echoLink - the Heartbeat of Berlin

Enhancing Social activities and Human well-being through Smart city technologies and Resilient landscape design:

Integrating Artificial Intelligence and Internet-of-Things into the Green network surrounding Tempelhofer Feld, Berlin, Germany

Hochschule Anhalt

Department of Agriculture, Ecotrophology, and Landscape Development

Master in Landscape Architecture

Thao Huynh Thi Thanh

MLA-[redacted]

Supervised by

Prof. Dr.-Ing. Nicole Uhrig

Dipl. Ing. B. Arch. Sc. Kieran Stanley

HOCHSCHULE ANHALT University of Applied Sciences
Department of Agriculture, Ecotrophology, and Landscape Development
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research submitted by
Thao, Huynh Thi Thanh
MLA [redacted]

Thesis submitted in partial fulfillment of the requirements for the degree of
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Dipl. Ing. B. Arch. Sc. Kieran Stanley
dan pearlman Experience Architecture

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Berlin, Germany

Declaration

I, ***Huynh Thi Thanh Thao***, matriculation number [redacted], hereby confirm that I have independently prepared this thesis with the title

"Enhancing social activities and human well-being through Smart city technologies and Resilient landscape design: Integrating Artificial Intelligence and Internet-of-Things into the green network surrounding Tempelhofer Feld, Berlin, Germany".

I have only used the sources and aids specifically indicated.

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Acknowledgement

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Abstract

This thesis explores the use of Smart City technologies, specifically Artificial Intelligence (AI) and the Internet of Things (IoT), along with resilient landscape design to turn Tempelhofer Feld (TF) into a dynamic social and ecological center within Berlin's green infrastructure. The project, which is based on the EchoLink idea, reimagines the park as a living, interacting ecosystem that improves human well-being, stimulates social interaction, and builds climate resilience using data-driven and participatory design approaches.

EchoLink creates a network of interactive social nodes, gamified wellness experiences, climate-adaptive green architecture, and responsive environmental solutions by integrating AI and IoT devices into the landscape. These include Echo-Points, which serve as digital and community touchpoints; augmented reality (AR) trails and stewardship programs that encourage movement and care; and machine learning algorithms that control adaptive lighting, irrigation, and comfort systems using real-time environmental data.

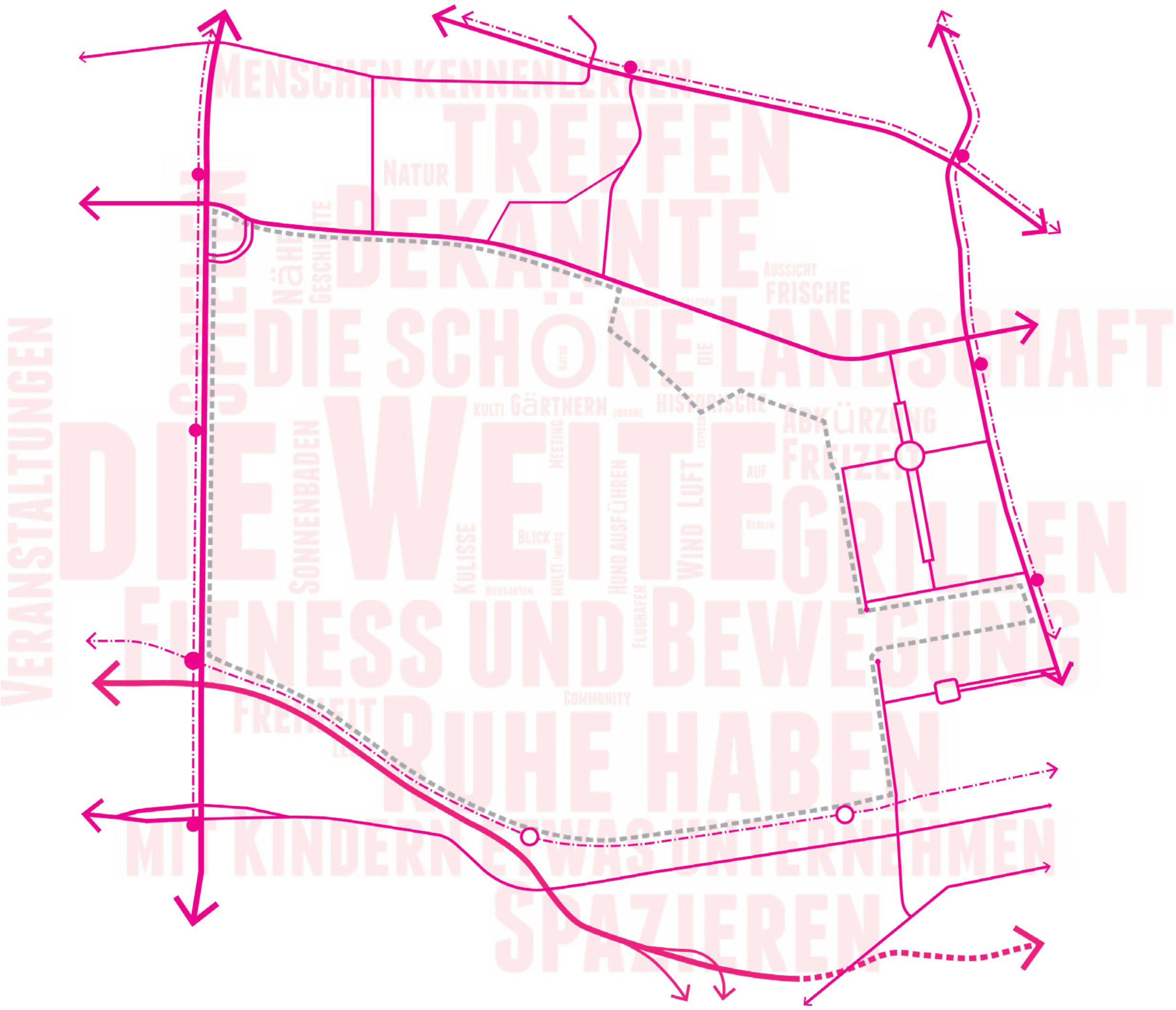
Using a research-by-design method, the thesis shows how combining technology and landscape may result in inclusive, adaptable, and future-ready public places. EchoLink not only preserves TF's historic character, but also offers it as a model for smart, human-centered urban green spaces—where ecological intelligence and social vitality flow through the city's green core.

Keywords: *Smart landscapes, Human well-being, IoT in public spaces, AI-driven design, Climate resilience, Social gamification, Tempelhofer Feld, Berlin.*











Photos and diagram by author
Background graphic's source:
TF's Development and
Maintenance Plan



"**Green infrastructure** can be a **centerpiece of smart regional** and metropolitan planning, **ensuring communities have a livable environment**, with clean air and water, **for generations to come.**"

- Yoshi Silverstein and Jared Green

Source: Google map

Table of Content

01

Prelude
Listening the Green Heartbeat

"The window of opportunity
for ***climate resilient development*** *that*
integrates adaptation and mitigation
to ***advance sustainable development for all****,*
is rapidly narrowing.

But…

the choices and actions
implemented in ***this decade***
will have impacts
now and for thousands of years
on ***human well-being***
and ***planetary health****"*

- United Nations System Staff College

1.1. Motivation

*...**plant** symbolizes **hope**, **renewal**, and the **interconnectedness** of humans, nature, and technology.*

Figure 01 (Left)

Wall-E and Eve with the small plant in Disney/ Pixar's Wall-E
Picture by Disney/ Pixar

Figure 02 (Right)

Man-made planting beds near Görlitzer Park, is that combination UTOPIA-vision for landscape (plants) - human (corner of building) - technology (recycled wooden boxes)?
Picture by author

Technologies like fire, the wheel, and electricity have altered society, starting with tiny trials and spreading widely. Breakthrough inventions added value, improved efficiency and affordability, and became part of human evolution (Suleyman). Therefore, the three industrial revolutions have had major effects on human society and spread values (Schwab). The Fourth Industrial Revolution, often known as the Digital Age or "*a new wave of technology, centered around artificial intelligence*" (Suleyman), is altering the globe faster than ever. The world is at the crossroads of utilizing digital technology to construct a sustainable future or letting it deepen the Triple Planetary Crisis—climate change, natural loss, and pollution. Consequently, Earth survival and environmental conservation have become global concerns.

