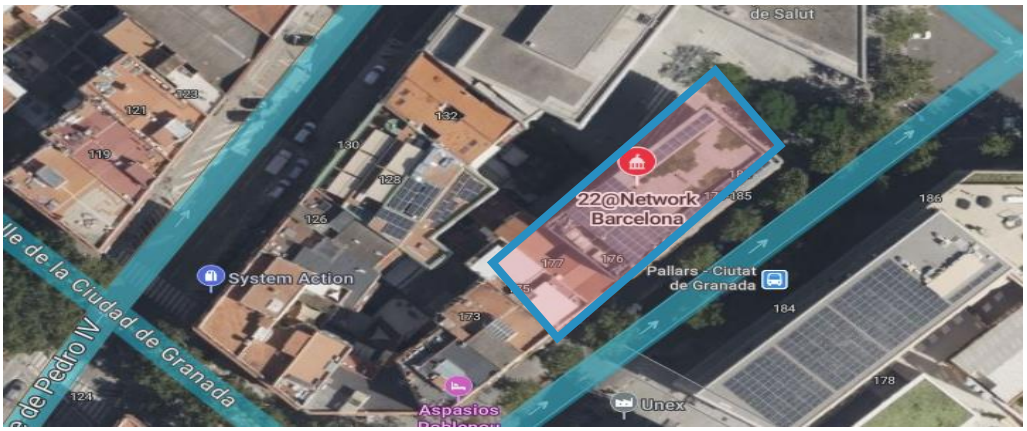

Figure 7. Map of 22@Barcelona innovation district, Spain (Source: Bing Maps, accessed March 2025).

The Melbourne Biomedical Precinct in Melbourne, Australia: Prestigious hospitals and research institutes can be found in this biomedical and life sciences-focused region. The state government has contributed to its growth by coordinating R&D activities and investing in infrastructure (Katz, Wagner, & Osha, 2019).

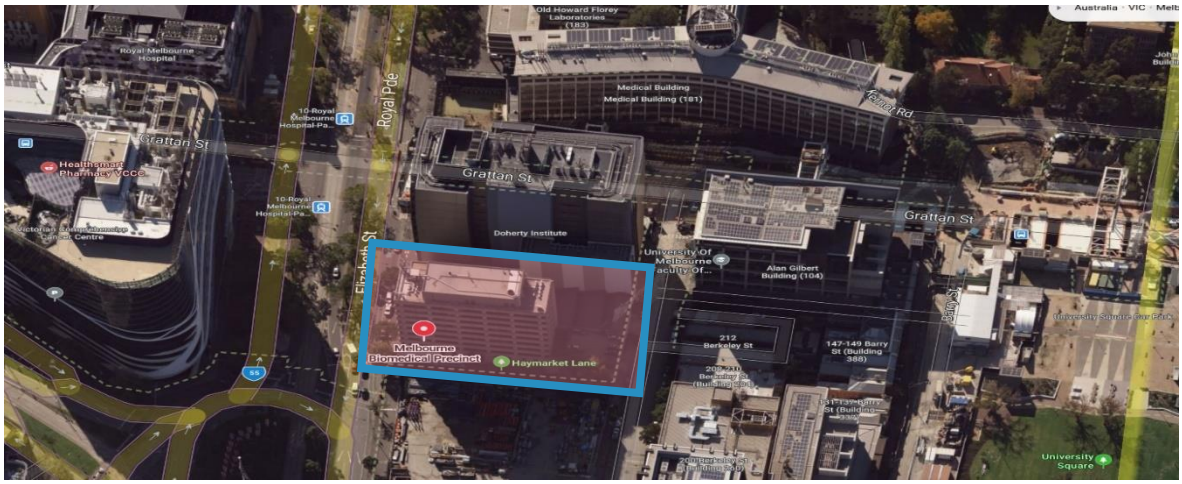

Figure 8. Map of The Melbourne Biomedical, Australia
(Source: Bing Maps, accessed March 2025).

USA's Buffalo Niagara Medical Campus: Anchor organizations like the University at Buffalo and Roswell Park Comprehensive Cancer Center have helped this district become a leader in the life sciences and healthcare. UsingInclusive growth tactics have improved the local neighborhoods and produced more than 12,000 new jobs (Katz, Wagner, & Osha, 2019).

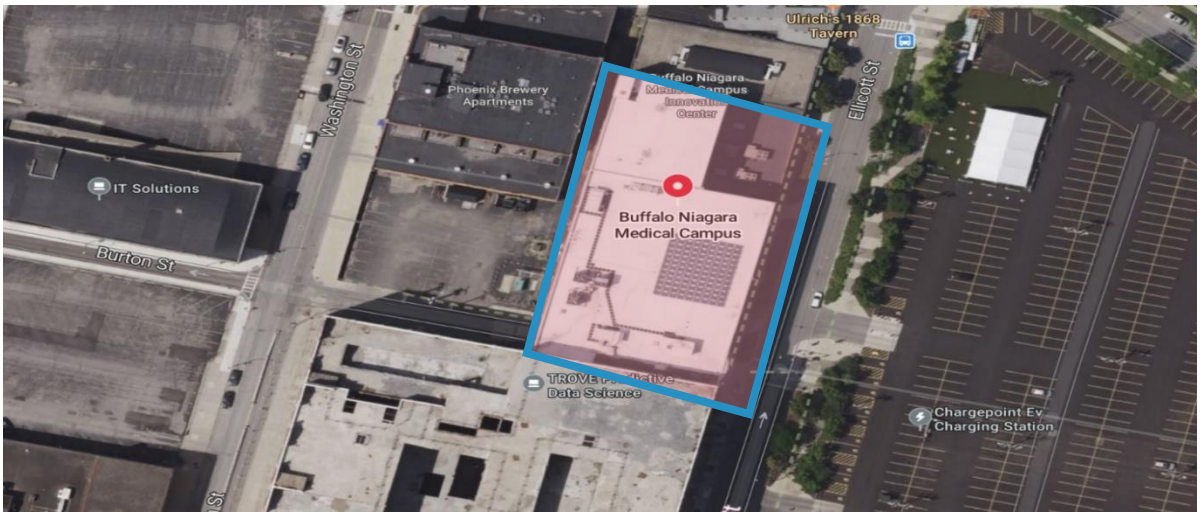

Figure 9. Map of USA's Buffalo Niagara Medical Campus
(Source: Bing Maps, accessed March 2025).

2.3 Sustainability in Innovation Districts

The innovation districts have recently been embracing more and more sustainability programs into their primary operations to realize environmental issues and foster economic and social well-being. Implementing sustainability within the districts is also key to fostering environmental stewardship and long-term development. These efforts employ collaborative frameworks to develop context-specific strategies tailored to urban needs, such as transition teams and the Quadruple Helix model (integrating academia, industry, government, and civil society). Such approaches advance environmental stewardship and ensure scalable, long-term impact by aligning stakeholder priorities with localized sustainability goals (Franco et al., 2022; Etzkowitz & Zhou, 2017).

2.3.1Comparative analysis

Around the world, innovation districts are putting sustainability strategies into practice to encourage long-term growth and environmental responsibility. Among the notable instances are the following. These approaches manifest differently across global innovation districts, as shown in Table 1's comparative analysis of key sustainability indicators.

Table 1. Comparative Overview of Sustainability Initiatives in Innovation Districts

District	**CO_2 Reduction Goals**	**Waste Management Initiatives**	**Energy Efficiency Targets**	**Mixed-Use Development**	**Sources**
22@Barcelona (Spain)	45% GHG reduction by 2030	Zero-waste by 2030 (Ajuntament de Barcelona, 2018)	20% residential retrofits for efficiency (Districlima, 2011)	3M+ sqm: tech, housing, parks	(Reinventing Cities, n.d.), (More than green, n.d.), (Gianoli & Henkes, 2020)
Kendall Square (Cambridge, MA)	Targets 10–20% energy reduction beyond LEED v4	Amgen: 75% waste reduction, 40% water cut by 2027	High-performance buildings; district steam systems	Labs, offices, housing, retail (e.g., "The Nexus" development)	(Massachusetts Institute of Technology, 2016), (Winn, 2022)
Stockholm Green Innovation District (Sweden)	Climate neutrality by 2030; Bio-CCS at Hjorthagen plant	AI vacuum waste system, 100% recycled construction waste	60% energy cut in Årsta via smart solutions	Housing, offices, green spaces (e.g., Stockholm Wood City)	(Stockholm Green Innovation District, n.d.)
Amsterdam Science Park (Netherlands)	Carbon-neutral labs by 2030	Circular labs (e.g., plastic-free zones)	Energy-neutral buildings (e.g., LAB42)	Primarily labs/education; limited housing	(Amsterdam Science Park, n.d.)
Rotterdam Innovation District (Netherlands)	50% CO_2 cut by 2030	Smart waste bins; 70% recycling target	Energy-positive buildings	Mixed-use towers (e.g., "The Sax")	(Rotterdam Innovation City, n.d.)

22@ Barcelona (Spain): Barcelona's 22@ sector, which was formerly an industrial area but is now a thriving center for innovation, is a shining example of urban rehabilitation. Through the creation of green areas, the use of cutting-edge transportation solutions, and the promotion of energy-efficient structures, the program aims to integrate environmental sustainability. The district, for example, has a district heating and cooling system, fiber-optic infrastructure, and selective pneumatic garbage collection. In addition to encouraging innovation, the Industrial Heritage Protection Plan preserves the region's cultural identity by safeguarding 114 historical features (TBS Education Barcelona, 2021).

Kendall Square, Cambridge (USA): Located in Cambridge, Massachusetts, Kendall Square is well-known for being home to a large number of high-tech companies and research facilities. Through programs like the Kendall GREEN program, which encourages trash reduction, energy efficiency, and environmentally friendly transportation alternatives, the district places a strong emphasis on sustainability. Green infrastructure and sustainable construction methods have been developed as a result of partnerships with organizations such as MIT, The Engine, and the Broad Institute (Kendall Square Association, n.d.).

Stockholm Green Innovation District, Sweden: stretching from Arsta to Sickla, this district is a hub for sustainability and innovation. Developed collaboratively by the City of Stockholm, Nacka Municipality, businesses, and research organizations like KTH Royal Institute of Technology, it aims to renew and build sustainable districts with innovative, climate-smart solutions. Initiatives include sustainable renovation projects and the development of wood-based urban structures to reduce carbon emissions (Stockholm Green Innovation District, n.d.).

Amsterdam Science Park: Aims to achieve carbon-neutral laboratories by 2030, with initiatives like the energy-neutral LAB42 building exemplifying this commitment. The park promotes circularity through projects such as plastic-free zones and supports startups focusing on sustainable technologies, including renewable energy and sustainable chemistry. While primarily dedicated to research and education, the park integrates green infrastructure and fosters collaborations between academia and industry to drive sustainable innovation (Amsterdam Science Park, n.d.), (Galán-Muros, Hegyi, Blancas, & Sagredo, 2021).

Rotterdam Innovation District: Targets a 50% reduction in CO_2 emissions by 2030, emphasizing energy-positive buildings and smart waste management systems with a 70% recycling goal. The district features mixed-use developments like "The Sax" towers, combining residential and commercial spaces to create a vibrant urban environment. Additionally, Rotterdam invests in green roofs, urban agriculture, and circular economy initiatives, transforming former industrial areas into hubs of sustainability and innovation (Rotterdam Innovation City, n.d.).

The Kendeda Building for Innovative Sustainable Design (USA): Located at Georgia Tech, The Kendeda Building is one of the world's most sustainable academic buildings. It is the first in Georgia and the 28th globally to achieve Living Building Challenge certification. The building generates energy, captures and treats all water on-site, and uses non-toxic materials, setting a new standard for sustainable architecture in innovation districts (Georgia Tech, 2025).

Kalundborg Eco-Industrial Park, Denmark: This park is a prime example of industrial symbiosis, in which businesses work together to use one another's waste products, improving both the environment and financial efficiency. For example, the Asnaes Power Station reduces mining by donating gypsum from its sulfur dioxide scrubber to a wallboard company and using excess heat from the power station to heat nearby houses. These transactions provide a practical illustration of industrial sustainability through resource efficiency and waste minimization (Kalundborg Symbiosis, n.d.).

High Tech Campus Eindhoven (The Netherlands): High Tech Campus Eindhoven (HTCE) is committed to becoming Europe's most sustainable innovation campus, integrating environmental stewardship into its core operations. HTCE has installed 11,000 solar panels across 30 campus roofs, ensuring 100% green electricity usage. The campus utilizes closed water management systems and seasonal thermal energy storage to optimize energy consumption. Nearly 80% of its buildings hold top energy efficiency ratings, with recent constructions like HTC 85 (Workplace Vitality Hub) being gas-free and incorporating advanced sustainable systems (High Tech Campus Eindhoven, n.d.).

Tech Lane Ghent Science Park (Belgium): Tech Lane Ghent Science Park is dedicated to fostering innovation within a sustainable and collaborative environment. Tech Lane emphasizes eco-efficient development, integrating green spaces and sustainable building practices. The park's design promotes biodiversity and environmental responsibility, establishing a harmonious equilibrium between ecological preservation and technological growth (Tech Lane Ghent, n.d.).

High Tech Campus Eindhoven (HTCE) and Tech Lane Ghent Science Park exemplify how innovation districts can lead in sustainability by integrating cutting-edge research and development with environmental and social responsibility. HTCE also has ambitious targets to be the most sustainable campus in Europe by 2025 through a thorough sustainability roadmap involving the installation of 30,000 solar panels, becoming CO_2 neutral, and decreasing the use of fossil fuels by 50%. The campus supports biodiversity through practices such as utilizing sheep to maintain the grass and providing habitats for different species. Additionally, HTCE encourages sustainable transportation by providing electric buses, bicycles, and car-sharing services. Tech Lane Ghent Science Park focuses on sustainability through collaborative efforts among its tenants. Initiatives include sustainable water management, mobility solutions like shuttle services and bicycle repair, and centralized waste collection. The park also organizes annual cleanup days involving volunteers from various organizations to maintain a clean environment. While Table 1 provides quantitative comparison from current available data, Section 4 will analyze qualitative differences in implementation between High Tech Campus Eindhoven and Tech Lane Ghent.

While these case studies demonstrate the diversity of sustainability initiatives in innovation districts, For most their effectiveness hinges on participatory approaches to innovation. This is where Living Labs (LLs) emerge as pivotal mechanisms for fostering user-centered, open innovation ecosystems.

2.3.2 Living Labs (LLs):

Functioning as dynamic, collaborative platforms, LLs unite diverse stakeholders, including researchers, businesses, public organizations, and citizens—to co-create, test, and refine innovative solutions within real-world contexts. By adhering to this user-centered approach, LLs ensure that the solutions developed are relevant and adequately address the specific societal needs of the community, thereby making them very likely to be embraced on a large scale. (Schuurman & Leminen, 2021) found that LLs facilitate cooperative experimentation and encourage knowledge sharing, which results in sustainable solutions carefully designed for extraordinary situations.

Moreover, LLs help bring sustainability by unifying knowledge from different fields and industries. They create structured environments for stakeholder engagement and co-creation, thereby driving systemic change toward sustainability within innovation districts. For example, the excellent cases of 22@ Barcelona and Kendall Square reveal how these spaces have successfully incorporated LLs, enabling the development of targeted strategies that solve environmental problems while promoting economic and social well-being. Such initiatives underscore the essential role of LLs as catalysts for advancing sustainability-oriented innovation through active user engagement and collaborative creation in real-world scenarios.

Innovation districts are not just centers of economic growth; they represent a transformative approach that harmonizes urban strategies with sustainability goals. By embedding environmental, social, and governance (ESG) principles into these districts, we can advocate for environmental responsibility and promote long-term growth. The 22@ Barcelona neighborhood is a prime example of such potential for transformation, highlighting the ability of urban renewal to express sustainability objectives through the revitalization of formerly industrial spaces into hubs of green infrastructure innovation (Gianoli & Henkes, 2020). Such a vision of the future encourages and paves the way for a sustainable future. While participatory approaches like Living Labs enable grassroots innovation, structural ESG frameworks provide the governance backbone for scalable impact. Recent research reveals how ESG principles directly catalyze technological advancement

2.3.3 Environmental, social, and governance (ESG) principles:

ESG principles are now integral to corporate strategy, particularly for those in innovation districts who seek economic growth and sustainable development. More recent empirical research highlights the interplay between good ESG performance and more corporate innovation. For instance, (Tang, 2023) analyzed data from 3,784 A-share listed manufacturing firms in China and found that strong ESG performance significantly promotes corporate innovation. This effect is mediated by factors such as alleviating financing constraints and increasing foreign institutional investment. Also supporting this correlation are executives with global and educational backgrounds, highlighting the leadership function in integrating ESG issues into innovation strategies.

Further research by (Wang, Wang, & Wen, 2024) supports these findings, demonstrating that ESG performance improves not only the quantity but also the quality of corporate innovation. Their study reveals that ESG initiatives reduce agency problems, enhance information disclosure, and improve internal corporate governance, creating an environment conducive to innovation.

Specifically, the contribution of ESG to innovation is more positive in firms located in central and western provinces and those from highly polluting industries, which suggests that the practices of ESG can exceptionally be beneficial in adverse situations.

In the realm of green innovation, (Wu, Yi, Hu, Lyulyov, & Pimonenko, 2024) found that companies with strong ESG performance exhibit heightened social responsibility, better information disclosure, and more straightforward navigation of financing constraints, all of which contribute to more effective green innovation initiatives. Besides, the study also emphasized that good ESG practices will promote green innovation efficiency through improved corporate value and reputation, innovation opportunities, and sustainable growth.

These studies collectively highlight that integrating ESG principles within innovation districts fosters sustainable practices and drives technological advancement and economic growth. Businesses may build robust, forward-thinking innovation ecosystems that tackle environmental issues while advancing social and economic well-being by incorporating ESG considerations into their core objectives. However, despite the clear benefits of ESG integration, innovation districts face significant implementation challenges that can hinder their sustainability transitions—particularly in balancing economic objectives with environmental and social goals

2.3.4 Sustainability implementation barriers:

Implementing sustainability in innovation districts faces organizational, social, and systemic barriers stemming from tensions between economic and sustainable development goals. These multi-level challenges range from governance structures to community impacts, each presenting distinct obstacles to sustainable urban transformation.

The most fundamental challenge emerges from the dominant economic model that prioritizes short-term financial profits over long-term sustainability. This emphasis frequently results in underinvestment in sustainable infrastructure, as the immediate returns on such investments remain less tangible than conventional development projects. (del Cerro Santamaría , 2021) demonstrates how property-led urban renewal often marginalizes socio-economic outcomes aligned with sustainability objectives in favor of quicker commercial returns.

Compounding these economic barriers are complex organizational hurdles. Innovation districts must coordinate diverse stakeholders including public authorities, business enterprises, and community organizations. As del Cerro Santamaría (2021) further notes, the absence of efficient governance systems to manage competing priorities and resource allocations frequently undermines cohesive sustainability initiatives.

Another area that faces difficulties is social sustainability, which includes elements like community involvement and inclusivity. Innovation districts may unintentionally fuel gentrification by uprooting existing communities and escalating social inequality. Deliberate planning and policies that put equitable development first are necessary to address these problems (Vallance, Perkins, & Dixon, 2011).

Beyond these operational challenges lie deeper Systemic barriers like funding sources and regulatory frameworks may also hamper sustainability initiatives. Traditional funding models may not support the long-term investments needed for sustainable infrastructure, and strict regulations may not allow for creative, sustainable practices (Sandberg & Aarikka-Stenroos, 2014).

Finally, open innovation presents a unique set of difficulties even though it is advantageous for encouraging cooperation and quickening technological progress. According to Dabić et al. (2023) companies frequently have trouble maintaining fair stakeholder participation, managing intellectual property rights, and balancing openness and strategic control. These complexities can impede the effective implementation of sustainability initiatives within innovation districts (Dabić, Daim, L.A.M. Bogers, & Mention, 2023).

In summary, sustainability implementation faces five interconnected barriers: (1) short-term economic priorities, (2) multi-stakeholder coordination challenges, (3) social equity tensions, (4) systemic regulatory and funding constraints, and (5) open innovation complexities. Overcoming these requires a comprehensive strategy that embeds sustainability into core district objectives through adaptable governance, inclusive policies, innovative financing mechanisms, and carefully structured collaboration frameworks.

Chapter 3: Methodology

3.1 Research design

This study adopted a comparative qualitative case study design to explore and contrast sustainability strategies within two leading European innovation districts: Tech Lane Ghent Science Park and High-Tech Campus Eindhoven (HTCE). The aim was to understand how each district approaches sustainability in areas such as waste reduction, energy efficiency, CO_2 emissions, and mixed-use development, and to examine the underlying governance structures and stakeholder engagement mechanisms. The case study method allowed for an in-depth exploration of context-specific practices and perceptions, particularly valuable when comparing place-based innovation ecosystems.

3.2 Data collection

To triangulate insights and ensure a strong understanding of both cases, the study relied on two primary data sources: semi-structured interviews and a stakeholder perception survey.

Semi-structured interviews: A total of nine interviews were conducted with stakeholders from both districts and innovation district experts. These included site managers, sustainability coordinators, project leads, and corporate sustainability professionals. The interviews were held between March and April 2025, using a semi-structured format to allow for both consistency and depth. Topics discussed included energy and waste systems, stakeholder engagement, infrastructure, and challenges in implementing sustainability measures.

Table 2. Overview of Interview Participants

Name	Role	Organization	District	Date
Thijs Urban	Site Manager	Tech Lane Ghent – Campus Ardoyen	Tech Lane Ghent	Apr-03-2025
Heleen Veys	Project Coordinator	POM Oost-Vlaanderen	Tech Lane Ghent	Apr-03-2025
Harrie Arends	Operations Manager	High Tech Campus Eindhoven	HTCE	Apr-07-2025
Wouter De Broeck	Sustainability Coordinator	VIB	Tech Lane Ghent	Mar-21-2025
Juliette Gaussem	Former sustainability board member HTCE	High Tech Campus Eindhoven	HTCE	Apr-04-2025
Anonymous	Sustainability responsible	(anchor tenant)	Tech Lane Ghent	Mar-21-2025
Laura Biancuzzo	Senior Research Associate	The Global institute of Innovation Districts		Apr-23-2025
Emiliano Boschetto	Chief Philosophy Officer	eFM		Apr-22-2025
Kshitij Goyal	AI Data Scientist	ASML	HTCE	Mar-30-2025

One interviewee, a sustainability responsible from an anchor tenant, requested anonymity and is referenced without attribution. All participants provided informed consent prior to the interviews.

Survey: A structured online survey was distributed to businesses and employees located within the two districts. The survey focused on perceptions of sustainability engagement, awareness of district-wide goals, participation in green practices (e.g., recycling), and communication effectiveness. A total of 41 responses were collected: 14 from Tech Lane Ghent and 27 from HTCE. Responses provided both quantitative insights and open-ended comments, which were used to supplement interview findings.

3.3 Data Analysis

The collected data were analyzed using a thematic coding approach, allowing for the identification of recurring patterns and themes across interviews and survey responses. Themes were initially derived from the research questions and literature review (e.g., governance, stakeholder engagement, energy strategy), and then refined through an inductive review of the data.

Interview transcripts and open-ended survey comments were coded manually and organized into matrices for comparison across the two cases. Recurring topics were grouped into higher-level themes such as “community participation,” “centralized governance,” “technical infrastructure,” and “policy alignment.”

This thematic analysis informed the structure of the results and discussion chapters, ensuring that interpretations were grounded in participant voices and stakeholder experience.

3.4 Ethical Considerations

All participants were fully informed about the study's objectives and provided voluntary consent for participation, including audio recording and the use of anonymized quotations. One participant was anonymized upon request to ensure confidentiality. All data were stored securely, and data management complied with GDPR standards. The study followed the ethical standards outlined by the university’s research guidelines.

Chapter 4: Results

4.1 Overview of Case Study Districts

This study focuses on two European innovation districts known for their contributions to sustainable innovation ecosystems: Tech Lane Ghent Science Park in Belgium and High-Tech Campus Eindhoven in the Netherlands. The analysis draws from nine semi-structured interviews and 41 survey responses (14 from Tech Lane and 27 from HTCE), supplemented by thematic coding. Key themes include waste reduction initiatives, energy efficiency measures, CO_2 emission reduction efforts, integration of mixed-use developments, governance structures, and stakeholder perceptions.

4.1.1 Tech Lane Ghent Science Park:

Located in the city of Ghent, Tech Lane Ghent Science Park comprises two main campuses—Campus Ardoyen and Campus Eiland Zwijnaarde. Together, they form a robust innovation ecosystem driven by research in digital technologies, biotechnology, and sustainable chemistry. The park hosts over 90 high-tech startups, 11 university labs, and leading research institutions such as VIB, IMEC, and VITO. With flexible lab and office spaces and proximity to Ghent University's talent pool of over 50,000 students and 15,000 researchers, the park continues to attract around 10 new startups annually (Tech Lane Ghent, n.d.).

As confirmed by Thijs Urban, Site Manager at Tech Lane Ghent, during the interview, Tech Lane is coordinated by a network of partners, including Ghent University, the Flemish investment group PMV, the City of Ghent, Alinso Group, and the East Flanders Development Agency (POM Oost-Vlaanderen). This multi-actor governance structure reflects a public-private partnership model aligned with innovation district principles. Stakeholders noted that sustainability is influenced by this governance diversity, coordinated primarily through VZW Ardoyen, which includes participatory committees on mobility, durability, and events involving park members.

One notable example of innovation-driven infrastructure is HomeLab, a 600 m² living lab for real-world testing of smart home and IoT technologies. In addition, the park recently welcomed a 22,000 m² CAR-T cell therapy facility built by Janssen Pharmaceutica and Legend Biotech, which achieved LEED Gold certification (Urban & Veys, personal communication, April 3, 2025). Ghent University also plans to relocate three additional faculties to Campus Ardoyen by 2050, further strengthening the park's academic and innovation base.

Furthermore, according to the park's regulatory framework (Parkreglement), all new buildings must meet the 'Bijna Energie Neutraal' (BEN) standard, meaning 'nearly energy neutral', which supports long-term goals for energy efficiency and CO_2 reduction.

Despite its strengths, governance fragmentation poses sustainability challenges. One board member noted:

"There's no common waste policy. Each company acts independently unless coordination is forced by external funding" (Anonymous, personal communication, March 21, 2025).

Similarly, a sustainability specialist explained:

"Sustainability initiatives remain fragmented. Individual labs or firms typically drive their own agendas" (Anonymous, personal communication, March 21, 2025).

The classification of Tech Lane Ghent as an innovation district is supported by Segers (2019). The study demonstrates that Tech Lane Ghent exhibits an innovation district's essential characteristics through its thriving ecosystem of biotechnology ventures emerging from a robust Triple Helix framework. This framework successfully integrates "small and large business, regional government and cluster organizations, with academia and top-level research" while fostering multiple strategic alliances. The density of red (pharmaceutical/medical) and green (agricultural/environmental) biotechnology enterprises within this collaborative environment substantiates Tech Lane Ghent's role as a functional innovation district (Segers, 2019).

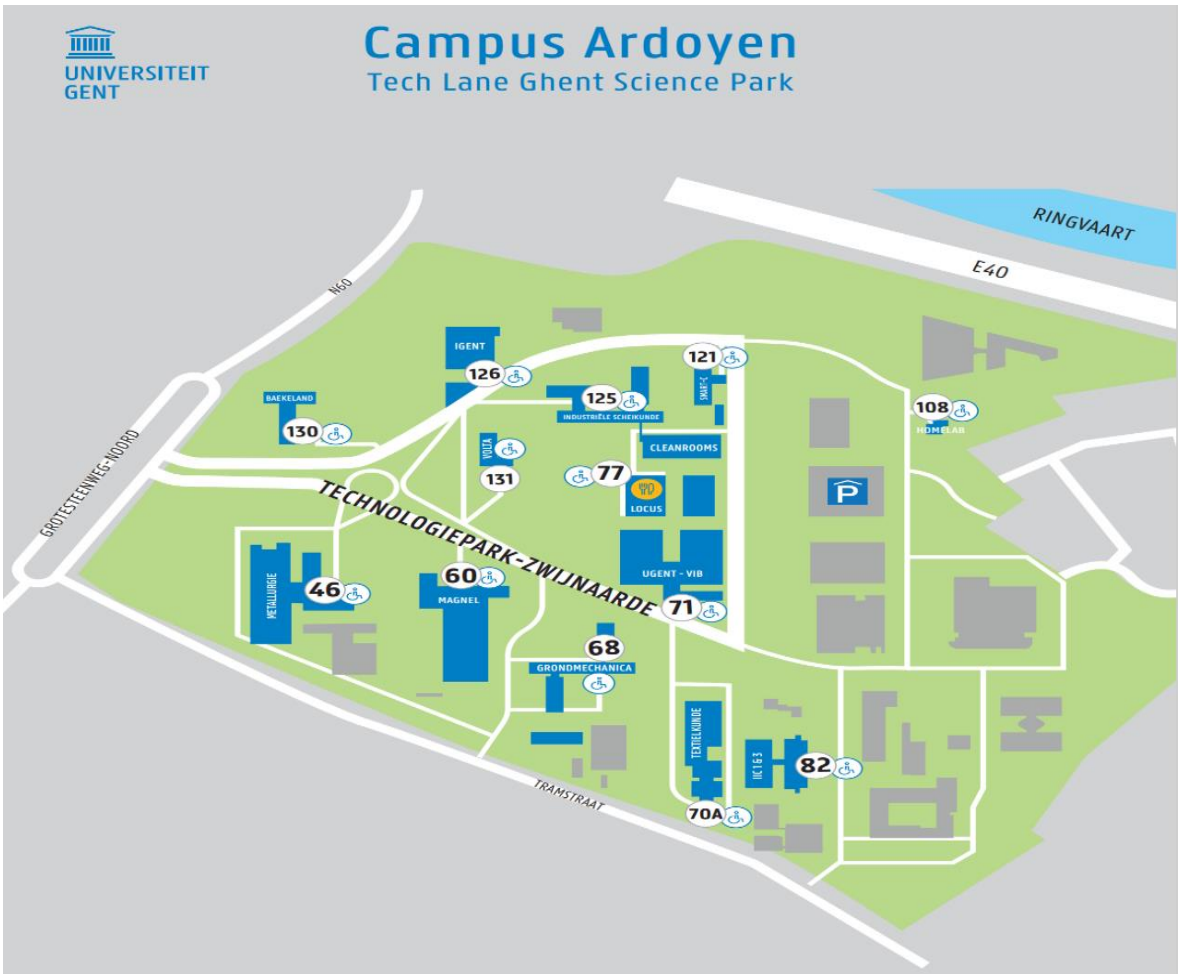

Figure 10. Map of Tech Lane Ghent Science Park — Campus Ardoyen
Source: (Ghent University, Campus Ardoyen map, 2025).