This recalls the movie ***Wall-E***, which poignantly portrays the story of alone garbage robot left on Earth and Eve, the robot tasked with discovering plant life. The presence of a small ***plant symbolizes hope, renewal, and the interconnectedness of humans, nature, and technology***. It emphasizes nature's resilience and the interconnectedness of human and environmental existence. The movie underlines the vital role of plants in supporting life on Earth and stresses the need to protect our world and balance humanity, technology, and environment.

Besides, Wall-E raised awareness about our overdependence on technology and its effect on human health. The movie shows how the consequence of life controlled by AI leads humanity to widespread obesity and the breakdown of social interaction. This utopian vision reminds an old state from many years ago, ***Smart city***, which "*uses technological solutions to improve the management and efficiency of the urban environment*" (Paiho et al.) or "*smartness is a means to an end: improving the quality of urban life.*" (Halegoua). Furthermore, technology is artificial equipment, from the rudimentary tools that help human hunting, gathering, and self-defense to high technologies that have reshaped the human environment and ensured humanity´s survival and development (Garza-Herrera). Therefore, the role of technology in urban context and landscape design to reinforce community and human health should be deliberately researched and implemented.

Technology, urban landscape design, and human health are increasingly linked as cities seek to balance innovation and well-being. Technology addiction may lead to inactivity and social isolation, as seen in Wall-E. Technology may improve public health and communal life if used wisely. Wall-E and Eve, the robots, save the plant (Figure 01), proving that technology can be useful when used in harmony with nature. To put it another way, the combination of technology, nature, and human may no longer be considered a Utopian goal (Figure 02).

Smart city technologies like AI and IoT help monitor and improve urban environment. These technologies may optimize green spaces, promote active lives, and improve living circumstances by delivering real-time air quality and public space utilization data (Panel). "*Green infrastructure can be a centerpiece of smart regional and metropolitan planning, ensuring communities have a livable environment, with clean air and water, for generations to come.*"[1]. Hence, including smart technology into urban design reduces technological overreliance and promotes a healthier, more connected community (Ghisleni).

The importance of green infrastructure and smart city technologies in urban environments becomes evident throughout this context. This discussion has inspired the researched topic for thesis.

1 *Yoshi Silverstein and Jared Green https://www.asla.org/greeninfrastructure.aspx (12.05.2025)*

1.2. Background and Context

Urbanization and the need for green spaces

The rapid urbanization of cities worldwide has generated significant challenges and opportunities in urban planning, particularly regarding the preservation and integration of green spaces. In Berlin, approximately 84% of the population lives in urban areas, rising to an expected 88% by 2050 according to the United Nations, these dynamics are particularly critical. Urban areas are increasingly characterized by concrete landscapes, which can negatively impact mental health, social cohesion, and environmental sustainability (Beatley). Understanding the importance of protecting these crucial ecosystems becomes essential for advancing social well-being, environmental sustainability, and public health as urban areas become denser, often at the price of green spaces.

Green spaces, for example parks and urban forests, are critical for providing ecosystem services and many beneficial mental and physical effects, improving air quality, and offering spaces for recreation and social interaction (WHO, Beatley, Kabisch et al.). However, many cities find it too difficult to strike a balance between development with the preservation and enhancement of these crucial areas (United Nations).

Impacts of urbanization on green spaces

Direct impacts on Green spaces

- *Reduction of natural areas*
- *Deforestation*
- *Habitat destruction*

Environmental consequences

- *Loss of biodiversity*
- *Air pollution*
- *Urban heat island effect*
- *Increased flooding due to poor drainage*

Social & Economic consequences

- *Reduced recreational areas*
- *Decline in mental well-being*

Benefits of green spaces

Climate & Sustainability benefits

- *Supports sustainable urban development*
- *Helps mitigate climate change effects*

Environmental benefits

- *Enhance biodiversity and wildlife habitat*
- *Improve air quality*
- *Reduce urban heat island effect*
- *Aids in water absorption and reduce flooding*

Social & Economic benefits

- *Promote social cohesiveness*
- *Improve mental and physical health*
- *Encourages community interaction and social bonding*

Challenges in balancing development and green spaces

Reconcile urban expansion with preservation

- *Balance residential and commercial growth with green infrastructure*
- *Housing and commercial constructions*
- *Urban green space financing*

Community engagement and social justice

Accommodate diverse population

- *Include communities in design and maintenance*
- *Citizen participation improves socioeconomic equity and green space*
- *Increase access to green spaces*

Green areas are crucial in Berlin's urbanization due to fast expansion and environmental issues. ***Urban green areas boost biodiversity, public health, and social interaction.*** *To balance urban expansion and the preservation of these critical regions, planners, lawmakers, and community members must work together.*

Integrating green infrastructure into urban planning and incorporating communities will help Berlin and other cities create sustainable and resilient landscapes as awareness of their value grows.

Photo's source:
https://www.berliner-zeitung.de/mensch-metropole/senat-laesst-ein-mini-berlin-ueber-zukunft-des-tempelhofer-feldes-debattieren-li.2228061

1.2. Background and Context

The rise of Smart city

The rise of smart city technologies has transformed urban planning and landscape design, allowing cities to address challenges presented by rapid urbanization, climate change, and increased population density. Berlin, a city that has embraced these technologies, serves as a significant case study in understanding how smart city initiatives can enhance urban infrastructure and community well-being through informed landscape design.

Overview of smart city technologies

Smart city technologies encompass a variety of tools and systems that facilitate real-time data collection, connectivity, and automation to optimize urban environments. In Berlin, these technologies enhance efficiency in transportation, energy management, waste management, and public safety. Tarek and Ouf noted that the incorporation of biophilic principles with smart technologies promotes urban resilience, allowing cities to harmonize nature and technology effectively. In this regard, Berlin exemplifies how smart city initiatives can integrate green infrastructure and technology to support residents' quality of life.

Applications of smart city technologies in Berlin

Mobility solutions: *Berlin has adopted various mobility solutions, including smart public transportation systems that utilize real-time data to optimize routes and improve service efficiency. This technological integration enhances accessibility for residents and promotes sustainable travel (Kang, Chao, et al.).*

Green infrastructure monitoring: *The implementation of IoT devices to monitor the health of urban green spaces is becoming increasingly common in Berlin. Sensors measuring soil moisture, air quality, and foot traffic allow city planners to make data-driven decisions regarding landscape maintenance and improvements. The insights generated by this data enable proactive management of green spaces, enhancing their ecological functions and improving community engagement (Kang, Chao, et al.).*

Public safety and community engagement: *Smart city technologies facilitate greater engagement with residents through platforms that encourage feedback on urban design proposals. For instance, AR applications can provide residents with visualizations of potential developments, fostering informed discussions about urban changes (Bakhtiar et al.). This participatory approach strengthens social cohesion and promotes a sense of belonging among citizens.*

Environmental sustainability and resilience

The integration of smart technologies in Berlin's urban planning underscores the city's commitment to sustainability and resilience. By optimizing resource management and incorporating renewable energy sources, smart city initiatives significantly reduce the ecological footprint of urban operations. According to research of Zhang, Youzhi, et al., smart energy systems may result in significant energy savings and lower greenhouse gas emissions. For example, the use of smart grids and energy-efficient public lighting systems aligns with the city's sustainability goals while enhancing residents' quality of life.

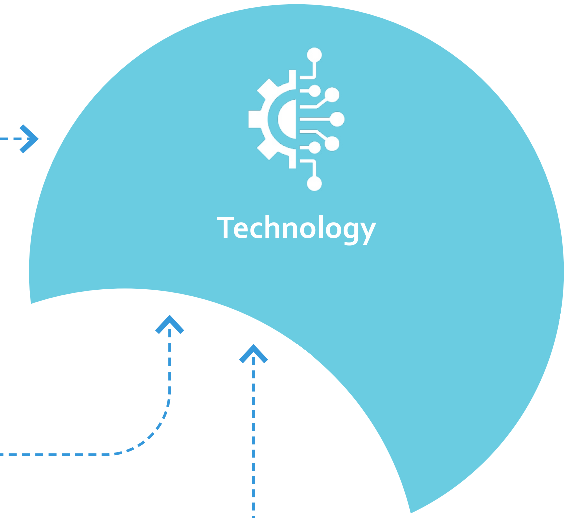
Integrating green infrastructure, such as green roofs and community gardens, is essential in Berlin's smart urban planning. These initiatives increase biodiversity, improve air quality, and control stormwater runoff — all critical factors in climate adaption (Schulders). Incorporating resilience-based approaches into landscape design reflects the evolution of smart urban initiatives toward fostering sustainability.