Figure 11. Map of Tech Lane Ghent Science Park — Campus Eiland Zwijnaarde

Source: (Eiland Zwijnaarde, 2024).

4.1.2 High Tech Campus Eindhoven:

Spanning over 100 hectares, High Tech Campus Eindhoven is home to more than 260 high-tech firms and over 12,500 researchers, engineers, and innovators. Its ecosystem includes major corporations like Philips, NXP, ASML, and Intel, alongside research institutes, SMEs, startups, and the Eindhoven University of Technology. The campus has earned the nickname "Europe's smartest square kilometer" for its concentration of advanced technology development. According to (DE PRETER, 2025), HTCE also plays a central role in the Eindhoven–Leuven–Aachen tech triangle, a cross-border ecosystem recognized for leadership in deep tech, semiconductors, and research collaboration across the Netherlands, Belgium, and Germany.

HTCE's innovation strategy is organized into five interconnected domains, including MedTech, energy systems, applied intelligence, digital transformation, and smart environments. These initiatives are supported by shared research facilities and open collaboration spaces that promote cross-disciplinary exchange. In sustainability terms, HTCE is privately governed and operates a centralized ESG dashboard, aiming to become CO_2-neutral by 2030.

"We report annually on KPIs covering energy, waste, commuting, and indirect emissions," explained the Operations Manager (Arends, personal communication, April 7, 2025).

The campus also applies a Living Lab model. According to Juliette Gaussem, a former sustainability lead at one of the anchor tenants:

"We tested solutions in real life—used solar energy, EV charging, green roofs—all of that was part of our sustainability efforts, I remember from HTCE" (Gaussem, personal communication, April 4, 2025).

The physical environment also reflects a mixed-use development approach, with food courts, bike-sharing schemes, wellness programs, and community-building activities such as cricket teams—all contributing to social sustainability and employee wellbeing.

HTCE emphasizes an open innovation model, where knowledge, expertise, and research facilities are shared among campus members. The multinational character of its workforce, spanning 85 different nationalities—adds to the diversity and global relevance of its innovation ecosystem (Brain Port Eindhoven, n.d.).

Recent infrastructure investments further reinforce the campus's position as a leading tech hub. In December 2024, Dutch tech companies including ASML committed around $230 million to regional

Figure 12. Map of High-Tech Campus Eindhoven

Source: (Bing Maps)

infrastructure, supporting "Operation Beethoven"—a $2.7 billion government initiative for housing, transport, and education in the Eindhoven tech corridor (Reuters, 2024). In 2025, NXP Semiconductors renovated and expanded its headquarters, creating collaborative workspaces that promote employee wellbeing (High Tech Campus Eindhoven , 2025).Looking ahead, HTCE aims to be among the world's top tech hubs by 2030, with strategic emphasis on AI, LiFi, sustainable energy, and smart cities.

4.2 Analysis of Sustainability Initiatives

This section presents a comparative thematic analysis of sustainability initiatives implemented at Tech Lane Ghent and High-Tech Campus Eindhoven. Drawing on interviews with site managers, sustainability board members, and employees, the analysis is structured around four key sustainability themes: waste reduction, energy efficiency, CO_2 emissions reduction, and mixed-use development. These themes were derived through inductive coding of the interview transcripts and supplemented by selected survey data to triangulate findings and identify patterns across both districts.

4.2.1 Waste Reduction Initiatives:

Tech Lane Ghent: Interview data reveals that waste reduction initiatives at Tech Lane Ghent are fragmented and vary between buildings and companies. A sustainability responsible from one of the major pharmaceutical firms at the park explained that:

"Waste is managed partially by the building owner and partially by the company I work for," but overall, structured waste reduction programs are "still scarce" (Anonymous, personal communication, March 21, 2025).

Initiatives largely depend on awareness campaigns and individual lab efforts, with some companies exploring supplier take-back programs. Reaffirming the uncoordinated nature of waste management strategies, one board member stated:

"There's no shared waste KPIs, each lab or company finds its own path" (De Broeck, personal communication, March 21, 2025).

Nonetheless, new efforts are emerging. Rebel, a spin-off company, has introduced sensor-enabled garbage bins linked to a mobile app, helping optimize pickup logistics and reduce overflow events (Urban & Veys, personal communication, April 3, 2025). Thijs urban further added that, VZW Ardoyen also organizes an annual clean-up day as a community engagement initiative.

Despite these pilots, coordination remains weak. Each company currently maintains its own waste collection contract, while Ghent University operates under a single waste contract across its sites. A prior attempt to organize a group purchasing agreement failed due to insufficient data from participating firms. This outcome reflects similar issues encountered at other industrial parks, where companies use the group quote to negotiate lower individual rates with their own contractors.

Yet another interviewee emphasized:

"We try awareness campaigns, but real change depends on voluntary participation" (Anonymous, March 21, 2025).

There is a shared perception among stakeholders that the park lacks a unified waste strategy. One sustainability board member rated the overall effectiveness as *"a five out of ten"* citing:

"There is absence of a common waste policy and the fact that companies are left free to join initiatives or not" (Anonymous, personal communication, March 21, 2025).

On the topic Thijs Urban further added that:

"Ongoing experimentation includes circular reuse ideas, such as using discarded pipet boxes from biotech labs as raw material for 3D printing within the on-site fab lab. These initiatives show promise but remain isolated."

High Tech Campus Eindhoven: By contrast, High Tech Campus Eindhoven (HTCE) employs a systematic, data-driven waste management strategy. Interviewees noted a two-step waste separation process supported by real-time monitoring.

"We use a Power BI dashboard to track waste streams per building," explained Arends, the campus operations manager (Arends, personal communication, April 7, 2025).

This centralized collection and data analysis enables targeted enhancements in waste reduction. Employees echoed the presence of a strong waste management culture. Goyal (personal communication, March 30, 2025) noted measures like separate waste bins as part of the park management initiative, and a ban on single-use cups in office areas, which is one of the strategies of ASML.

Juliette Gaussem, a former sustainability board member, emphasized HTCE's circular economy practices, stating:

"The idea was to reuse lighting or modular installations across new buildings" (Gaussem, personal communication, April 4, 2025).

Survey results confirmed contrasting employee perspectives: 79% of Tech Lane respondents reported participation in recycling, compared to 54% at HTCE. However, HTCE employees indicated more visible infrastructure and awareness around recycling practices, which is consistent with stakeholder observations.

While both districts express commitment to waste reduction, HTCE demonstrates greater integration of waste metrics, infrastructure, and accountability mechanisms. In contrast, Tech Lane Ghent continues to rely on voluntary and decentralized efforts, though pilot programs like smart bins, fab-lab reuse projects, and park-wide clean-up actions suggest early momentum toward more coordinated and circular waste solutions.

4.2.2 Energy Efficiency Measures:

Tech Lane Ghent: Efforts to enhance energy efficiency at Tech Lane Ghent are currently more decentralized initiatives and exploratory projects. One key project under exploration is a district heating feasibility study led by Sweco in partnership with VIB, the City of Ghent, and other park stakeholders.

"We've begun discussions with the City of Ghent to examine the potential of district heating, but it's still early-stage," explained De Broeck (personal communication, March 21, 2025).

Individual organizations have also taken initiatives. Several labs have implemented smart meters and real-time energy monitoring systems, particularly in the pharma and biotech sectors. One anonymous sustainability manager noted:

"We monitor our lab energy use in real-time and have set internal targets, but there's no shared system at park level" (Anonymous, personal communication, March 21, 2025).

Rainwater harvesting and digital twin technologies are also used to optimize water and energy usage in select buildings. Urban and Veys (personal communication, April 3, 2025) emphasized that while *"companies are innovating,"* the park still lacks an overarching energy strategy that aligns these efforts. As they noted:

"It remains fragmented because there is no shared framework or joint reporting mechanism."

In parallel with these bottom-up efforts, the park's regulatory framework, the Parkreglement, mandates that all new buildings comply with the 'Bijna Energie Neutraal' (BEN) standard, meaning 'nearly energy neutral.' Developers must follow a four-part energy strategy: rational electricity use, on-site generation of renewable energy without CO_2 emissions, purchase of certified green electricity, and where necessary acquisition of emission rights. To further align energy infrastructure, Tech Lane Ghent has initiated the Energetisch Masterplan Ardoyen, a feasibility study examining collective solutions for heating, cooling, and electricity provision across the park.

In addition to interview insights, survey results from Tech Lane sustainability board members reflected moderate satisfaction with energy-saving efforts, scoring them between 6 and 8 out of 10. Comments frequently referred to "promising pilots" but pointed to a lack of coordination or visibility across the broader campus.

High Tech Campus Eindhoven: In contrast, HTCE operates an integrated energy management system. Site operations manager Arends described several flagship initiatives:

"We've installed 12,000 solar panels and implemented Aquifer Thermal Energy Storage (ATES), which connects 30 buildings. Instead of using gas, we draw heat and cold from central wells, saving about one million cubic meters of gas every year" (Arends, personal communication, April 7, 2025).

In addition to 100% green electricity purchases, HTCE uses real-time data dashboards to monitor energy usage per building. Arends added,

"It's not just about hardware; we use KPIs to track consumption and continuously improve," (Arends, personal communication, April 7, 2025).

Goyal (personal communication, March 30, 2025) confirmed that automated lighting, sensor-controlled blinds, and energy-efficient elevators are standard across buildings. Smart building design and solar orientation further enhance performance.

On energy efficiency, a survey response from a sustainability expert who was a previous board member of the HTCE sustainability board was highly positive, with 9 out of 10 satisfaction ratings.

Survey responses from sustainability experts ranked HTCE's energy efforts between 8 and 9 out of 10, frequently highlighting the visibility and consistency of initiatives: "You feel the system working around you," noted one respondent.

There is a noticeable difference between the two campuses. Even though Tech Lane Ghent is looking into ways to save energy, its efforts are still mostly project-based and decentralized. On the other hand, HTCE has implemented an integrated energy management system with validated metrics, demonstrating a strategic alignment and operational scalability model.

To summarize, Tech Lane Ghent demonstrates strong potential and isolated innovation but lacks a unified strategy to scale energy efficiency across the park. The recent Parkreglement mandates and the launch of the Energetisch Masterplan suggest early movement toward more centralized energy governance.

Meanwhile, HTCE illustrates how centralized governance, real-time data, and KPIs can create an operationally scalable and visible energy-saving model.

4.2.3 CO_2 Emission Reduction Efforts:

Tech Lane Ghent: Similar to other initiatives, CO_2 emission reduction initiatives at Tech Lane Ghent are mostly fragmented and initiated at the level of individual companies. Interviewees frequently pointed out the absence of a unified decarbonization framework across the park. As one sustainability board member clearly put it when asked about common CO_2 emission reduction plans:

"There is no unified plan for the park… there is no common goal. Some companies have done carbon accounting, but it's not coordinated" (De Broeck, personal communication, March 21, 2025).

Some companies, like the pharmaceutical firm represented by an anonymous interviewee, have started to inventory their Scope 1 and 2 emissions and are "now working on Scope 3," with the aim of developing concrete reduction strategies:

"We started inventorizing our Scope 1 and Scope 2 emissions. The company is now inventorizing Scope 3, and from that we'll start planning to reduce CO_2" (Anonymous, personal communication, March 21, 2025).

VIB, another key institution on site, is collaborating with consultants on a district heating feasibility study as a potential large-scale step toward decarbonization:

"There has been a study recently where we are looking into the creation of a district heating network that would be a major contribution to decarbonization" (De Broeck, personal communication, March 21, 2025).

Efforts are also underway to encourage sustainable procurement. A recent meeting of the Tech Lane sustainability committee focused on Scope 3 emissions from single-use lab consumables and chemical supplies:

"About one-third of our emissions come from single-use materials… we're trying to share insights on green suppliers across the park" (De Broeck, personal communication, March 21, 2025).

In terms of mobility-related emissions, the RUP (Ruimtelijk Uitvoeringsplan) for the site includes a formal objective to reduce commuting by car to 50% by 2029. This regulation directly targets Scope 3 emissions by encouraging modal shift strategies and sustainable commuting infrastructure.

Despite these efforts, most stakeholders described the initiatives as early-stage and uncoordinated. One interviewee summed it up by stating:

"There is availability to exchange data, but no plan. That's the problem" (Anonymous, personal communication, March 21, 2025).

High Tech Campus Eindhoven: on the other hand, High Tech Campus Eindhoven (HTCE) is taking a structured and proactive approach. The campus has committed to becoming CO_2-neutral by 2030, a goal backed by strong internal governance and performance tracking systems. Arends, HTCE's operations manager, stated:

"We have clear KPIs for gas use, electricity, and even indirect emissions from commuting and waste. These are all tracked in our ESG dashboard, and we report them to our parent company" (Arends, personal communication, April 7, 2025).

Survey results from sustainability board members of both districts support this while Tech Lane Ghent respondents rated CO_2 efforts not so good, 3 and 4 out of 10. HTCE respondent rated efforts significantly higher, scoring 8.

Furthermore, HTCE's visible commitment is further backed by on-site infrastructure like solar panels, aquifer thermal energy systems, and fully green electricity procurement, all contributing to an integrated CO_2 management system.

Overall CO_2 reduction at Tech Lane Ghent is characterized by isolated, company-driven initiatives with limited cross-campus coordination or measurable collective targets. While early-stage actions such as Scope 1 and 2 inventories, sustainable procurement discussions, and feasibility studies on district heating show promise, these efforts remain fragmented and informal. The inclusion of car reduction targets within the RUP marks an important exception, signaling a shift toward regulatory intervention in emission mitigation. In contrast, High Tech Campus Eindhoven presents a structured and strategic approach, with clear KPIs, annual ESG reporting, and centralized site governance enabling effective implementation. The difference highlights the impact of governance architecture and performance monitoring on shaping decarbonization outcomes at the innovation district level.

4.2.4 Integration of Mixed-Use Developments:

Tech Lane Ghent: Mixed-use development at Tech Lane Ghent remains limited due to zoning restrictions, particularly the RUP (Rup Uitvoeringsplan), which designates most of the park's zones for research and industry only. As a result, no residential housing exists within the campuses themselves (Urban & Veys, personal communication, April 3, 2025). One stakeholder explained, *"We can't have anything else but industry… the zoning doesn't allow for residential use".* This separation challenges the typical innovation district ideal of integrating living, working, and recreation.

Despite the absence of residential zones, some elements of functional diversity exist. The Campus Ardoyen area includes a pond and event square that doubles as a water infiltration zone and outdoor meeting space. Project manager Tech Lane explained:

"We have at the center, since last year, a new event square at the Ardoyen complex, featuring a pond with a bridge above it. This pond serves as a rainwater infiltration zone. The soil has a clay layer to retain a small water reserve, which also enhances aesthetics. Along the boundary, there's a dedicated infiltration zone that captures rainwater runoff from surrounding company buildings (though not from university structures). This water gradually infiltrates the ground before any excess is diverted to drainage systems."

The park is surrounded by residential neighborhoods such as Zwijnaarde and Meerelbeke, which are accessible by foot or bike. However, some stakeholders emphasized that *"the proximity is a bit far to call it walking distance."*

Facilities supporting community and employee well-being there, but not much. A few amenities exist, including a student cafeteria, picnic benches, and plans for a running track. However, one stakeholder remarked:

"We don't have gyms, cafes, or restaurants; there's more green space with a few benches" (Anonymous, personal communication, March 21, 2025).

Moreover, one of the interviewees noted that communication around existing initiatives is lacking:

"There are initiatives, but they are not always well communicated to companies or employees" (De Broeck, personal communication, March 21, 2025).

High Tech Campus Eindhoven: HTCE has embraced a more comprehensive approach to mixed-use development. The operations manager of HTCE stated:

"While there are no residential buildings directly on campus, plans are underway to construct a short-stay hotel and 650 accommodation units within 3–4 km of the campus, specifically aimed at researchers and international employees" (Arends, personal communication, April 7, 2025).

These future developments aim to reduce commuting-related emissions.

Moreover, Arends also stated that HTCE already integrates a wide range of functions on campus. These include multiple local and international restaurants, gyms, childcare services, green areas, walking trails, and tennis, cricket, and padel sports facilities. Arends added:

"We have our own sports fields and a large conference center… even childcare is available on campus," noted by operations manager (Arends, personal communication, April 7, 2025).

The central boulevard, the Strip, is a social and recreational hub, supporting campus vibrancy.

Employees highlighted how these features impact daily life. One respondent added:

"Having restaurants and gyms on campus improves the quality of life; it's all in one place" (Goyal, personal communication, March 30, 2025).

While both districts recognize the importance of functional integration, their implementation differs significantly. Tech Lane Ghent is constrained by zoning laws and limited infrastructure for mixed-use

functions, though green zones and public paths are being developed. HTCE, on the other hand, exemplifies the innovation district model with robust recreational and service infrastructure already in place and a strategic push toward residential integration.

4.3 Stakeholder Perception and Community Engagement

Beyond infrastructure and policy, the success of sustainability initiatives is closely tied to how stakeholders perceive and participate in them. This section explores the level of awareness, engagement, and satisfaction among key actors at Tech Lane Ghent and High-Tech Campus Eindhoven. Insights are drawn from both qualitative interviews and structured surveys, offering a dual lens on stakeholder experience. The section is divided into two parts: 4.3.1 outlines findings from interview data, while 4.3.2 analyzes responses from employees through a 10-question survey.

4.3.1 Qualitative Perspectives from Interviews:

Tech Lane Ghent: Stakeholder perceptions at Tech Lane Ghent reveal a mixed but evolving engagement landscape. While interviewees pointed to challenges in strategic coordination, they also acknowledged grassroots efforts and increasing collaboration. One sustainability board member highlighted the lack of formal structures, stating:

"Companies or buildings are left free to join initiatives or not. They should try to put it in policy or something." (Anonymous, personal communication, March 21, 2025).

Others pointed out a lack of overarching vision, which affects motivation and alignment:

"If there would be a clearer vision, it would help companies to jump on the Tech Lane boat… but I think there is a lack of long-term vision." (Anonymous, personal communication, March 21, 2025).

However, there are signs of positive momentum. The recently formed sustainability committee, "echo teams" at VIB, and initiatives like plogging and clean-up events indicate emerging participatory culture. A sustainability manager of a firm within district shared:

"It is very volunteer based. Some things are appreciated, but overall, there's room for improvement within community as far as sustainability is concerned." (Anonymous, personal communication, March 21, 2025).

Survey results highlight specific areas of strength:

- 79% of Tech Lane respondents reported participating in waste recycling programs, compared to 54% at HTCE.
- 36% said they had been asked for feedback on sustainability, more than double the 15% at HTCE.
- 62% said their companies collaborate with the park on sustainability initiatives.
- 36% bike or walk to work, indicating a strong base for sustainable commuting.

That said, familiarity with overarching sustainability goals was low: 57% reported being "not familiar at all." Importance of carbon footprint reduction was split 42% found it important or very important, but 42% also found it slightly or not at all important. These results suggest a willing and active subset, but also highlight the need for stronger internal communication and shared purpose.

High Tech Campus Eindhoven: HTCE's stakeholder engagement is characterized by a strategic and visible approach supported by its centralized operations team. Although only 15% of survey respondents said they had been directly asked for sustainability feedback, the clarity of direction, performance tracking, and the physical presence of sustainability infrastructure contribute to a strong perception of engagement. Arends noted:

Each project has KPIs, and success is measured. That gives clarity and credibility." (Arends, personal communication, April 7, 2025).

HTCE employees benefit from diverse on-campus amenities, including sports fields, a gym, food courts, walking trails, and daycare facilities. These offerings foster day-to-day engagement and work-life integration. As one employee described:

"We have table tennis, a personal trainer, and group fitness sessions. That's a huge plus." (Survey response, HTCE, April 2025).

Here are some other survey highlights:

- Only 4% of respondents were very familiar with HTCE's sustainability goals, and none reported being extremely familiar, suggesting room for improvement in internal communication.
- 42% ranked reducing their carbon footprint as "very important," and 23% as "extremely important," indicating strong individual alignment with sustainability values.
- 69% of respondents commute by car, though upcoming plans for short-stay housing aim to reduce commuting-related emissions.
- 46% reported using campus recreational spaces occasionally, and 31% used them frequently, supporting HTCE's mixed-use development strategy.

Stakeholder and community engagement reveal key contrasts between the two districts. At Tech Lane Ghent, engagement efforts are present and, in some cases, stronger than expected—with high rates of recycling participation (79%), sustainability collaboration (62%), and feedback involvement (36%). However, these efforts remain informal, inconsistently communicated, and disconnected from a central strategy, with many employees (57%) still reporting no familiarity with sustainability goals.

However, High Tech Campus Eindhoven (HTCE) benefits from a structured and well-resourced engagement environment, supported by strong amenities, regular performance tracking, and integrated site management. Yet only 15% of employees said they were asked for feedback, and no one reported being extremely familiar with the campus's sustainability goals, indicating a gap in two-way communication.

Survey and interview data converge to show that engagement is most effective when it is supported by both infrastructure and clear communication. While HTCE offers high satisfaction and visibility, Tech Lane Ghent's active grassroots involvement and higher employee participation in sustainability programs point to untapped potential that could be scaled with better coordination and shared direction.

4.3.2 Quantitative Perceptions from Survey Data

To complement the qualitative insights from interviews, this subsection presents findings from two structured surveys conducted among employees and businesses located at Tech Lane Ghent and High-Tech Campus Eindhoven. A total of 41 responses were collected 14 from Tech Lane Ghent and 27 from HTCE. The survey included ten multiple-choice questions addressing themes such as awareness of sustainability goals, participation in recycling and energy-saving practices, personal values, commuting habits, and perceptions of district-level sustainability engagement.

The results offer a quantitative lens into how sustainability is experienced on the ground. Figure 4.1 presents a side-by-side comparison of key survey responses to the first eight questions.

Figure 9 shows the comparison of survey responses on sustainability-related perceptions of stake holders at Tech Lane Ghent and High-Tech Campus Eindhoven **(n = 41).**

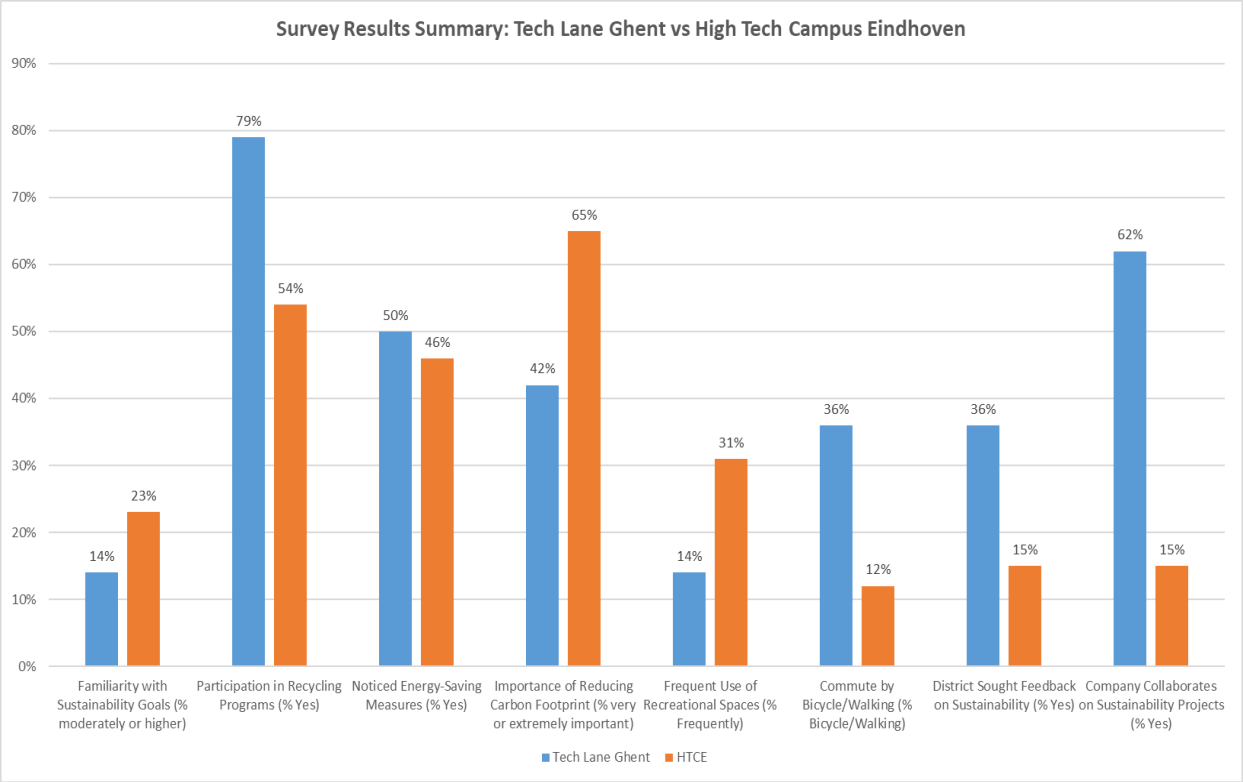

Figure 13. Stakeholder Survey Results on Sustainability Perception

The chart illustrates differences in familiarity, participation, perceived importance, commuting practices, and access to amenities across both campuses, based on eight core survey questions.

The figure shows that Tech Lane Ghent employees report higher participation in waste recycling (79%), more frequent collaboration on sustainability initiatives, and greater likelihood of being asked for feedback (36%). In contrast, HTCE respondents report stronger use of on-site amenities, a more integrated work-life campus model, and higher personal prioritization of carbon reduction, though they also reported lower levels of formal engagement. These results reinforce interview findings: Tech Lane's grassroots engagement has potential, but HTCE benefits from visible structure and systemic integration.

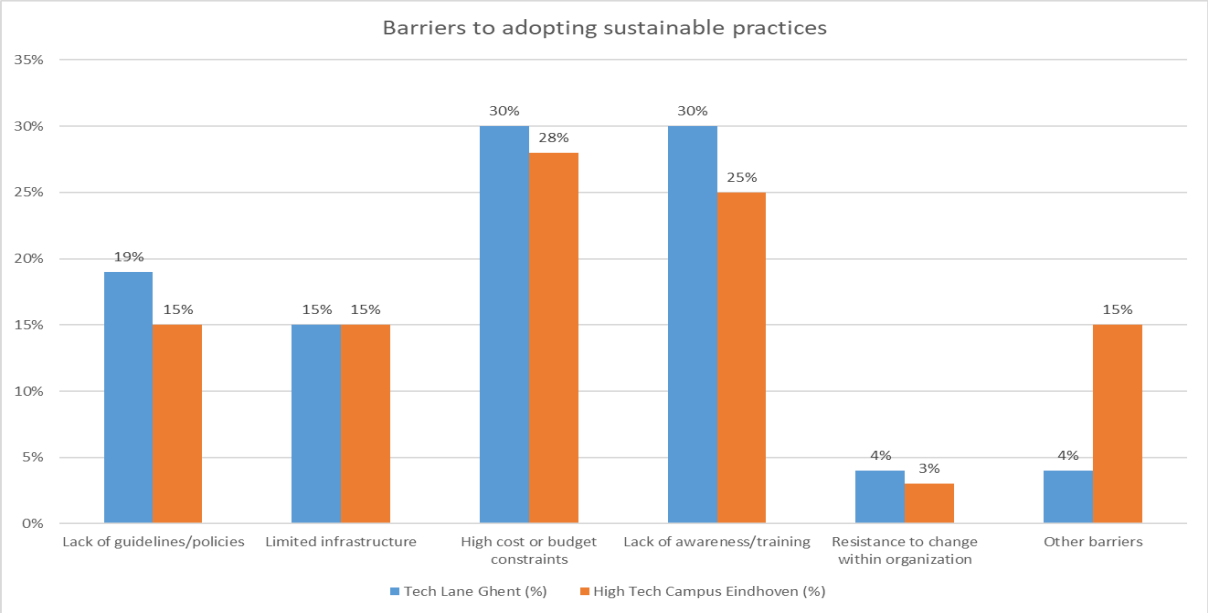

Figure 14. Perceived Barriers to Adopting Sustainable Practices

This chart visualizes employee-identified challenges to sustainability implementation across the two innovation districts, based on survey responses.

Survey responses to Q9 reveal that the top barriers to adopting sustainable practices at both campuses are high costs and lack of awareness or training. At Tech Lane Ghent, 30% of respondents cited each of these two factors as significant obstacles, suggesting that while interest in sustainability exists, practical knowledge and financial resources remain limited. HTCE employees reported similar constraints but to a slightly lesser extent, 28% identified cost, and 25% mentioned awareness gaps. Notably, Tech Lane respondents reported slightly more confidence in available policies and infrastructure, while HTCE had a higher share of "other" barriers (15%), possibly reflecting more individualized concerns or expectations.