Challenges in implementation

Funding and resource allocation: *The financial implications of smart technology implementation can strain municipal budgets, particularly in Berlin where competing priorities exist (Verrest and Pfeffer). Securing funding for sustainable projects may require innovative public-private partnerships and the development of strong business cases for investment.*

Integration with Existing Infrastructure: *Many smart city initiatives necessitate adapting or retrofitting existing infrastructure, leading to potential logistical and planning challenges (Ji, Mingbo, et al.). Ensuring that new technologies mesh seamlessly with current systems while minimizing disruptions is important.*

Public Perception and Trust: *Maintaining public trust in data privacy and security is essential as cities adopt more connected technologies. Successfully addressing these concerns through transparent policies and communication strategies is vital for fostering public acceptance (Saker).*



Photo's source: https://www.bnova.it/analytics/smart-city/

*The rise of smart city technologies represents **a transformative opportunity for urban landscape design** in Berlin and beyond. By **integrating innovative solutions** into urban planning, cities can **enhance sustainability, improve resource management, and foster community engagement**. Despite challenges, the continuous evolution of smart technologies, combined with principles of landscape design, holds promise for building resilient, livable urban environments that promote ecological health and social equity.*

Ensuring that smart city initiatives prioritize both technological solutions and the unique needs of communities will be crucial for shaping the future of urban living.

1.2. Background and Context

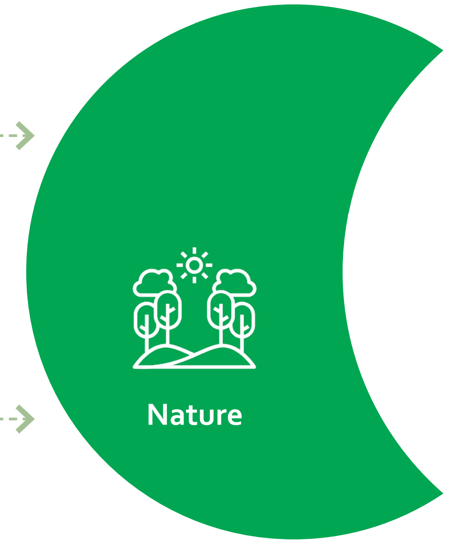
The role of resilient landscape design

Resilient landscape design creates locations that can adapt to environmental, social, and economic changes as well as climate change and urbanization. Climate change threatens metropolitan areas with severe weather, heatwaves, and biodiversity loss, making this strategy crucial (IPCC). Resilient landscapes mitigate threats to the environment and help populations survive challenges (Ahern). Green infrastructure and urban biodiversity may promote ecosystem health and social and psychological well-being in these designs (Mell).

Resilient landscape design and smart technology may construct adaptable green networks that meet urban populations' demands, including post-pandemic mental health and social well-being (Jiang et al., Muntean and Bochiş). Well-designed green spaces minimize loneliness and improve mental health, making them crucial in urban areas (Nováková and Orosová).

Berlin's development has changed its environment, affecting green space management. The balance between development and open places has gotten more delicate as cities grow to accommodate more people. This study shows urbanization's issues, green spaces' importance, and Berlin's distinctive urban landscape's solutions.

Challenges in Balancing Urban Development and Green Preservation	Emerging Responses and Strategies
Urban Pressure: *The demand for housing and infrastructure often overshadows the provision of green spaces, leading to tensions in urban planning discussions. The struggle is exemplified in public debates surrounding development proposals that threaten existing parks or natural areas (Landor-Yamagata et al.).*	**Integrated Urban Planning:** *The city has begun to adopt integrated urban planning practices that prioritize the inclusion of green infrastructure within new developments. This approach emphasizes multifunctionality—designing urban areas that provide ecological, social, and recreational benefits in tandem with urban growth (Carver and Gardner).*
Equity and Access: *Disparities in access to green spaces are prevalent, particularly affecting marginalized communities in urban settings. Research emphasizes the necessity of equitable distribution of urban green spaces to ensure all community members benefit from their associated health and social advantages (Rosol).*	**Community Engagement Initiatives:** *Community gardens and participatory planning efforts have gained momentum within Berlin. Engaging communities in the design and upkeep of public green areas generates a feeling of ownership and responsibility, as well as ensuring that urban green projects are informed by local needs and preferences (Beninde et al.).*
Policy and Governance: *For the management of urban green areas, efficient governance and policy frameworks are essential. The complexity of navigating varied interests among stakeholders, including government bodies, private developers, and community groups, can impede the implementation of coherent green space policies (Chen et al.).*	**Green Infrastructure Development:** *Efforts to develop green infrastructure, such as green roofs, urban forests, and bioswales, are becoming more widespread in Berlin as part of a larger plan for environmental quality and resilience (Kabisch and Haase). Incorporating these components into urban landscapes increases sustainability while also increasing the aesthetic and recreational value of public places.*



Photo's source: https://www.tempelhofer-park.de/

*The evolution of urbanization in Berlin highlights the **critical need for maintaining and enhancing green spaces within the urban landscape**. The challenges posed by rapid growth demand innovative solutions that prioritize ecological health, social cohesion, and community well-being. By adopting integrated planning strategies, fostering community engagement, and promoting the development of green infrastructure, Berlin can create a resilient urban environment that effectively balances development and green space preservation. Continued research and collaboration among stakeholders will be essential for ensuring that the **city's green spaces remain a vital component of its urban fabric, enhancing the quality of life for all residents**.*

1.2. Background and Context

Human well-being in a post-pandemic world

Human well-being has become more important post-pandemic. The pandemic has increased awareness of mental health issues, with research showing that social isolation and lifestyle changes impact well-being (González-Sanguino et al., Ma et al.). The COVID-19 pandemic highlighted the physical and mental health benefits of green spaces. Urban parks become safe havens for leisure, relaxation, and socialising during lockdowns, demonstrating their value to human well-being (Samuelsson et al.).

The pandemic revealed urban systemic problems such social isolation, uneven access to green places, and the need for crisis-resilient infrastructure (UN-Habitat). As cities recover, inclusive, accessible green spaces that encourage community involvement, social cohesion, and environmental resilience may be created to emphasize mental health and well-being. These venues may be enhanced with smart technology to provide real-time use statistics and promote community-driven public health initiatives.

Recent study has examined how the COVID-19 epidemic has affected mental health and well-being, with consequences for Berlin. Understanding social well-being, community resilience, and mental health is crucial as urban communities cope with the pandemic's long-term psychological repercussions. This study investigates Berlin's human well-being post-pandemic, highlighting difficulties and potential.

Impact of the COVID-19 Pandemic on Mental Health

Pandemic psychological effects on many populations are well established. Ekici and Watson found that university students had significant academic and social interruptions, resulting in increased stress and mental health issues. Though Berlin data is insufficient, such disruptions reflect larger demographic patterns, particularly disadvantaged and marginalized people that experienced heightened difficulties during this time (Lyons et al.).

Despite differences in pandemic effect, studies shows that social isolation and uncertainty promote anxiety, sadness, and psychological discomfort (Tilburg et al., Huang and Zhang). Kumar et al.'s comprehensive analysis emphasizes the need of studying how pandemic-related daily life disruptions caused mental health issues in young people (Wang et al.).

Social Interaction and Community Engagement

Social connection is important for well-being, especially during the epidemic. Isolation highlighted the need of community interaction (Knights et al.). Parks and neighborhood centers are increasingly important for social cohesion and mental health (Jiang et al.).

Community engagement projects in Berlin emphasize inclusive public areas that promote social interaction and activity. Redesigning public spaces for meetings and interaction may boost community resilience to future obstacles (Muntean and Bochiş). This supports research linking accessible public areas to better well-being (Nováková and Orosová).

Promoting Resilience through Design

Cities like Berlin must prioritize resilience after the epidemic. Research indicates that improving urban green areas might reduce the psychological impact of crises by promoting relaxation and social interaction (González-Sanguino et al.). Biophilic design—incorporating natural elements into urban landscapes—can improve mental health and make cities more restful and inclusive (Ma et al.).