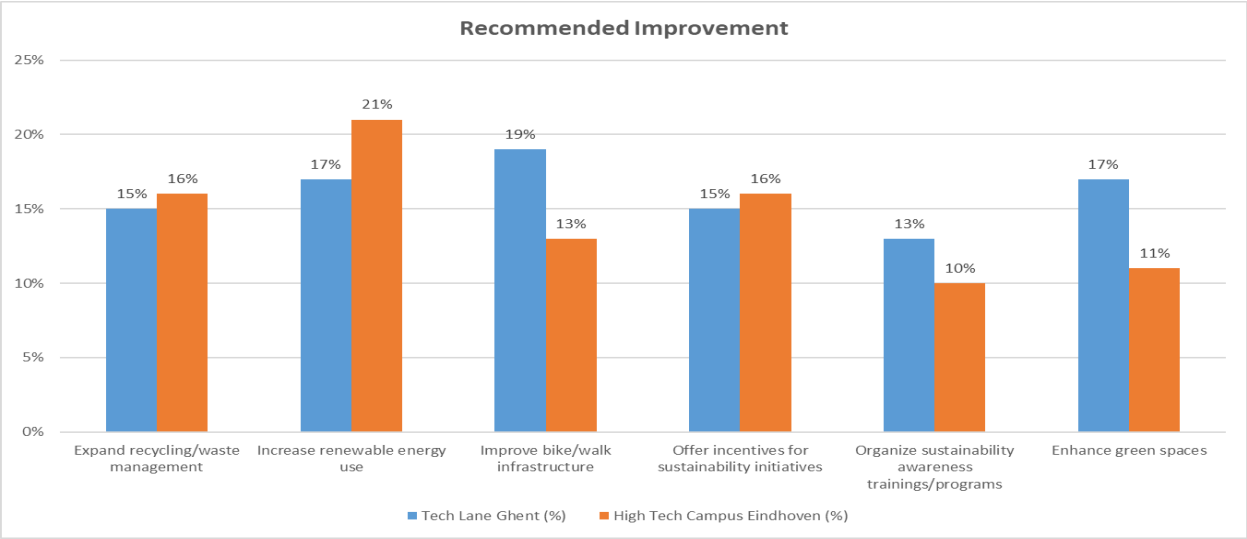

Figure 15. Recommended Sustainability Improvements by Employees

Figure 11 shows Employee-Recommended Sustainability Improvements at Tech Lane Ghent and High-Tech Campus Eindhoven (Q10). This chart compares respondents' suggestions for enhancing sustainability efforts, highlighting shared priorities and district-specific needs.

In terms of recommendations, both groups called for improvements in renewable energy use, waste/recycling systems, and incentives for sustainability efforts. Tech Lane respondents additionally emphasized the need for better bike/walk infrastructure (19%) and enhancing green spaces (17%), while HTCE respondents prioritized renewable energy (21%) and offering incentives (16%). These responses suggest a clear desire for more visible, accessible sustainability options, backed by training, infrastructure, and collaborative programs.

Together, the interview and survey findings reveal that while both Tech Lane Ghent and High-Tech Campus Eindhoven are actively pursuing sustainability, the ways in which stakeholders are involved and how they perceive their role, differ noticeably. Tech Lane Ghent demonstrates notable grassroots engagement, with higher recycling participation, collaboration, and willingness to contribute to sustainability initiatives. However, this energy is often undermined by a lack of strategic direction and clear communication. In contrast, HTCE's centrally managed model fosters strong alignment with broader sustainability goals and offers a high-quality campus experience, though it leaves room to improve participatory feedback mechanisms and employee familiarity with district-wide strategies. These contrasts underscore the importance of not only investing in infrastructure but also cultivating a shared vision and two-way engagement to sustain momentum and foster long-term environmental and social impact.

4.4 Expert Perspectives

To complement stakeholder interviews from Tech Lane Ghent and High-Tech Campus Eindhoven (HTCE), two additional expert interviews were conducted: one with Emiliano Boschetto (Chief Philosophy Officer at eFM, Italy) and one with Laura Biancuzzo (Senior Research Associate at the Global Institute on Innovation Districts, GIID). These interviews provided broader comparative insights into the governance, sustainability, and spatial strategies of innovation ecosystems internationally.

Boschetto emphasized the evolution of workspaces within innovation districts. He described how traditional centralized headquarters are increasingly being replaced by more distributed, hybrid spatial models, such as eFM's Hubquarter concept. As he explained,

"The space is not just something you go to. It becomes a tool to maximize social capital and relational value" (Boschetto, personal communication, April 23, 2025).

This shift supports sustainability by encouraging adaptive reuse of urban spaces and enabling flexible work arrangements. Boschetto illustrated how a single building, such as a school, could serve multiple community purposes throughout the day, for example, becoming a coworking hub in the evening, thus maximizing space utilization and minimizing the need for new construction.

On the governance side, Laura Biancuzzo stressed the importance of context-sensitive and evolving governance structures in innovation districts. She noted that,

"There is no magic recipe... governance evolves based on the actors at the table, and it must remain adaptive to the district's context and future goals" (Biancuzzo, personal communication, April 24, 2025).

Her insights align with the case study findings: HTCE demonstrates a centralized, strategic governance model, while Tech Lane Ghent displays a more fragmented and stakeholder-led approach.

Biancuzzo also emphasized that innovation districts should not apply a top-down model of development; instead, they should meaningfully involve local communities in shaping the district's evolution. As she stated,

"It shouldn't be a top-down approach. Communities should help shape what the innovation district becomes" (Biancuzzo, personal communication, April 24, 2025).

Furthermore, both experts underlined the critical role of digital tools and infrastructure in future-proofing innovation districts. Boschetto pointed to the potential of smart contracts and data-driven management systems for optimizing real estate sustainability metrics, while Biancuzzo stressed the need for investment in both physical infrastructure such as green spaces and transit and virtual infrastructure such as broadband to support innovation, collaboration, and sustainability at scale.

The perspectives of these experts reinforce key findings from the case studies: sustainability in innovation districts is not merely about installing green infrastructure, but also about nurturing flexible governance, adaptive space reuse, community engagement, and future-oriented design strategies.

4.5 Governance Structures for Sustainability Initiatives

Governance structures at innovation districts play a pivotal role in shaping the effectiveness and coherence of sustainability initiatives. Interviews from both sites revealed stark contrasts in the degree of centralization, leadership continuity, and strategic oversight.

Tech Lane Ghent: Governance of sustainability initiatives at operates through a decentralized and multi-actor governance model, primarily involving VZW Ardoyen (the nonprofit entity managing the park's development and coordination), Ghent University (as a key landowner and academic stakeholder), and POM Oost-Vlaanderen (the regional development agency). While these actors contribute expertise and institutional support, there is no single body or sustainability directorate responsible for overseeing park-wide environmental performance. As noted by several stakeholders, coordination is often fragmented and voluntary.

"It's not really stipulating how things should be, it's a voluntary initiative." (Urban & Veys, personal communication, April 3, 2025).

Stakeholders emphasized that no single organization leads sustainability strategy across the park. Instead, progress depends on the commitment of individual actors and informal working groups. According to a board member from VIB:

"We are a member of the board, and we try to play an active role when it comes to sustainability, but it's still quite fragmented." (De Broeck, personal communication, March 21, 2025).

Efforts to coordinate sustainability have recently gained momentum through the establishment of a sustainability committee, where participants from several institutions discuss common challenges and share best practices. However, respondents repeatedly cited the lack of a long-term vision or campus-wide sustainability policy. One sustainability manager observed:

If there would be a clearer vision, it would help companies to jump on the Tech Lane boat, but right now, everyone has their own initiatives and priorities." (Anonymous, personal communication, March 21, 2025)

According to Thijs Urban, VZW Ardoyen also facilitates structured coordination through three active thematic committees; Mobility, Durability, and Events, which provide participatory platforms for all member organizations to engage in sustainability dialogue and joint initiatives. While participation remains voluntary, these committees offer continuity, knowledge exchange, and early forms of policy co-creation.

Additionally, UGent plays a continuing governance role even on plots that were sold to other landowners. All new buildings, regardless of plot ownership, are required to comply with the binding Parkreglement. The Parkreglement includes environmental guidelines, such as energy efficiency standards and water management norms, which lend regulatory weight to what was previously considered voluntary.

Decision-making authority was previously seen to shift depending on the topic or location within the park. Although the City of Ghent may be involved in broader urban sustainability discussions (e.g., district heating studies), it does not play a direct governance role within Tech Lane Ghent's sustainability management. The rotating nature of board roles and reliance on goodwill rather than formal mandates have historically limited continuity and scalability.

However, the combination of policy instruments (e.g., Parkreglement), university-led oversight, and participatory committees points to a shift toward a hybrid governance model, one that blends bottom-up participation with emerging regulatory mechanisms.

High Tech Campus Eindhoven: HTCE operates under a centralized and professionally managed governance structure. The campus is privately owned and operated by a dedicated site management organization of roughly 40 employees, responsible for overseeing logistics, infrastructure, and sustainability implementation. Governance is embedded through internal reporting mechanisms and clear operational oversight. As the operations manager explained:

"*The policy is made by us, by the High-Tech Campus management team. We make a report to the owners every year, which includes ESG performance metrics." (Arends, personal communication, April 7, 2025).*

HTCE's governance model ensures strategic alignment, performance monitoring, and data-driven decision-making. Sustainability performance is measured through KPIs, and progress is formally tracked via ESG dashboards. Although the HTCE Sustainability Board, once composed of company representatives, is no longer active, site management continues to guide sustainability policy through internal review processes.

A former sustainability board member of HTCE described the governance model as both structured and outcome-oriented:

"Sustainability reporting is tied to performance metrics and is audited annually." (Gaussem, personal communication, April 4, 2025).

This centralized structure enables consistency across projects, faster implementation of campus-wide strategies (such as the CO_2-neutrality roadmap), and greater transparency in communication. Decision-making is streamlined, with site management acting as a single point of accountability.

It is evident how the two governance models differ from one another. Although Tech Lane Ghent's volunteer-based, decentralized approach promotes inclusivity, it leads to uneven implementation, little strategic continuity, and a lack of clarity regarding who is responsible for sustainability results. However, recent developments such as the activation of thematic committees and the enforcement of environmental standards through the Parkreglement, suggest a transition toward a more structured and hybrid governance model. In comparison, HTCE's centralized and professionalized governance system enables coordinated action, robust monitoring, and policy follow-through. These structural differences play a critical role in shaping how sustainability is implemented, perceived, and experienced across both innovation districts.

4.6 Alignment with Sustainability Frameworks

This section evaluates how Tech Lane Ghent and High-Tech Campus Eindhoven (HTCE) align with key sustainability frameworks: Environmental, Social, and Governance (ESG) criteria, green building standards (e.g. BREEAM), and the helix models of innovation.

4.6.1 ESG Framework Alignment

Environmental:

HTCE demonstrates structured environmental practices, including the integration of renewable energy, smart lighting, and energy-efficient buildings. Survey data supports this: 46% of HTCE respondents noticed energy-saving measures, and 21% recommended further use of renewables.

Tech Lane Ghent, while historically more fragmented, is now moving toward a formalized approach. All new buildings must meet the 'Bijna Energie Neutraal' (BEN) standard as per the Parkreglement, supported by a penalization clause. The Energetisch Masterplan Ardoyen explores collective energy infrastructure. Other environmental initiatives include smart waste bins, EV charging expansion, and circular projects like SkyWater (rainwater reuse) and pipet box upcycling.

One sustainability manager added:

"We moved to green energy contracts last year… and rainwater was separated from the sewer, which is visible initiative." (Anonymous Sustainability responsible, Tech Lane Ghent)

These actions indicate partial but growing alignment with the Environmental pillar of ESG.

Social:

Tech Lane's social engagement is more participatory, involving informal sustainability committees and events like park clean-ups. 79% of respondents reported participating in recycling programs, and many suggested improving community infrastructure.

Participation is also structurally supported through VZW Ardoyen's three thematic committees: Mobility, Durability, and Events , open to all companies.

HTCE, though offering broader amenities, shows weaker stakeholder engagement. 77% of respondents said their feedback on sustainability had not been requested, suggesting a gap in the social pillar's inclusiveness.

Governance:

HTCE operates under a centralized governance model with clearly defined sustainability goals and KPI tracking, aligning well with ESG expectations.

Tech Lane Ghent takes a more decentralized, voluntary approach. As one interviewee stated:

"There is no formal mandate. The committee meetings depend on who shows up and what gets followed up." (Anonymous Sustainability Manager, Tech Lane Ghent).

4.6.1 Green Building Certifications

HTCE's facilities reflect BREEAM/LEED principles, particularly through the development practices of large firms like Philips and ASML. While certification details are not always public, building design and infrastructure suggest high compliance.

At Tech Lane, the Bio Accelerator building is pursuing BREEAM certification, supported by initiatives like LED lighting, HVAC optimization, and EV charging stations. In addition, the new 22,000 m² CAR-T cell therapy facility by Janssen Pharmaceutica and Legend Biotech has achieved LEED Gold certification, further advancing the park's alignment with global green building standards. However, there is no park-wide certification strategy in place.

4.6.2 Helix Model Alignment

HTCE aligns with the Triple Helix model, facilitating innovation through structured collaboration among academia (TU/e), government, and industry.

Tech Lane Ghent, while initially built on a Triple Helix foundation, increasingly exhibits features of the Quadruple Helix model, incorporating civil society through volunteer committees, sustainability events, and community feedback:

"Every company should have a sustainability ambassador that would help with communication and shared goals." (Anonymous Sustainability responsible, Tech Lane Ghent)

This participatory culture echoes the Living Lab and co-creation models often seen in more adaptive, socially grounded innovation systems.

Overall, HTCE demonstrates stronger alignment with formal sustainability frameworks and centralized governance, while Tech Lane Ghent shows a participatory, community-based approach, progressively integrating environmental and social goals. Together, they illustrate two complementary models of sustainable innovation.

4.7 Comparative Analysis

This section explains findings from previous chapters to provide a structured comparison between Tech Lane Ghent Science Park and High-Tech Campus Eindhoven (HTCE), with a focus on strengths, weaknesses, and areas where cross-learning may enhance sustainable innovation outcomes.

4.7.1 Strengths and Weaknesses of Each District

To better understand the operational and strategic positioning of each district, this section compares their respective strengths and weaknesses across key sustainability dimensions. These include governance, waste and energy systems, carbon emission strategies, stakeholder engagement, and infrastructure. The analysis integrates both qualitative insights from interviews and quantitative evidence from survey responses. A comparative summary is presented in Table 2 below.

This table summarizes the relative strengths and weaknesses of both innovation districts across seven sustainability dimensions, combining insights from interviews and survey data.

Table 3. Comparative Overview of Strengths and Weaknesses of Tech Lane and HTCE

Dimension	Tech Lane Ghent	High Tech Campus Eindhoven
Governance & Coordination	Emerging Hybrid governance model: VZW Ardoyen coordinates development, supported by the Parkreglement and committees.	Centralized governance with clearly defined ESG roadmap and KPIs. Regular performance monitoring.
Waste Reduction	Some local efforts like sensor-enabled bins and workshops. 79% of survey participants recycle. But lacks a common waste policy.	Campus-wide waste sorting and monitoring via Power BI dashboard. Supported by events like waste cleanup days.
Energy Efficiency	Ongoing feasibility studies (e.g., district heating) and smart meters in select labs. No unified energy framework. Working on BEN standard.	Mature system: 12,000 solar panels, ATES thermal storage, 100% green electricity. KPIs monitored in real time.
CO_2 Emission Reduction	Individual company efforts (Scope 1 and 2). No park-wide targets or reporting framework.	Central roadmap toward CO_2 neutrality by 2030. Progress tracked and communicated to tenants.
Mixed-Use Development	Limited. Few amenities; minimal integration of residential/recreational infrastructure.	Rich in amenities—sports, daycare, restaurants. Promotes a live-work-play environment.
Stakeholder Engagement	Strong grassroots efforts and high recycling and feedback participation. 62% reported company collaboration on sustainability.	Professional, structured engagement. But low feedback participation (15%). Amenities foster daily engagement.
Awareness	57% of respondents reported being "not familiar at all" with sustainability goals. Reflects limited internal communication.	Better, but still limited. 44% slightly familiar; only 4% very familiar. Room for improved internal awareness.

The table highlights distinct operational philosophies between the two districts. High Tech Campus Eindhoven demonstrates institutionalized strength in governance, energy systems, and measurable outcomes, supported by a centralized management team and formal sustainability policies. In contrast, Tech Lane Ghent shows strong grassroots engagement and collaborative potential, now complemented by evolving regulatory and participatory structures. Initiatives like the Parkreglement, thematic sustainability committees, and district-scale energy and water planning suggest a shift toward hybrid governance capable of scaling local efforts. While HTCE leads in integrated systems and long-term vision,

Tech Lane's strengths in local participation and sustainability culture point to a different but complementary approach. These differences suggest that both districts could benefit from mutual learning HTCE from Tech Lane's community-driven momentum, and Tech Lane from HTCE's operational consistency.

4.7.2 Opportunities for Cross-Learning and Best Practices

While Tech Lane Ghent and High-Tech Campus Eindhoven differ in structure, both districts share the goal of fostering sustainable innovation. Their contrasting strengths present an opportunity for mutual learning and practical improvement.

From HTCE to Tech Lane Ghent: Strengthening Structure and Strategy:

Tech Lane Ghent is beginning to move toward stronger coordination through tools like the Parkreglement and the Energetisch Masterplan. However, it could further benefit from adopting HTCE's centralized tracking systems, such as a unified ESG dashboard and site-wide KPIs—to reinforce this transition and improve monitoring. The implementation of a dedicated sustainability coordination team, combined with KPI tracking and a shared roadmap, would bring consistency and strategic clarity. HTCE's ESG dashboard, for instance, could serve as a model for monitoring collective progress toward carbon reduction and energy efficiency.

Tech Lane could also draw from HTCE's infrastructure investments, such as its ATES thermal storage, solar installations, and campus-wide waste tracking system, to enhance its fragmented technical efforts and develop scalable systems.

From Tech Lane Ghent to HTCE: Strengthening Community and Participation:

While HTCE excels in system-level integration, it could benefit from Tech Lane's participatory culture and grassroots energy. Initiatives such as echo teams, volunteer-led clean-up events, and a relatively high percentage (36%) of employees providing feedback on sustainability highlight a culture of bottom-up involvement that HTCE may seek to replicate.

HTCE could reintroduce or adapt its former Sustainability Board or introduce community co-creation workshops to increase direct engagement and awareness of campus goals, which remains low (0% reported being "extremely familiar" with HTCE's sustainability targets).

Shared Priorities and Best Practices:

Both campuses face challenges related to internal communication, awareness-building, and Scope 3 emissions. Opportunities for joint development include:

- Shared digital platforms for sustainability communication and updates
- Benchmarking green procurement and lab supply chains to reduce emissions.
- Cross-district collaboration programs, such as exchange workshops, joint pilots, or employee engagement campaigns.

This contrast highlights two viable yet distinct pathways to sustainability institutional efficiency vs. participatory innovation setting the stage for deeper reflection in the next chapter.

Chapter 5: Discussion

5.1 Introduction

This chapter interprets the study's main findings considering the research questions, theoretical frameworks, and relevant literature. By comparing the sustainability practices of Tech Lane Ghent Science Park and High-Tech Campus Eindhoven (HTCE), it explores both theoretical implications and practical applications in the context of innovation districts. Special attention is given to stakeholder engagement, governance structures, and implementation strategies. The discussion also reflects on areas for improvement and the broader relevance of the findings for innovation districts across Europe.

5.2 Revisiting the Research Question

This research examined sustainability strategies in two leading European innovation districts: Tech Lane Ghent Science Park and High-Tech Campus Eindhoven (HTCE), with a comparative focus on four core sustainability dimensions: waste reduction, energy efficiency, CO_2 emissions, and mixed-use development. It also explored the governance structures and stakeholder dynamics that influence implementation and perception.

Primary Research Question:

What sustainability initiatives are in place at Tech Lane Ghent, and how do they compare to those at High Tech Campus Eindhoven in terms of waste reduction, energy efficiency, CO_2 emissions, and mixed-use development?

The findings reveal distinct sustainability pathways. HTCE follows a centralized, metrics-driven model, guided by roadmaps, KPIs, and professional site management. This structure supports campus-wide coordination, including integrated energy systems, waste dashboards, and a goal of CO_2 neutrality by 2030. In contrast, Tech Lane Ghent employs a hybrid governance approach, where grassroots momentum is now complemented by formal tools such as the park regulations, thematic sustainability committees, and feasibility studies on energy and water systems. Individual companies and institutions initiate sustainability projects as well. Despite lacking formal coordination, Tech Lane shows notable grassroots momentum, including a newly established sustainability committee and high recycling participation (79%).

Sub-Question 1:

How does integrating residential, commercial, and recreational spaces at Tech Lane Ghent and High-Tech Campus Eindhoven contribute to sustainability?

High Tech Campus Eindhoven (HTCE) demonstrates a successful mixed-use model with sports fields, cafés, daycares, and planned short-stay housing all of which reduce commuting and enhance on-site engagement. This design aligns with "15-minute city" principles and sustainability goals by promoting low-carbon mobility and convenience.

In contrast, Tech Lane Ghent has limited mixed-use infrastructure. Although respondents expressed a desire for more green spaces and cycling paths, such developments remain underexplored.

The findings support literature highlighting the role of proximity and urban form in enabling sustainable behavior (Katz et al., 2019; Carlino et al., 2012). Additionally, the ongoing construction of "The Nucleus," a multifunctional building intended to serve as a central meeting point for researchers and entrepreneurs, is in progress and expected to enhance community building within the science park (Ghent University, n.d.).

Sub-Question 2:

What governance structures are in place to oversee sustainability initiatives at Tech Lane Ghent and High-Tech Campus Eindhoven?

Governance emerged as one of the most significant differentiators. HTCE is governed by a professional operations team, using dashboards, ESG reporting, and annual reviews to guide sustainability efforts. In contrast, Tech Lane's governance is more distributed, involving actors such as VZW Ardoyen, UGent, and POM Oost-Vlaanderen, with no single centralized authority coordinating sustainability across the campus. While a new sustainability committee has recently been established, formal structures are emerging. The Park regulation provides building guidelines (e.g., BEN standard), and thematic committees under VZW Ardoyen now facilitate ongoing stakeholder participation. However, long-term strategic alignment and centralized oversight remain areas for development.

Sub-Question 3:

How do stakeholders (e.g., businesses, employees, local communities) perceive the sustainability efforts at both campuses?

Stakeholder perceptions closely mirrored governance structures. At Tech Lane, respondents were more likely to participate in sustainability programs (79%) and provide feedback (36%), indicating a strong culture of informal engagement. However, awareness of park-wide sustainability goals remains low (57% not familiar at all). HTCE respondents reported less direct involvement (15% feedback participation) despite greater visibility of sustainability infrastructure. This highlights a trade-off: top-down coordination enables delivery but may limit participatory influence, while bottom-up approaches foster ownership but lack institutional consistency.

5.3 Thematic Interpretation of Findings

Building on the specific research questions, this section interprets the results across six thematic areas that emerged during analysis. This section interprets the thematic results presented in Chapter 4 through the lens of the academic frameworks and theories discussed in Chapter 2. By linking on-the-ground findings to literature on innovation ecosystems, ESG integration, and governance models, it reveals how strategic, operational, and socio-environmental dynamics shape sustainability outcomes in innovation districts.

5.3.1 Waste Reduction:

Waste reduction practices at Tech Lane Ghent are predominantly decentralized. Interview data reveal that companies and buildings operate independently, without a shared waste policy or coordinated goals. However, the high level of employee participation in recycling (79%) and emerging innovations like

sensor-enabled bins suggest a strong culture of bottom-up engagement. This reflects (Ostrom, 2010) concept of polycentric governance, where multiple, overlapping decision-making centers operate independently yet within an overarching system, allowing for diverse and adaptive solutions.

Conversely, HTCE employs a centralized waste strategy guided by KPIs and digital monitoring tools (e.g., Power BI dashboards). Waste cleanup days, supplier reuse programs, and circular economy initiatives demonstrate the effectiveness of institutionalized environmental governance, aligning with frameworks where formal coordination enables more efficient resource flows (Etzkowitz & Leydesdorff, 2000).

5.3.2 Energy Efficiency:

Energy-saving efforts at Tech Lane Ghent are fragmented and experimental. However, recent developments such as the BEN standard and the Energetisch Masterplan suggest a shift toward more coordinated infrastructure planning. Furthermore, Projects like district heating feasibility studies, smart meters, and rainwater harvesting are promising but isolated. Interviewees noted the lack of a campus-wide energy strategy, echoing the implementation barriers discussed by del Cerro Santamaría (2021), where decentralized governance hinders long-term infrastructure planning.

HTCE, in contrast, reflects a mature eco-district model (Gianoli & Henkes, 2020). Its use of solar panels, ATES systems, and real-time monitoring dashboards exemplifies how integrated energy systems can support operational sustainability. These findings resonate with ESG-aligned innovation frameworks, where environmental KPIs are monitored and refined over time (Guo & He, 2024).

5.3.3 CO_2 Emission Reduction:

Tech Lane Ghent has limited park-wide CO_2 reduction targets. Although some companies track Scope 1 and 2 emissions and are piloting Scope 3 efforts (e.g., green procurement), no overarching framework exists. This aligns with challenges highlighted by Boschma et al. (2025), where short-term economic priorities and dispersed governance limit climate action.

By contrast, HTCE has set a clear goal of CO_2 neutrality by 2030, embedding carbon reduction into operational plans and ESG dashboards. This reflects the strategic alignment proposed by Tang (2023), who found that strong ESG governance improves innovation by reducing financing and disclosure barriers.

5.3.4 Mixed-Use Development:

HTCE offers a highly developed live-work-play model, integrating amenities such as sports fields, restaurants, and short-stay housing. This supports the "15-minute city" and proximity-driven knowledge spillover theories articulated by Katz, Wagner, & Osha (2019). Employees at HTCE reported frequent use of recreational spaces, which supports daily sustainability through reduced commuting and enhanced well-being.

At Tech Lane Ghent, mixed-use elements are still under development. While stakeholders voiced interest in green infrastructure and bike-friendly design, the lack of retail, recreational, and residential options limits the district's ability to activate sustainable behaviors through urban form.

5.3.5 Stakeholder Engagement:

Surprisingly, Tech Lane Ghent outperformed HTCE in qualitative stakeholder engagement metrics. While governance is less centralized, survey responses showed higher feedback participation (36% vs. 15%), stronger recycling culture, and greater employee involvement in sustainability initiatives. This supports the Living Lab approach described by Schuurman & Leminen (2021), in which real-world collaboration drives place-based innovation.

HTCE, despite its strong infrastructure and amenities, exhibited lower perception of engagement among employees. (Dempsey, Bramley, Power, & Brown, 2011) emphasize, social sustainability relies not just on infrastructure but on inclusive processes and shared agency. Tech Lane's grassroots energy and volunteer initiatives (e.g., echo teams, plogging events) exemplify this dynamic, though they lack long-term institutional support.

5.3.6 Governance:

Governance emerged as the clearest differentiator. Tech Lane Ghent's multi-actor governance, involving VZW Ardoyen, Ghent University, and POM Oost-Vlaanderen, lacks a central body with long-term oversight. Voluntary engagement and unclear mandates have slowed implementation. As del Cerro Santamaría (2021) notes, this absence of durable coordination structures weakens urban sustainability transitions. However, stakeholder interviews reveal that Tech Lane is evolving toward a hybrid governance model. While grassroots participation and informal initiatives remain core features, these are increasingly supported by formal regulatory frameworks.

This form of participatory governance closely aligns with what Böhm and Alexander (2024) conceptualize as a "circular innovation ecosystem," where five interconnected loops, resource, social, ecological, economic, and policy, must co-evolve to support sustainability. Rather than top-down control, Tech Lane's model reflects a place-sensitive, relational form of coordination that enhances adaptability and empowers local actors to innovate from the ground up.

In contrast, HTCE's professional site management team offers strategic clarity and data-driven decision-making. ESG performance is audited annually, and sustainability is embedded in operational dashboards. This reflects Carayannis et al.'s (2021) Quintuple Helix model, where innovation, governance, and environmental values are aligned through institutional leadership.

The six themes: waste, energy, carbon emissions, urban form, engagement, and governance—illustrate two different models of sustainable innovation: one rooted in centralized planning and infrastructure (HTCE), the other in grassroots energy and participatory experimentation (Tech Lane). While HTCE reflects the advantages of strategic alignment and resource coordination, Tech Lane embodies the principles of inclusivity and adaptive innovation. Together, they demonstrate that sustainability in

innovation districts is not a fixed model but a dynamic interplay between institutional design, local culture, and stakeholder capacity.

Expert perspectives further emphasized the importance of flexible, evolving governance models. Laura Biancuzzo, Senior Research Associate at the Global Institute on Innovation Districts, highlighted that " Governance evolves based on the actors at the table, and it must remain adaptive to the district's context and future goals" (Biancuzzo, personal communication, April 24, 2025).

Similarly, Emiliano Boschetto, Chief Philosophy Officer at eFM, stressed that innovation spaces must be designed as relational hubs, where "the space is not just something you go to. It becomes a tool to maximize social capital and relational value" (Boschetto, personal communication, April 23, 2025). These insights align with the findings that successful innovation districts must balance strategic oversight with flexibility and relational design.

5.4 Theoretical Implications: Innovation Models in Practice

The comparative analysis of Tech Lane Ghent and High-Tech Campus Eindhoven (HTCE) offers insights into the practical application of innovation district models, particularly the Triple and Quadruple Helix frameworks.

HTCE exemplifies the Triple Helix model, characterized by structured collaboration among academia, industry, and government (Etzkowitz & Leydesdorff, 2000). This alignment is evident in its centralized governance, formalized sustainability strategies, and integrated infrastructure. The campus's coordinated efforts towards CO_2 neutrality by 2030, utilization of renewable energy sources, and comprehensive waste management systems reflect a top-down approach that facilitates scalability and efficiency.