Human-centered design (HCD) has spurred public place accessibility efforts. Urban planners may promote equitable post-pandemic solutions that reflect citizens' different needs and preferences by promoting inclusion and involvement (Giuntella et al.).

Photo's source: https://www.tempelhoferfeld.de/entdecken-erleben/projekte-buergerschaftlichen-engagements/stadtacker/

Challenges in the Post-Pandemic Context

Social Inequality: *The pandemic disproportionately affected already vulnerable populations, exacerbating existing health disparities. Access to mental health resources and supportive services remains inconsistent across socioeconomic lines (Vieira et al.).*

Infrastructure and Resources: *As cities strive to enhance mental well-being through urban design and public space initiatives, securing funding and resources for these improvements can present a significant challenge (Wang'ombe).*

Long-term Psychological Effects: *Understanding and addressing the lasting psychological impact of the pandemic is essential. Many studies indicate that individuals may face prolonged mental health challenges as societies transition to post-pandemic norms, emphasizing the need for ongoing support systems (Jabbar et al.).*

*The post-pandemic context in Berlin highlights the critical intersection between urban design, community engagement, and mental well-being. By **focusing on inclusive public spaces** that foster social interaction and resilience, **the city can mitigate the long-term psychological impacts of the pandemic and strengthen community ties**. Continued research in these areas will be essential for promoting human well-being and ensuring that Berlin can adapt to future challenges effectively.*

*In summary, while the pandemic has presented significant challenges, it has also encouraged innovative approaches to **enhancing resilience in urban environments through thoughtful landscape design and community engagement**.*

In urban planning and development, the interaction of technology, nature, and community is becoming more significant, particularly in in the context of the COVID-19 pandemic's effects. The integration of smart technology into urban green spaces, which aims to improve community involvement, wellbeing, and environmental concerns, defines this intersection (Figure 03).

With significant implications for improving social activities and fostering well-being, the interaction of technology, nature, and community is becoming more widely acknowledged as being essential to the design of urban settings. Rapid growth in the population, degradation of the environment, and social injustice are some of the urgent issues facing urban regions, which calls for creative solutions that combine cutting-edge technology with natural aspects. Sustainable urban ecosystems, increased social connectedness, and better quality of life are the results of this junction.

Enhancing Community Engagement Through Technology

Technology has changed the way communities connect and engage with their surroundings as well as with others. Digital platforms and mobile apps make it easier for people to communicate and become involved in urban planning. Shank stresses that technology interacts within broader social settings, enabling engagement in ways that conventional techniques may not. The involvement of community people in design processes not only generates a feeling of ownership, but it also guarantees that public spaces are suited to their requirements.

AI-powered apps may assess community preferences and habits, enabling the creation of inclusive, user-centered public places. For example, surveys done via mobile platforms may collect real-time input from citizens on local green spaces, allowing urban planners to make educated choices based on the community's genuine requirements (Koen et al.). Such technologies serve to bridge the gap between urban design and community well-being, enabling a more flexible and adaptable response to urban concerns.

Integrating Nature for Mental and Physical Health

The incorporation of nature into urban surroundings serves as vital for improving human well-being. Access to green areas has been connected to a variety of mental health advantages, including less stress, higher mood, and better social interactions (Wester et al.). Nature's importance in urban life is increasingly acknowledged in terms of design, with parks, gardens, and other landscapes made accessible and used by inhabitants.

Sensor networks can monitor environmental conditions and public use patterns in green areas, enabling cities to better manage them (Dinu et al.). For example, air quality sensors put in parks may warn urban managers to pollution levels, encouraging efforts to keep these locations beneficial to community health. By combining nature and technology, cities can improve the healing effects of green areas, making them essential for their residents' mental and physical health.

Fostering Sustainable Practices through Community Involvement

The interaction of technology and environment also includes supporting sustainable practices in urban development. According to Dinu et al., urban infrastructure may use technology to make decision-making processes more transparent and community-centered, hence improving sustainability. Initiatives that promote local engagement in environmental stewardship, such as community gardening initiatives or urban reforestation efforts, may improve social relationships while cultivating a sustainable culture (Waight et al.).

The application of IoT technology in green infrastructure management, such as smart irrigation systems that monitor soil moisture levels in community gardens, highlights this strategy. These technologies improve resource efficiency and allow individuals to actively participate in the maintenance of their local surroundings (Beuret et al.). Technology may help to improve community cohesiveness while also tackling environmental issues.

1 *The integration of technology and human well-being in urban planning includes **applications** that improve social, communal, and environmental sustainability. Urban planners may increase people' quality of life, social connection, and community spirit by using innovative technology. The following sections discuss how IoT, AI, and data analytics might improve urban well-being and community activities.*

2 *Technology and nature in urban design are becoming more important as cities seek sustainable solutions to urbanization. Urban planners may build efficient, user-friendly, and environmentally sensitive habitats by merging smart technology with natural features. Cities need this combination to improve livability while tackling climate change, resource management, and social equality.*

3 *The relationship between nature and human well-being is fundamental to understanding the role of green spaces in urban environments. Integration of natural components into urban architecture is crucial for social engagement, psychological wellness, and urban issues as cities grow. After the COVID-19 epidemic, the focus on connecting people with environment has highlighted the need for outdoor places for socializing and community building.*

4 *The intersection of technology, nature, and community in urban design offers a pathway to creating responsive, inclusive, and sustainable environments that enhance social activities and human well-being. By incorporating advanced technologies in conjunction with nature, urban planners introduce innovative solutions that cater to diverse community needs while promoting ecological sustainability. Future urban design efforts must prioritize collaborative decision-making and inclusivity to ensure that all residents can enjoy the benefits of intelligent urban environments.*