In contrast, Tech Lane Ghent is transitioning towards a Quadruple Helix model, incorporating civil society into its innovation ecosystem (Carayannis & Campbell, 2009). The emergence of grassroots initiatives, such as volunteer-led sustainability committees and community engagement in recycling programs, indicates a bottom-up approach. This participatory model fosters inclusivity and adaptability, aligning with the principles of Living Labs, where real-world experimentation and user involvement drive innovation (Schuurman & Leminen, 2021).

These models were echoed in expert interviews. For example, Emiliano Boschetto explained that spatial flexibility and choice are now critical:

"You choose your workplace depending on your goals. That's how you create value—from the relational, not just functional perspective" (Boschetto, personal communication, April 23, 2025).

Laura Biancuzzo affirmed the growing need for such user-oriented, adaptable systems:

"Districts should not identify with what they are today but with what they are becoming. The governance must remain open and future-focused" (Biancuzzo, personal communication, April 24, 2025).

These views support the idea that innovation districts should develop flexible infrastructures, prioritize stakeholder inclusion, and adapt continuously to technological and societal change.

5.5 Practical Implications: Strategies for Sustainable Innovation

The experiences of HTCE and Tech Lane Ghent provide practical lessons for the development and management of sustainable innovation districts.

For HTCE, the centralized governance model has enabled the implementation of comprehensive sustainability initiatives. However, the limited stakeholder engagement, as indicated by only 15% of survey respondents reporting involvement in sustainability feedback, suggests a need to enhance participatory mechanisms. Incorporating elements from Tech Lane's approach, such as establishing forums for community input and fostering volunteer-led initiatives, could improve stakeholder buy-in and the effectiveness of sustainability programs (Dempsey et al., 2011).

For Tech Lane Ghent, the strong community engagement and grassroots initiatives are commendable. Nevertheless, the absence of a unified sustainability strategy and fragmented governance structures hinder the scalability of these efforts. Adopting a more structured approach, possibly by forming a dedicated sustainability coordination team and setting clear KPIs, could provide the necessary framework to amplify and align individual initiatives (del Cerro Santamaría , 2021).

Shared Opportunities:

- Digital Platforms: Both districts could benefit from implementing digital platforms to facilitate communication, track sustainability metrics, and share best practices among stakeholders.
- Collaborative Workshops: Organizing joint workshops and knowledge exchange programs can foster mutual learning and the dissemination of successful strategies.
- Policy Alignment: Aligning district-level sustainability goals with broader municipal or national policies can enhance coherence and access to funding opportunities.

In summary, the integration of structured governance with active community participation appears to be a promising pathway for innovation districts aiming to achieve sustainable development goals. Balancing top-down strategic planning with bottom-up engagement can lead to more resilient and inclusive innovation ecosystems.

Chapter 6: Conclusion, Limitations, and Future Research

6.1 Introduction

This last chapter brings everything together and concludes the research journey. It considers the main conclusions drawn from contrasting the sustainability strategies used at High Tech Campus Eindhoven (HTCE) and Tech Lane Ghent. It also takes an honest look at the study's limitations and shares ideas for where future research could go. The aim is not just to summarize the work completed, but to reflect on its significance and outline pathways for future sustainable innovation in similar districts.

6.2 Conclusion

This research sets out to understand how two leading European innovation districts approach sustainability by focusing on waste, energy, carbon emissions, and mixed-use development. What became clear is that there's no single formula for success; each district brings something valuable.

High Tech Campus Eindhoven HTCE represents a structured, top-down model of sustainability. Backed by strong leadership, clear goals, and advanced infrastructure, it shows what's possible when large organizations and institutions work closely together. Its use of renewable energy, data-driven systems, and a clear plan to reach CO_2 neutrality by 2030 are potent examples of centralized coordination.

Tech Lane Ghent, in contrast, combines a more community-driven path with emerging formal structure. Although it doesn't have a unified strategy across the park, it makes up for that with energy from the ground up, volunteer-led initiatives, strong recycling habits (with 79% participation), and regular cooperation between companies. It's a place where sustainability grows through people, not just policies.

These two strategies, the participatory momentum of Tech Lane and the institutional efficiency of HTCE offer complementary lessons. The most viable course of action for innovation districts hoping to take the lead in sustainability may be a hybrid model that combines strategic planning with community involvement. Ultimately, achieving sustainability in innovation districts will require balancing infrastructure-driven efficiency with the creativity and resilience of grassroots participation.

6.3 Limitations

Like any research project, this study has its limits.

First, the number of survey participants was modest: 14 from Tech Lane Ghent and 27 from HTCE. While this gave us a meaningful snapshot, a larger sample could have provided a broader view of stakeholder perceptions.

Second, the study mainly focused on environmental and governance-related aspects of sustainability (ESG). Other essential elements like economic performance, startup culture, or national policy impacts were beyond its scope.

Third, since the research looked at just two innovation districts, we need to be careful when thinking about how the findings apply to other regions. Each innovation district operates within a unique local context, meaning findings may not generalize to all settings.

Fourth, not every dimension of sustainability could be equally researched. Some themes, such as Scope 3 emissions, water reuse, or sustainable procurement, emerged during the study but could not be thoroughly examined due to data availability or project boundaries.

Lastly, timing played a role. Some initiatives, like Tech Lane's new sustainability committee, were still evolving during the interviews, so we couldn't fully evaluate their long-term impact.

Despite these limitations, the study offers grounded, original insights based on multiple data sources, interviews, surveys, and literature and helps move the conversation on sustainable innovation districts forward.

6.4 Suggestions for Future Research

There are plenty of exciting opportunities to build on this research.

- Follow-up studies could track how sustainability evolves in these districts over time, especially as newer initiatives gain traction.
- Researchers might also compare many innovation districts across different countries to explore patterns, differences, or shared best practices. Such comparative work could also shed light on how differing policy frameworks, urban planning laws, ESG mandates, or innovation incentives, shape local sustainability models.
- Examining how local and national policies, funding, and public-private partnerships affect sustainability outcomes would be helpful.
- Another valuable direction would be to hear more from residents, local entrepreneurs, or community groups better to understand the social side of sustainability in these spaces.
- Finally, future work could focus on developing quantitative indicators for things like Scope 3 emissions, circular economy practices, and sustainable commuting.

By exploring these areas, future studies can offer even more profound insights into what makes innovation districts innovative and sustainable.

References

Agger, A., & Lund, D. (2017). Collaborative innovation in the public sector: New perspectives on the role of citizens? *Scandinavian Journal of Public Administration, 21*(3), 17–37. Retrieved from https://forskning.ruc.dk/en/publications/collaborative-innovation-in-the-public-sector-new-perspectives-on

Ajuntament de Barcelona. (2018). *Climate Plan 2018–2030.* Barcelona: Barcelona City Council. Retrieved from https://www.barcelona.cat/barcelona-pel-clima/sites/default/files/climate_plan_maig.pdf

Amsterdam Science Park. (n.d.). Retrieved 04 13, 2025, from https://www.amsterdamsciencepark.nl/focus-areas/sustainability/?_gl=1*1hsrqxr*_up*MQ..*_ga*NDg1MzQ0MDQwLjE3NDQ1NDA1NTU.*_ga_6XZNCVJJ48*MTc0NDU0MDU1MS4xLjEuMTc0NDU0MDYwMi42MC4wLjA.

Autio, E., & Thomas, L. (2014). Innovation ecosystems: Implications for innovation management. In M. Dodgson, D. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (pp. 204–228). Oxford University Press. Retrieved from https://www.researchgate.net/profile/Llewellyn-Thomas/publication/282122544_Innovation_Ecosystems_Implications_for_Innovation_Management/links/5603a91f08ae460e2704f055/Innovation-Ecosystems-Implications-for-Innovation-Management.pdf

Bing Maps. (n.d.). *Bing Maps: Eindhoven High Tech Campus.* Retrieved April 05, 2025, from Bing Maps: https://www.bing.com/maps?cp=38.636554%7E-90.253492&lvl=18.4&style=h

Böhm, S., & T. Alexander, A. (2024). Towards a Place-based Approach to CircularInnovation. *Journal of Innovation Management, 12*(1), XII-XXII. doi:https://doi.org/10.24840/2183-0606_012.001_L002

Boschma, R., Dahl Fitjar, R., Giuliani, E., & Lammarino, S. (2025, Jan 29). Unseen costs: the inequities of the geography of innovation. *Regional Studies* . doi:https://doi.org/10.1080/00343404.2024.2445594

Boyd, N. (2023, April 11). *Top Business Sustainability Issues of 2023*. Retrieved 5 3, 2025, from Network for Business Sustainability: https://nbs.net/top-business-sustainability-issues-of-2023/

Brain Port Eindhoven. (n.d.). Retrieved 04 06, 2025, from https://brainporteindhoven.com/int/business/campuses/high-tech-campus-eindhoven

Bronneberg, M., Pieterse, J., & Post, G. (2023). Brainport Eindhoven: born from crisis - 25 years asa Triple Helix Governed Ecosystem. *Journal of Innovation Management, 11*(1), 36-67. doi:https://doi.org/10.24840/2183-0606_011.001_0003

Carayannis, E., & Campbell, D. (2009, February 23). 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management, 46*, 201-234. doi:https://doi.org/10.1504/IJTM.2009.023374

Carayannis, E., Barth , T., & Campbell , D. (2012, August 08). The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*.

Carayannis, E., Campbell , D., & Grigoroudis , E. (2021, June 25). Helix Trilogy: the Triple, Quadruple, and Quintuple Innovation Helices from a Theory, Policy, and Practice Set of Perspectives. *Journal of the Knowledge Economy, 13*(3), 2272-2301. doi:https://doi.org/10.1007/s13132-021-00813-x

Carlino, G., Hunt, R., Carr, J., & Smith, T. (2012). *THE AGGLOMERATION OF R&D LABS.* Research department, Federal Reserve Bank of Philadelphia . Federal Reserve Bank of Philadelphia. Retrieved from https://www.philadelphiafed.org/-/media/frbp/assets/working-papers/2012/wp12-22.pdf

Chesbrough, H. (2003). *Open innovation: The new imperative for creating and profiting from technology.* Boston: Harvard Business Press.

Christensen, C., Raynor, M., & McDonald, R. (2015, December). What is disruptive innovation? *Harvard Business Review*. Retrieved from https://hbr.org/2015/12/what-is-disruptive-innovation

Clark, J., Huang, H.-I., & Walsh, J. (2010, January 2010). A typology of 'innovation districts': What it means for regional resilience. *Cambridge Journal of Regions, Economy and Society, 3*(1), 121-137. doi:https://doi.org/10.1093/cjres/rsp034

Dabić, M., Daim, T., L.A.M. Bogers, M., & Mention, A.-L. (2023, August). The limits of open innovation: Failures, risks, and costs in open innovation practice and theory. *Technovation, 126*. doi:https://doi.org/10.1016/j.technovation.2023.102786

DE PRETER, W. (2025). *Eindhoven, de verborgen techvallei van Europa.* De tijd. Retrieved from https://www.tijd.be/ondernemen/technologie/eindhoven-de-verborgen-techvallei-van-europa/10607515.html

del Cerro Santamaría , G. (2021, March 15). Innovation districts and complex sustainability in urban economies. *International Journal of Research and Innovation in Applied Science (IJRIAR), 5*(3), 10-26. Retrieved from https://www.academia.edu/63715666/Innovation_Districts_and_Complex_Sustainability_in_Urban_Economies

Dempsey, N., Bramley, G., Power, S., & Brown, C. (2011, September). The social dimension of sustainable development: Defining urban social sustainability. *Sustainable Development, 19*(5), 289 - 300. doi:DOI: 10.1002/sd.417

Districlima. (2011). *Enter Expansion of District Heating and Cooling in Barcelona.* Barcelona: Global District Energy Climate Awards. Retrieved from https://www.districtenergyaward.org/wp-content/uploads/2012/10/Expansion_Spain_Barcelona_2011.pdf

Eiland Zwijnaarde. (2024). *Bereikbaarheid (accessibility map).* Retrieved April 10, 2025, from Eiland Zwijnaarde: https://eilandzwijnaarde.be/bereikbaarheid

Eilandzwijnaarde. (2022, December 19). *A cell therapy collaboration at Campus Ardoyen & Eiland Zwijnaarde.* Retrieved April 15, 2025, from https://eilandzwijnaarde.be/a-cell-therapy-collaboration-at-campus-ardoyen-eiland-zwijnaarde:contentReference[oaicite:0]{index=0}

Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix -- University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development. *EASST Review, 14*(1), 14-19. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2480085

Etzkowitz, H., & Leydesdorff, L. (2000, February). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy , 29*(2), 109-123. doi:https://doi.org/10.1016/S0048-7333(99)00055-4

Etzkowitz,, H., & Zhou, C. (2017). *The Triple Helix University–Industry–Government Innovation and Entrepreneurship.* London: Routledge. doi:https://doi.org/10.4324/9781315620183

European Commission. (2019). *The European Green Deal.* Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52019DC0640

Florida, R. (2014). *The rise of the creative class, revisited.* Basic Books. Retrieved from https://s3.amazonaws.com/files.commons.gc.cuny.edu/wp-content/blogs.dir/17962/files/2021/10/Richard-Florida-The-Rise-of-the-Creative-Class-Revisited-Preface-Intro.pdf

Franco, D., Segers, J.-P., Herlaar, R., & Richt Hannema, A. (2022). Trends in Sustainable Energy Innovation -. *Journal of Innovation Management, 10*(2), 22-46. doi:https://doi.org/10.24840/2183-0606_010.002_0002

Galán-Muros, V., Hegyi, F., Blancas, A., & Sagredo, A. (2021). *Exploring the concept of geographies of innovation: Case studies from Amsterdam, Barcelona, Melbourne, and Stockholm.* Luxembourg: Publication office of the European Union . doi:10.2760/268816

Georgia Tech. (2025, 04 12). Retrieved from https://livingbuilding.gatech.edu/

Ghent University. (2025, April 10). *Campus Ardoyen map.* Retrieved from Ghent University: https://www.ugent.be/nl/univgent/campussen/campussen-gent/grondplan_campusardoyen.pdf

Ghent University. (n.d.). *Construction of multifunctional Park building commences on Tech Lane Ghent Science Park*. Retrieved March 20, 2025, from Ugent: https://www.ugent.be/en/news-events/nucleus-en.htm

Gianoli, A., & Henkes, R. P. (2020). The Evolution and Adaptive Governance of the 22@ Innovation District in Barcelona. *Urban Science, 4*(2), 16. doi:https://doi.org/10.3390/urbansci4020016

Google maps. (n.d.). *google maps*. Retrieved April 2025, from https://www.google.com/maps/place/Cortex+I/@38.636444,-90.2528228,1033m/data=!3m3!1e3!4b1!5s0x87d8b4dcaea514fb:0xe2fdef35a559a73f!4m6!3m5!1s0x87d8b4dcaea55203:0x1847409d115f5d82!8m2!3d38.636444!4d-90.2528228!16s%2Fg%2F11fz9y__mc!5m1!1e3?entry=ttu&g_ep=Ego

Google Maps. (n.d.). *The Cortex Innovation Community, St. Louis, Missouri [Map]*. Retrieved March 23, 2025, from from https://www.google.com/maps

GPSC & World Bank. (2018). *Urban Sustainability Framework (1st ed.).* Washington, DC: World Bank. Retrieved from https://www.thegpsc.org/knowledge-resources/urban-sustainability-framework-usf

Guo, Z., & He, Y. (2024). ESG and Urban Sustainable Development. *ransactions on Economics, Business and Management Research, 5*, 250–265. doi:https://doi.org/10.62051/xhvk2482

High Tech Campus Eindhoven. (n.d.). Retrieved from https://www.hightechcampus.com/about-us

High Tech Campus Eindhoven . (2025, 03 13). Retrieved from blog : https://blog.hightechcampus.com/htce/nxp-semiconductors-reaffirms-long-term-commitment-to-high-tech-campus-eindhoven

imec. (n.d.). *HomeLab: Europe's first independent testing ground for smart home applications and services.* Ghent, Belgium.: imec. Retrieved from https://www.imec-int.com/drupal/sites/default/files/inline-files/imec_homelab_opening_folderA5_WEB.pdf

Kalundborg Symbiosis. (n.d.). Retrieved 04 12, 2025, from https://www.symbiosis.dk/en/

Karl-Filip. (2019, February 13). *Meeting the needs of the smart citizen: The quadruple helix approach in a local, European and global perspective.* Retrieved April 14, 2025, from Cities of People: https://citiesofpeople.com/en/2019/02/13/meeting-the-needs-of-the-smart-citizen-the-quadruple-helix-approach-in-a-local-european-and-global-perspective/

Katz, B., & Wagner, J. (2014). *The Rise of Innovation Districts: A New Geography of Innovation in America.* Brookings Institution.