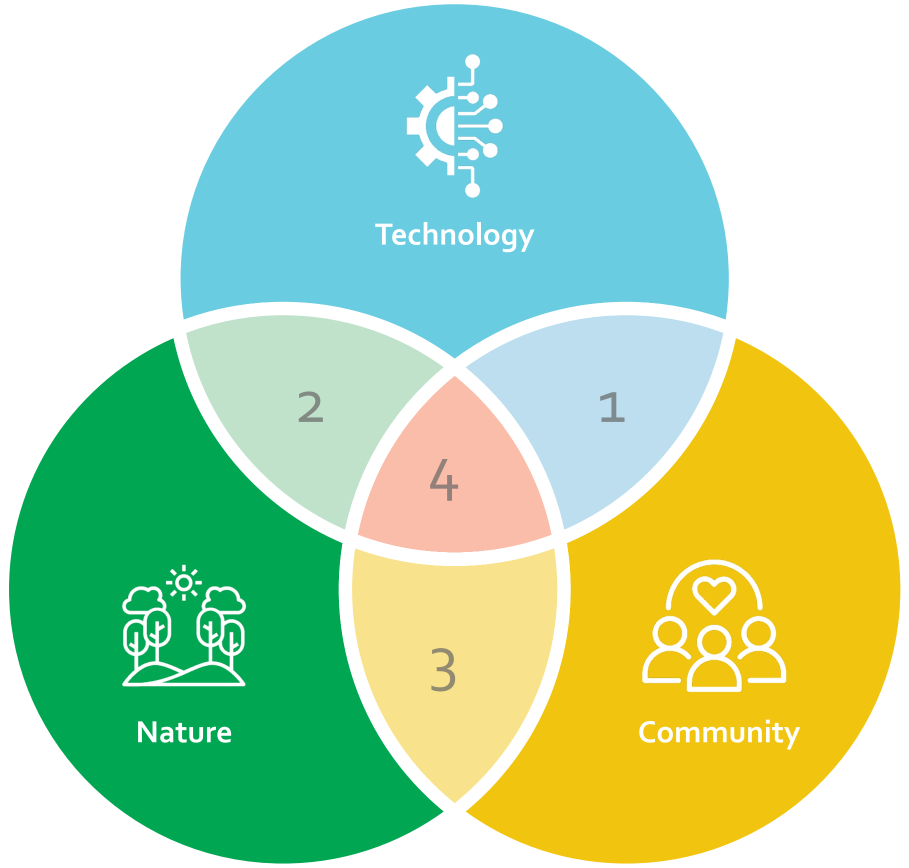


Figure 03

Intersection of Technology, Nature and Community
Drawn by author

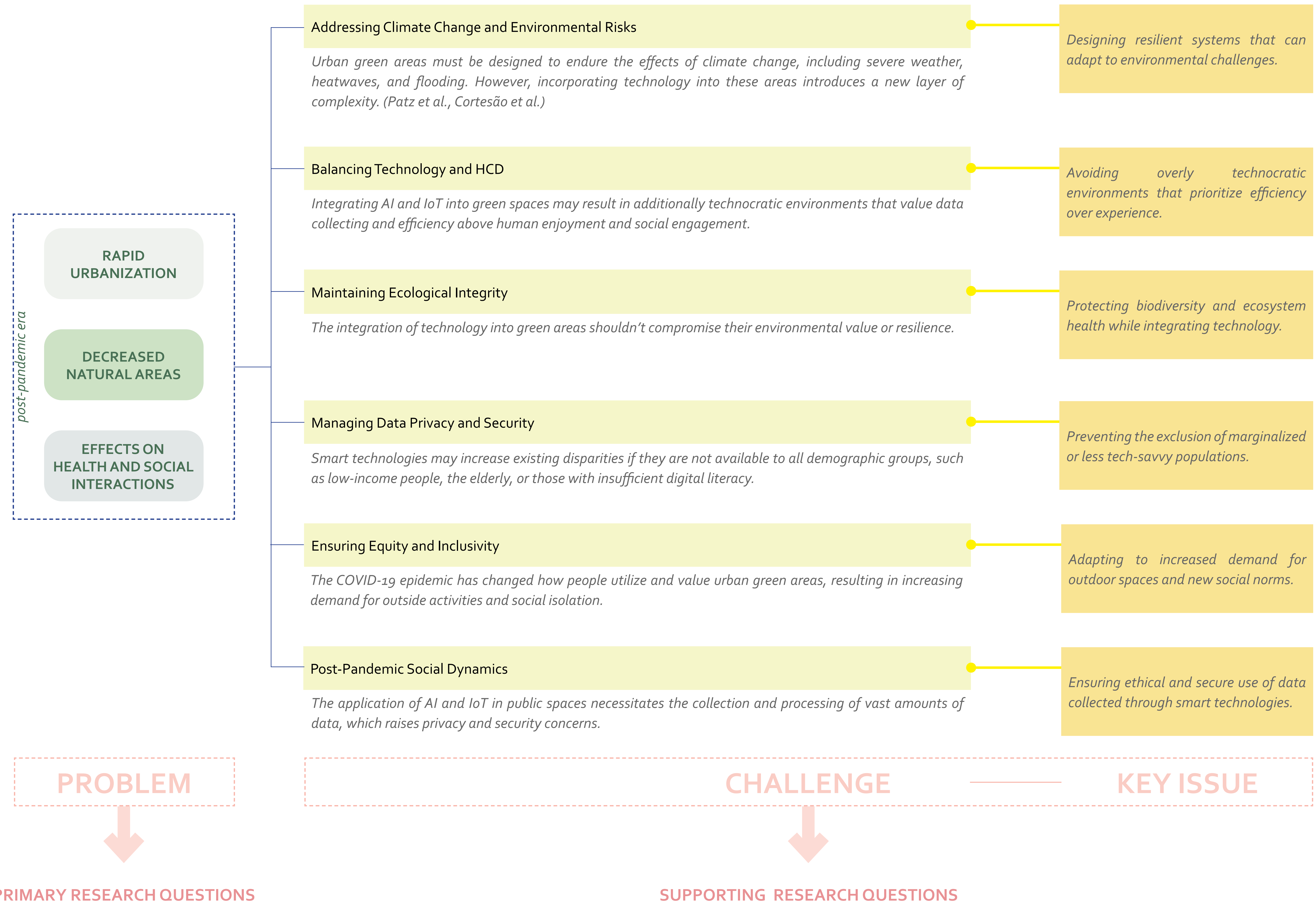
1.3. Problem Statement

Rapid urbanization, the loss of natural spaces, and their consequences on human well-being and social activities, particularly post-pandemic, must be addressed. Green areas, essential for community health and social interaction, have been displaced by structures due to urbanization. Policies that favour impermeable surfaces over green spaces have reduced urban residents' quality of life (Vieira et al.).

Unequal access to green spaces, particularly for disabled people, is a major issue. Research shows that socially poor groups lack green spaces, which worsens health and social isolation (Wang'ombe). Since urban green spaces improve interactions and minimize isolation, their lack may affect physical and mental health (Jabbar et al., Enßle-Reinhardt and Kabisch). The COVID-19 epidemic showed that low-income people had more difficulty accessing secure outdoor spaces for recreation and socialising, which caused mental health concerns (González-Sanguino et al., Ma et al).

Additionally, smart city technologies like AI and IoT provide both opportunities and challenges. These technologies may enhance urban green space management and accessibility, but also pose data privacy, cybersecurity, and technological advantage distribution problems (Vempati, Anjum et al.). The challenge is to use new technology to improve community engagement and well-being without exacerbating inequality (Alahi et al.).

The development of sustainable urban habitats that can adapt to climate change and urban stresses requires resilient landscape design. However, combining these designs with smart technologies to increase functionality and accessibility remains difficult (Kang et al., Krefis et al.). Multidisciplinary approaches that include ecological, technological, and social views are needed to solve these problems and improve urban life.



PRIMARY RESEARCH QUESTIONS

*How can **smart city technologies** be integrated into **urban green spaces** to **enhance social activities** and **human well-being** without compromising their ecological and cultural value?*

*How can **resilient landscape design** principles be combined with **smart city technologies** to create **adaptive**, **inclusive**, and **sustainable green networks** that address **contemporary urban challenges**?*

SUPPORTING RESEARCH QUESTIONS

*What are the **principles/ theories** concerning resilient landscape design, smart technologies, and enhancing social activities and human well-being?*

*How can resilient landscape design and smart technologies **work together to mitigate climate risks** and **enhance environmental sustainability**?*

*How can smart technologies be designed **to enhance, rather than replace**, human connection and interaction in urban green spaces?*

*How can smart technologies be used **to enhance, rather than degrade**, the ecological resilience of urban green spaces?*

*How can smart city technologies be implemented in a way that **ensures equitable access and inclusivity** for all users?*

*How can smart technologies and resilient design **address the evolving needs of urban communities** in a post-pandemic context?*

Photo: Imago/Zeitz
https://www.tip-berlin.de/stadtleben/tempelhofer-feld-typen-besucher-lieben-hassen/

1.5. Goals, Research objectives and Expected Outcomes

GOAL

To Explore the Integration of Smart City Technologies into Urban Green Spaces

Investigate how AI and IoT can be used to enhance the functionality, accessibility, and sustainability of TF and its surrounding green network.

Identify specific technologies (e.g., sensor networks, interactive lighting, mobile apps) that can improve user experiences and environmental outcomes.

To Develop a Framework for Resilient Landscape Design

Propose a design framework that combines resilient landscape principles (e.g., biodiversity, climate adaptation, multifunctionality) with smart technologies.

Demonstrate how this framework can address contemporary urban challenges, such as climate change, social equity, and post-pandemic recovery.

To Enhance Social Activities and Human Well-Being

Explore how smart technologies and resilient design can foster social interaction, community building, and mental and physical well-being in urban green spaces.

Provide evidence-based recommendations for creating inclusive and engaging environments that cater to diverse user groups.

To Promote Environmental Sustainability and Resilience

Assess how the integration of smart technologies and resilient design can enhance the ecological health and climate resilience of TF.

Highlight the role of green networks in supporting biodiversity, mitigating urban heat islands, and managing stormwater.

PRIMARY OBJECTIVE

To investigate the future role of smart city technologies (AI and IoT) in enhancing social activities and human well-being

To assess the potential of resilient landscape design in addressing urban challenges

To develop a framework transferable role model of TF for integrating smart technologies and resilient design

post-pandemic context

Case study

TEMPELHOFER FELD

SECONDARY OBJECTIVE

To analyze user needs and preferences in TF

Conduct surveys, interviews, or focus groups to understand how different user groups (e.g., residents, tourists, elderly, children) currently use TF and what improvements they desire.

Identify barriers to access and usage, particularly for marginalized or less tech-savvy populations.

To evaluate the environmental and social impacts of smart technologies (AI and IoT)

Assess the potential ecological impacts of integrating IoT devices and AI systems into urban green spaces (e.g., energy consumption, habitat disruption).

Investigate how smart technologies (AI and IoT) can promote environmental awareness and stewardship among users.

To explore post-pandemic urban dynamics

Examine how the COVID-19 pandemic has altered the use and perception of urban green spaces, particularly in terms of social interaction and well-being.

Identify opportunities for smart technologies (AI and IoT) and resilient design to address the evolving needs of urban communities in a post-pandemic context.

To address equity and inclusivity in smart city development

Explore strategies for ensuring that smart technologies (AI and IoT) are accessible and beneficial to all demographic groups, including low-income populations and those with limited digital literacy.

Propose measures to prevent the exacerbation of social inequalities through technology-driven urban interventions.

To provide policy and design recommendations

Develop actionable recommendations for policymakers, urban planners, and landscape architects on integrating smart technologies (AI and IoT) and resilient design into urban green spaces.

Highlight the potential of TF as a model for other cities seeking to enhance social activities, human well-being, and environmental sustainability through innovative design and technology.

EXPECTED OUTCOME

Provide a deeper understanding of how smart technologies (AI and IoT) and resilient design can be integrated into urban green spaces.

Offer practical insights and recommendations for enhancing TF and similar sites.

Contribute to the broader discourse on sustainable urban development, smart cities, and HCD.

Serve as a valuable resource for policymakers, urban planners, and landscape architects working at the intersection of technology and environmental design.

KEY DELIVERABLE

Conceptual framework

Case study analysis of TF

Design proposals

Policy recommendations

1.6. Significance of the study

Using AI and IoT in urban green spaces to improve human well-being is one of the thesis's primary achievements. The COVID-19 pandemic has proven how crucial outdoor spaces are for mental health and socialization. Green environments boost mental health, especially in crises (Xie et al.). ***IoT and AI can help urban planners create flexible green networks that match community needs.*** Smart technology can monitor park use in real time, helping municipal officials maximize maintenance and maintain these spaces safe and accessible.

Technology, nature, and community are examined in the thesis, emphasizing the need for inclusive urban environments. Smart technology may increase community engagement by providing venues for public participation in decision-making in green spaces (An et al.). This participatory strategy ***encourages community ownership and accountability, making urban ecosystems more sustainable and resilient.*** As cities grow, equal access to green areas and their benefits is essential for social cohesion and well-being (Salama).

The thesis ***examines how resilient landscape design mitigates climate change in sustainable urban development.*** Climate issues like floods and heatwaves may aggravate inequality in urban areas (Beshley et al.). Cities may adapt to changing climatic conditions and promote biodiversity and ecosystem health by including resilient design into green space development (Yu et al.). This concept ***promotes livable and environmentally friendly urban design*** in line with global sustainability goals.

This thesis discusses ***important technological and urban planning challenges.*** Data ***privacy, security, and ethics must be addressed when cities use smart technology***. Stakeholders can ensure that smart urban systems support community well-being by including ethical frameworks. Post-pandemic, public acceptance and engagement depend on digital solution credibility, therefore ethical technology use is crucial (Li et al.).

The significance of this topic lies in its potential to **enhance social activities and human well-being through** the integration of smart technologies (especially **IoT and AI**) and **resilient landscape design** in urban green spaces. By addressing the pressing challenges of the post-pandemic world, this research can contribute to the development of inclusive, sustainable, and resilient urban environments that promote community engagement and well-being.

1.7. Scope and Limitation

SCOPE

Integration of Smart Technologies

The thesis will explore the integration of smart technologies, including AI and IoT, into urban green spaces. This includes examining how these technologies can enhance the management and accessibility of green spaces, thereby improving community engagement and human well-being.

Resilient Landscape Design

The research will delve into principles of resilient landscape design that can adapt to climate change and urban pressures. This includes exploring how such designs can promote biodiversity and ecosystem health while meeting the social needs of urban populations.

Focus on Human Well-Being

The research will assess the impact of enhanced green spaces on human well-being, particularly in the context of the post-pandemic recovery. This includes evaluating how access to outdoor spaces can mitigate mental health issues exacerbated by the pandemic.

Community Engagement

The thesis will investigate the role of community involvement in the design and implementation of smart technologies in green spaces. This component underlines the need of participatory planning methods that take into account the different needs and preferences of community members.

Case Study of TF

The thesis will focus on TF and its surrounding green network as a specific case study, analyzing its unique characteristics and the potential for integrating smart technologies and resilient design principles to enhance its role as a community space.

LIMITATION

Technological Limitation

The study focuses on specific technologies (AI and IoT) and does not explore other advanced technologies such as blockchain, AR/VR, or autonomous systems in detail.

Proposals for technology integration will remain conceptual or speculative, as their actual implementation requires technical expertise and collaboration with engineers and technologists.

Design Limitation

The landscape design will emphasize conceptual frameworks and principles rather than detailed construction plans. The focus is on outlining strategic interventions rather than producing technical blueprints or engineering specifications.

Geographical Boundaries

The thesis concentrates solely on TF and its surrounding green network includes parks, open spaces (such as allotment gardens, open lawn, cemetery), and the blue-green axis within a radius of 6 km from the center, connected to Natur Park Südgelände, Gleisdreieck + Viktoriapark, Tiergarten, Volkspark Hasenheide, Volkspark Friedrichshain, Görlitzer Park, Treptower Park, Britzer Garten and Volkspark Mariendorf, and does not address broader connections to the entire green system of Berlin.

Social Limitation

While aiming to enhance social well-being, the study does not delve deeply into the psychological or sociological aspects of individual users. Instead, it emphasizes the broader impact of design on community well-being.

Environmental Analysis

Environmental assessments, such as biodiversity studies or soil/ground conditions and water analyses, are beyond the scope of this thesis. These aspects may be referenced but not extensively investigated.

Practical Implementation

The thesis presents theoretical and conceptual strategies rather than actionable implementation plans. Cost analysis, funding mechanisms, and regulatory processes for project execution are not included.

Data Availability

The analysis relies on existing data and resources. Any gaps in data collection or availability may limit the depth of analysis in the thesis.

02

The Science behind the Rhythm
Chords of Connection

2.1. Overview of Smart city technologies
2.2. Resilient landscape design principles
2.3. Human-Centered Design and Social well-being
2.4. Case studies of smart green networks

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"**Green fingers** *are*
the **extensions** *of*
a **verdant heart.**"

- Russell Page

2.1. Overview of Smart city technologies

Overview of Smart City Technologies in Urban Design

A smart city is a complex structure that employs sophisticated technology, notably ICT, to enhance urban life while addressing socioeconomic and environmental challenges. Multiple definitions have been presented, stressing various features of this notion, creating a wide but sometimes unclear definition of a smart city. ***"Smart"*** is used deliberately to highlight the ***logistical excellence of a city***. The uncertainty of the phrase enables companies interested in diverse urban challenges to use it to ***concentrate on different areas of innovation*** (e.g., in governance, public safety, transportation) ***or improvement*** (e.g., in health and well-being, sustainability, quality of life) (Halegoua).

Smart cities rely on technology and data to improve infrastructure, public services, sustainability, and livability. Interconnected networks provide real-time data collecting and analysis for transportation, energy, water management, and health services in this comprehensive approach. This approach is consistent with studies demonstrating that a smart city employs technology to enhance residents' quality of life and stimulate economic growth.

Smart cities have increased public safety, energy efficiency, waste management, and transportation systems underpinned by a strong digital infrastructure (Baltac, Naoui et al.). Such cities use IoT, big data analytics, and cloud computing to build a linked urban environment that proactively meets residents' needs. Sensors can monitor air quality and traffic patterns, helping municipal authorities make real-time choices to solve urban issues (Khalil et al.).

The smart city model stresses public participation in urban planning and administration, hence smart governance is essential. Effective governance promotes smart technology implementation and ensures that all communities benefit from it, reducing social inequality (Baltac, Dameri). This participative approach ***addresses both the "how" and "why" of smart city initiatives by combining technology and social solutions***.

A growing consensus is that ***smart cities must include environmental sustainability and resilience.*** Smart cities counteract climate change by adopting sustainable practices, decreasing carbon footprints, and improving urban green areas (Aloi et al., Neirotti et al.). Sustainability, economic prosperity, and social fairness are increasingly interwoven, creating a 21st-century smart city idea.