Katz, B., Wagner, J., & Osha, T. (2019). *The Evolution of Innovation Districts: The New Geography of Global Innovation.* The Global Institute on Innovation Districts.

Kendall Square Association. (n.d.). Retrieved 04 12, 2025, from https://kendallsquare.org/kendall-green/

Massachusetts Institute of Technology, M. (2016). *MIT Kendall Square Initiative Project: Sustainability Strategies.* Cambridge, MA: City of Cambridge, Community Development Department. Retrieved from https://www.cambridgema.gov/-/media/Files/CDD/ZoningDevel/SpecialPermits/sp302_303_mit/sp302_303_sustainabilitystrategies_20160512.pdf

Mazzucato, M. (2018). Mission-Oriented Innovation Policies: Challenges and Opportunities. *Industrial and Corporate Change, 27*(5), 803-815. doi:10.1093/icc/dty034

Mazzucato, M. (2024, September). Policy with a Purpose Modern industrial policy should shape markets, not just fix their failures. *Finance & Development.* Retrieved from https://www.imf.org/en/Publications/fandd/issues/2024/09/policy-with-a-purpose-mazzucato

McGann, M., Blomkamp, E., & Lewis, J. (2018, March 09). The rise of public sector innovation labs: Experiments in design thinking for policy. *Policy Sciences*, 249–267. doi:https://doi.org/10.1007/s11077-018-9315-7

More than green. (n.d.). Retrieved 04 13, 2025, from https://www.morethangreen.es/en/22barcelona-the-innovation-district/

OECD, O. f.-o. (2015). *The Innovation Imperative: Contributing to Productivity, Growth and Well-Being.* Paris: OECD Publishing. doi:http://dx.doi.org/10.1787/9789264239814-en

Ostrom, E. (2010, June). Beyond Markets and States: Polycentric Governance of Complex Economic Systems. *American Economic Review, 100* (3), 641–72.

Ramge, T., & Laguna de la Vera, R. (2023). *On the Brink of Utopia: Reinventing Innovation to Solve the World's Largest Problems.* Cambridge, MA: MIT Press.

Reinventing Cities. (n.d.). Retrieved 04 13, 2025, from C40 reinventing cities: https://www.c40reinventingcities.org/en/students/winning-projects/22-innovation-district-1471.html

Reuters. (2024). Retrieved from https://www.reuters.com/technology/firms-including-chip-equipment-maker-asml-set-up-fund-eindhoven-development-2024-12-18/

Rotterdam Innovation City. (n.d.). Retrieved 04 13, 2025, from https://www.rotterdaminnovationcity.com/

Ryan, S., & Umberto Cantafio, G. (2020, June 02). Incorporating innovation metrics in urban indices: the Sustain-LED Index. *Regional Studies, Regional Science, 7*(1), 133-163. doi:https://doi.org/10.1080/21681376.2020.1760731

Sandberg, B., & Aarikka-Stenroos, L. (2014, November). What makes it so difficult? A systematic review on barriers to radical innovation. *Industrial Marketing Management, 43*(8), 1293-1305. doi:https://doi.org/10.1016/j.indmarman.2014.08.003

Schuurman, D., & Leminen, S. (2021, September 26). Living labs—Past achievements, current developments, and future trajectories. *Sustainability, 13*(19), 10703. doi:https://doi.org/10.3390/su131910703

Segers, J. P. (2019). The Rise of the Ghent Innovation District. *Scientific Conference on Economics and Entrepreneurship.* Retrieved from https://orbi.uliege.be/handle/2268/212196

Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy, 42*(9), 1568-1580. doi:https://doi.org/10.1016/j.respol.2013.05.008

Stockholm Green Innovation District. (n.d.). Retrieved 04 13, 2025, from https://stockholmgreeninnovationdistrict.se/

Storper, M., & Venables, A. J. (2004). Buzz: Face-to-face contact and the urban economy. *Journal of Economic Geography*, 351–370.

Tang, Y. (2023, 12 25). The impact of ESG performance on innovation research: Empirical evidence from A-share listed manufacturing industry. *Transactions on Economics, Business and Management Research, 3*, 1-9. doi:https://doi.org/10.62051/eq7zp675

TBS Education Barcelona. (2021, 01 20). Retrieved from https://barcelona.tbs-education.com/news/meet-the-22-district-barcelonas-innovation-district/

Tech Lane Ghent. (n.d.). Retrieved from https://www.techlane.be/about/

Tech Lane. (n.d.). *Opening of HomeLab at Tech Lane Ghent Science Park/ Campus A*. Retrieved April 15, 2025, from https://www.techlane.be/news/opening-of-homelab-at-tech-lane-ghent-science-park-campus-a/.

Tidd , J., & Pavitt, K. (2011). *Managing Innovation: Integrating Technological, Market and Organizational Change.* Wiley. Retrieved from https://www.researchgate.net/publication/228315617_Managing_Innovation_Integrating_Technological_Market_And_Organizational_Change

Tõnurist, P., Kattel, R., & Lember, V. (2017, Feb 14). Innovation labs in the public sector: What they are and what they do? *Public Management Review*, 1455–1479.

Vallance, S., Perkins, H., & Dixon, J. (2011, June). What is social sustainability? A clarification of concepts. *Geoforum., 42*(3), 342-348. doi:https://doi.org/10.1016/j.geoforum.2011.01.002

Voorberg, W., Bekkers, V., & Tummers, L. (2015, June 30). A systematic review of co-creation and co-production: Embarking on the social innovation. *Public Management Review*, 1333–1357. doi:https://doi.org/10.1080/14719037.2014.930505

Wagner, J. (2023, June 20). *Why governance matters: An analysis on how innovation districts organize for success.* The Global Institute on Innovation Districts. Retrieved 04 15, 2025, from https://giid.org/research/why-governance-matters-an-analysis-on-how-innovation-districts-organize-for-success/

Wagner, J. (2024). *Innovation Districts and the Centrality of Land.* The Global Institute on Innovation Districts. Retrieved from https://giid.org/research/innovation-districts-and-the-centrality-of-land/

Wang, M., Wang, Y., & Wen, S. (2024, August). ESG performance and green innovation in new energy enterprises: Does institutional environment matter? *Research in International Business and Finance, 71*, 102495. doi:https://doi.org/10.1016/j.ribaf.2024.102495

West, J., Salter, A., Vanhaverbeke, W., & Chesbrough, H. (2014, June). Open innovation: The next decade. *Research Policy, 43*(5), 805-811. doi:https://doi.org/10.1016/j.respol.2014.03.001

Winn, Z. (2022, October 24). Doubling down on sustainability innovation in Kendall Square. *The Kendall Square Association's annual meeting*. Retrieved from https://news.mit.edu/2022/kendall-square-association-sustainability-1024

World Economic Forum. (2025, April 11). *Innovation districts: What makes them tick, from Detroit to Diriyah.* Retrieved from https://www.weforum.org/stories/2025/04/innovation-districts-detroit-diriyah-governance-wef/

Wu, L., Yi, X., Hu, K., Lyulyov, O., & Pimonenko, T. (2024, June 3). The effect of ESG performance on corporate green innovation. *Business Process Management Journal, 31*(8), 24-48. doi:https://doi.org/10.1108/BPMJ-04-2023-0237

Yigitcanlar, T., O'Connor, K., & Westerman, C. (2008). The making of knowledge cities: Melbourne's knowledge-based urban development experience. *Cities*, 63-72. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0264275108000024?casa_token=VzDTtIdxyvwAAAAA:m0AwJVaX7TFhXz_992yUzOrTL3P7RzbFjRgXxKyk2OuvvjENBAF9G6BRogxa81HLP1fdW9gagRU

Appendices

Appendix A: Interview Questions- *Interview Consent & Introduction (Standard Across All Interviews)*

Do I have your permission to record our conversation?

I can keep your responses anonymous or include your name and role—do you have a preference?

Your data will be securely stored and used only for academic research.

Your participation is voluntary, and you can stop at any time.

Interviewee 1: Harrie Arends - *Site Manager, HTCE – Site-level operational focus*

Can you describe your role and how it connects to sustainability at HTCE?

What are the broader sustainability goals at HTCE?

What are the key sustainability projects underway?

How is the success of these projects measured?

What waste reduction strategies or circular economy initiatives are in place?

What portion of energy at HTCE is from renewable sources?

What are the main sources of CO_2 emissions and how are they being reduced?

How is mixed-use development integrated at HTCE?

Who oversees sustainability policies and initiatives?

How does HTCE collaborate with other organizations?

How is stakeholder feedback collected and acted upon?

What future sustainability plans exist?

How are upcoming challenges like climate change being addressed?

Is there collaboration with Tech Lane Ghent?

Interviewee 2: Juliette Gaussem - *Sustainability Board Member, HTCE – Strategic and board-level perspective*

Same themes as Interviewee 1, adjusted to focus on strategic planning and board-level decisions.

Interviewee 3: Kshitij Goyal - *AI Data Scientist, ASML at HTCE – Employee and technological perspective*

What is your role at ASML and how does it connect to HTCE?

What sustainability efforts have you observed at HTCE?

Have you participated in any specific sustainability projects?

How does HTCE's design support a live-work-play environment?

What role do public spaces play in your experience?

Does HTCE support work-life balance?

Are there any impactful AI-driven sustainability projects?

How do ASML employees perceive HTCE's sustainability initiatives?

How does HTCE compare to other innovation districts you know?

What is AI's future role in sustainability?

Interviewee 4: Anonymous – *Sustainability department responsible of an anchor institute, Tech Lane Ghent – Corporate sustainability implementation*

What is your role and what sustainability initiatives are you part of?

What metrics or frameworks are used to assess success?

How does Tech Lane's mixed-use design impact sustainability?

What governance structure oversees sustainability and how does your organization participate?

How do employees perceive Tech Lane's sustainability efforts?

How does Tech Lane compare to other campuses?

What are your future sustainability goals?

Interviewee 5: Wouter De Broeck - *Sustainability Coordinator, VIB at Tech Lane Ghent – Institutional sustainability and metrics*

What is your role at VIB and how does it support sustainability?

What specific sustainability initiatives has VIB launched?

What are your sustainability goals?

What measurement tools are used (e.g., BREEAM)?

How does Tech Lane's mixed-use structure contribute?

What partnerships or collaborations are involved?

What role does VIB play as an anchor institution?

What feedback have you received from employees?

What are VIB's future plans in alignment with global sustainability?

Interviewee 6: Thijs Urban - *Site Manager, Tech Lane Ghent (Campus Ardoyen)*

Interviewee 7: Heleen Veys - *Project Coordinator, POM Oost-Vlaanderen (Zwijnaarde)*

Questions align with those posed to HTCE managers, focusing on governance, infrastructure, stakeholder engagement, and planning.

Interviewee 8: Emiliano Boschetto - *Chief Philosophy Officer, eFM – Global innovation perspective*

What is the "Hubquarter" model and its significance?

How can public/private integration support sustainability?

What is the role of adaptive reuse in urban transformation?

How does a data-driven ecosystem support sustainability goals?

How can innovation and environmental goals be balanced?

Why is user experience central to sustainable design?

How can communities be engaged in innovation districts?

What governance models are most effective?

What is the future of workspaces post-pandemic?

How does technology support human-centric design?

How do tools like MySpot increase flexibility and sustainability?

What role do universities and research centers play?

Interviewee 9: Laura Biancuzzo - *Senior Research Associate, GIID – Practice-oriented and policy perspective*

How does GIID's applied research guide district sustainability?

What features define successful innovation districts?

Can you give examples of locally driven sustainable projects?

Which governance structures work best for collaboration?

How can local communities be better included?

What common barriers do districts face and how are they solved?

What are the most critical success factors?

What are your top policy suggestions for innovation districts?

Appendix B: Survey Questions for Stakeholders in Both Districts

Purpose: To assess stakeholder perceptions of sustainability initiatives and identify challenges and improvement areas.

Q1. How familiar are you with your district's sustainability goals (e.g., energy efficiency, waste reduction)?

Not familiar at all

Slightly familiar

Moderately familiar

Very familiar

Extremely familiar

Q2. Do you actively participate in your district's waste separation/recycling programs?

Yes

No

Q3. Have you noticed energy-saving measures in your workplace (e.g., smart lighting, renewable energy)?

Yes (please specify)

No

Q4. How important is it to you that your district reduces its carbon footprint?

Not at all important

Slightly important

Moderately important

Very important

Extremely important

Q5. Do you use recreational/spaces in the district (e.g., parks, cafés, gyms) during or after work hours?

Frequently

Occasionally

Never

Q6. How do you typically commute to the district?

Car

Public transport

Bicycle/Walking

Other (please specify)

Q7. Has your district sought your feedback on sustainability initiatives?

Yes (e.g., surveys, meetings)

No

Q8. Does your company collaborate with other firms or the campus itself on sustainability projects?

Yes (please provide an example)

No

Q9. What barriers do you face in adopting sustainable practices? (Select all that apply)

☐ Lack of clear guidelines/policies

☐ Limited infrastructure (e.g., bins, EV chargers)

☐ High costs or budget constraints

☐ Lack of awareness/training

☐ Resistance to change within my organization

☐ Other (please specify)

Q10. What sustainability improvements would you recommend for your district? (Select all that apply)

☐ Expand recycling/waste separation facilities

☐ Increase renewable energy use (e.g., solar panels)

☐ Improve bike/walking infrastructure

☐ Offer incentives for sustainable commuting

☐ Organize sustainability training/workshops

☐ Enhance green spaces

☐ Other (please specify)