Purpose of Smart City Technologies in urban and landscape design

Enhancing Sustainability: *The core objective of smart city initiatives is to promote sustainability and resilience in urban areas. According to Fefta et al., efficient resource utilization, energy conservation, and reduced environmental impact are vital components of smart city development. This includes not just technological innovations, but also policies that facilitate sustainable practices among businesses and communities).*

Improving Public Services: *Smart city technologies significantly enhance public services and infrastructure. Lee emphasizes that integrating advanced communication systems can streamline various municipal services, making them more accessible and efficient. This involves redefining how services are offered and ensuring that they meet the changing requirements of the people.*

Fostering Social Inclusivity: *Another essential aspect of smart cities is the focus on social inclusivity and community engagement. Smart cities are aimed to improve the well-being of all people by providing fair access to services and building a feeling of community (Tekin et al.). Engaging citizens in planning processes is crucial for addressing diverse needs and ensuring that the resulting urban environments are welcoming and functional for everyone.*

Key Components of Smart City Technologies in urban and landscape design

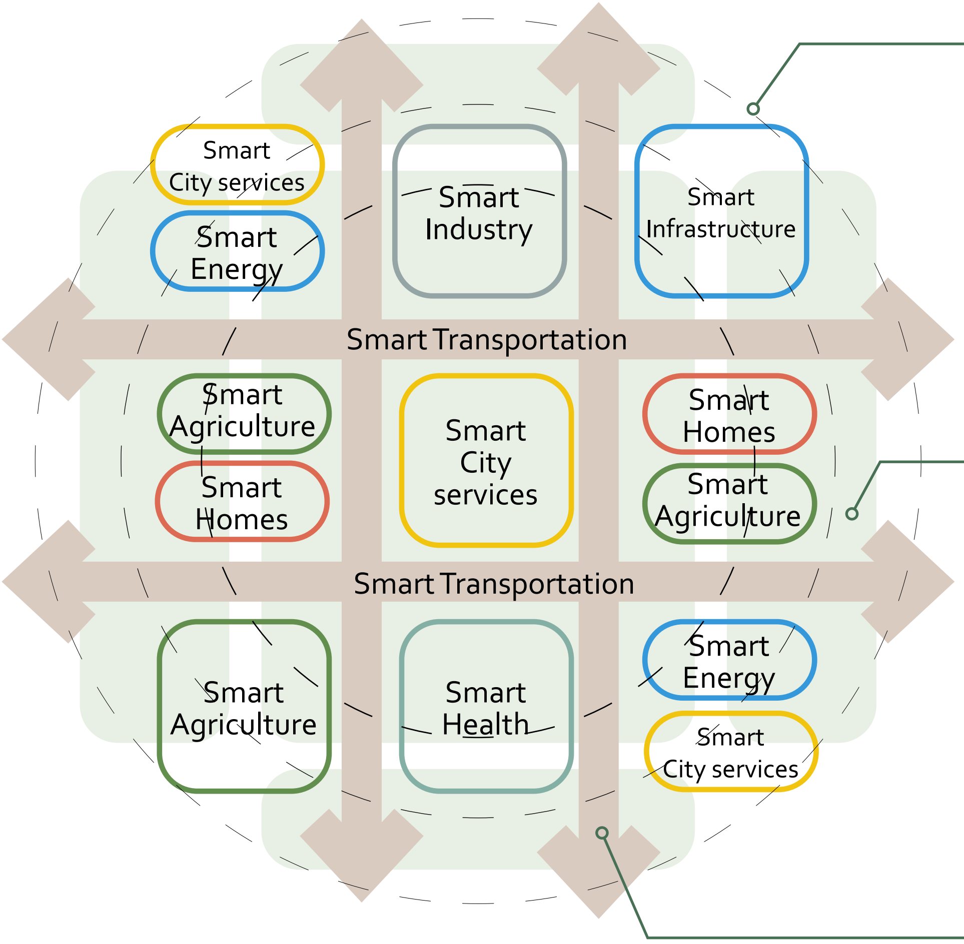


Figure 04

Key components of Smart city technologies in Smart city components (Syed)
Picture by author

Data Utilization

Data gathering and real-time analysis drive smart city decision-making. Muktiono says ICT is necessary for effective public services including transportation, healthcare, and infrastructure management. Sensors and big data analytics let cities meet inhabitants' demands swiftly and enhance quality of life.

Connectivity and Integration

Combining smart technology makes cities more linked. ICT helps cities perceive, evaluate, and integrate essential public security, industrial, and social service data (Wang, Jingjing, et al.). This interconnection improves urban service performance and interactivity, making city infrastructure more responsive.

Smart Mobility

Transportation is crucial to urban design. Smart mobility solutions enhance traffic management, decrease congestion, and encourage green travel. Connected cars and intelligent public transit networks increase efficiency and user experience, making cities easier to navigate (Cohen et al.).

Challenges in Implementation

While the integration of smart technologies in urban design offers substantial benefits, it also faces several obstacles. Cohen et al. observe that a lack of consensus on what constitutes a "smart city" and the diversity of implementations can complicate planning efforts. Additionally, concerns around digital equity arise, where the benefits of smart technologies might not be distributed evenly across all community segments, potentially leading to a digital divide (Foley et al.).

Furthermore, ensuring the security and privacy of data collected through smart city initiatives poses significant challenges, with potential repercussions on public trust and acceptance. Studies indicate that privacy and security remain key concerns within smart cities, emphasizing the need for robust frameworks to protect citizens' information (Ismagilova et al., Zhang, Xihua, et al.). The complexity of managing these various technologies and their interdependencies further complicates their deployment.

*Smart city technologies represent a transformative approach to urban design, emphasizing the integration of advanced data systems, connectivity, and sustainability. These technologies have the **ability to reinvent urban living** by concentrating on **improving public services, boosting social inclusion, and increasing overall quality of life.** However, careful consideration must be given to the challenges of implementation, including issues surrounding **equity, privacy**, and **the need for collaborative governance**. Through thoughtful planning and engagement with local communities, the promise of smart city technologies can be fully realized.*

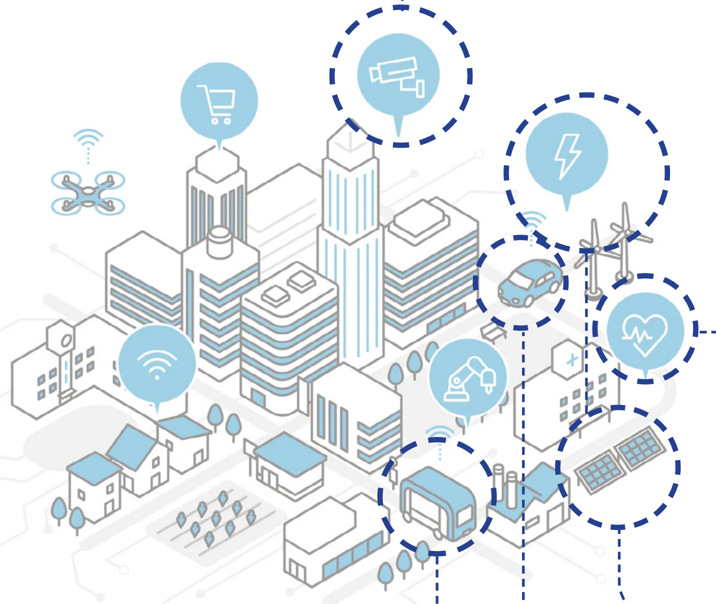
2.1. Overview of Smart city technologies

IoT in Urban Design

The IoT is transforming urban design by enabling the connection of devices and systems that facilitate real-time data collection and communication. This integration enhances urban infrastructure and assists stakeholders in making informed decisions about urban management and planning. This research highlights the critical roles, diverse applications, and implications of IoT technology in urban design (Figure 05).

Role of IoT in Urban Design

IoT technologies enable a data-informed approach to urban design by connecting various systems and devices across the city. This interconnectedness allows for streamlined communication between infrastructure and stakeholders, leading to more effective urban management. The ability of IoT devices to gather data in real-time leads to improvements in resource management and environmental monitoring, which are crucial for developing smarter and more efficient urban areas (Ekici and Watson).



Public spaces monitoring

IoT sensors can monitor foot traffic, air quality, and noise in parks and other public places to optimize use. Environmental sensors may gather particulate matter concentration data to assist urban health efforts and enhance air quality management, as shown by Shi et al.

Well-Being Metrics

Wearables and environmental sensors gather public health measures, enabling city planners to tailor initiatives that improve citizen well-being. This healthcare element of urban design is becoming more important, particularly with the COVID-19 epidemic and public health awareness (Liu and Chen).

Energy Efficiency

IoT-enabled streetlights and energy management systems modify power use in real time. Dynamic energy management cuts expenses and urban carbon emissions. Porru et al. show how smart systems may save operating costs and promote sustainability.

Smart Public Transport

IoT data analysis optimizes public transport operations, ensuring safety, punctuality, and improved passenger experience.

Smart Parking

IoT sensors in parking lots identify occupancy, providing vehicles with real-time assistance to discover open spaces, decreasing congestion and search times.

Smart Traffic Management

By installing IoT sensors on traffic signals, roads, and cars, communities may collect information on traffic patterns, congestion, and accidents. This information helps to optimize traffic flow, reduce congestion, and improve road safety.

Figure 05

Applications of IoT in urban design
Picture's source: iStock/emma
https://ea-rlp.de/so-wird-die-wirkung-der-smart-city-messbar/

IoT technologies play a transformative role in urban design by facilitating real-time data collection, communication, and analysis. Their applications across public space monitoring, energy efficiency, waste management, and public health create opportunities for more sustainable and efficient urban environments. However, addressing challenges related to privacy, equity, and infrastructure is essential for realizing the full potential of IoT in creating smart, livable cities.

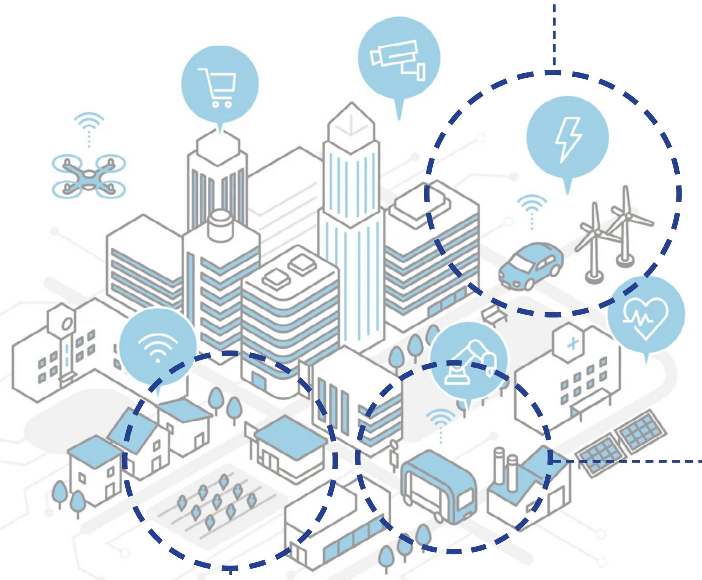
AI in Urban Design

AI plays an increasingly pivotal role in urban design, acting as a transformative tool for optimizing city functions and addressing complex urban challenges (Figure 06). Its integration into various urban planning processes enhances the efficiency and effectiveness of public services, promotes sustainability, and fosters community engagement.

Key Functions of AI in Urban Design

Data-Driven Insights: AI utilizes vast amounts of urban data to inform decision-making processes related to urban planning, resource allocation, and infrastructure management. The technology enables planners to extract actionable insights from data analytics, which is instrumental in enhancing the quality of urban life. Mashhood et al. noted that AI can significantly contribute to urban planning processes, utilizing historical data to predict and model urban growth and sustainability outcomes.

Predictive Modeling: One of the most significant applications of AI in urban design is its ability to create predictive models. Through machine learning algorithms, urban planners can simulate different scenarios regarding urban growth and new infrastructure projects. Yiğitcanlar et al. observe that AI can inform planning by forecasting the impacts of proposed developments on communities. By using such simulations, decision-makers can better understand potential challenges and opportunities, allowing for more informed planning practices.



Sustainability Analysis

AI tools assess the environmental impact of urban infrastructure and assist in designing sustainable solutions. AI analytics can effectively evaluate the ecological footprint of urban projects and help implement sustainable practices, such as designing green roofs and urban forests (Muzdalifah et al.). This shift towards sustainability is essential for creating resilient urban environments that can adapt to climate change.

Traffic Management

AI-powered systems are crucial for improving traffic flow and reducing congestion. Real-time analysis of traffic data allows for the optimization of public transportation routes and traffic light management, ultimately enhancing urban mobility. Automated traffic systems can adjust signal timings based on current conditions, reducing wait times and emissions (Becic).

Social Activities

AI facilitates community engagement by enhancing platforms that connect residents with urban development initiatives. By using data-driven interfaces, municipalities can foster communication and participation, allowing residents to express their preferences for urban designs, events, or services. This participatory approach ensures that community voices are heard and integrated into urban planning (Becic).

Figure 06

Applications of AI in urban design
Picture's source: iStock/emma
https://ea-rlp.de/so-wird-die-wirkung-der-smart-city-messbar/

The integration of AI in urban design carries immense potential for transforming cities into smarter, more inclusive, and sustainable environments. By optimizing urban functions through data-driven approaches, predictive modeling, and community engagement, AI provides urban planners with tools to tackle complex urban issues effectively. However, given the rapid advancement of AI technologies, constant evaluation of ethical implications and data governance is imperative (Wanume et al.). Ultimately, embracing AI in urban design can lead to enhanced quality of life, sustainable practices, and resilient urban landscapes.

The integration of AI and the IoT is revolutionizing urban design by providing powerful tools that enhance city management, resource allocation, and community engagement. This integration creates a framework for smarter, data-informed decision-making, allowing urban planners and managers to optimize urban environments more effectively. (Figure 07)

1. Collaborative Role of AI and IoT

At the core of the collaboration between AI and IoT is the ability of AI to process and analyze vast datasets collected by IoT devices. This synergistic relationship enhances the responsiveness of urban systems by creating feedback loops that facilitate continuous improvement. For instance, AI algorithms can analyze data from IoT sensors deployed in urban infrastructure to identify patterns and predict future conditions, enabling proactive management (Ma, Ying, et al.). This dynamic feedback process supports immediate decision-making and informs long-term urban strategies.

An exemplary application of this collaboration can be seen in smart irrigation systems utilized in urban parks. These systems integrate IoT soil sensors, which collect data on moisture levels, with AI algorithms that optimize water usage based on weather forecasts and current soil conditions. By employing IoT devices that monitor real-time data, the systems enable more efficient water management strategies, thus conserving resources and promoting sustainability (Bokhari et al.).

2. Focus on Human-Centric Design

The integration of AI and IoT allows for the design of more personalized urban experiences tailored to user needs. Smart technologies can gather user feedback and preferences, enabling cities to fine-tune services offered in public spaces. For example, AI-enhanced platforms can analyze data to improve safety in urban environments while ensuring compliance with privacy and ethical considerations (Knights et al.). These technologies empower communities by providing customized experiences, thereby enhancing satisfaction with urban public services.

One of the prominent applications is the design of public transportation systems, where integrated AI and IoT optimize routes and schedules based on real-time user data and traffic conditions. This adaptability increases ridership and improves overall accessibility for community members, including individuals with disabilities (Shkalenko and Nazarenko).

3. Urban Mobility and Accessibility

The fusion of AI and IoT technologies significantly impacts urban mobility and accessibility. Smart city initiatives harness these technologies to enhance public transport systems by optimizing routes and predicting maintenance needs. Data gathered from IoT devices on public transport can help cities make informed decisions that improve operational efficiency and passenger satisfaction (Lin, Yun-Wei, et al.).

Smart mobility solutions, such as dynamic traffic light systems, adjust in response to real-time traffic conditions collected through IoT devices, illustrating how AI can minimize congestion and improve the flow of urban traffic (Wang, Ke, et al.). In the realm of accessibility, AI can analyze patterns in mobility among different demographic groups, ensuring that transportation and urban infrastructure meet the needs of all citizens, thus promoting inclusivity (Kang et al.).

4. Challenges and Future Directions

Despite the promising advantages of integrating AI and IoT into urban design, several challenges remain. The complexity and interconnectedness of IoT systems introduce potential cybersecurity vulnerabilities that must be addressed to safeguard urban infrastructure (Sujata et al.). Additionally, ethical concerns surrounding data privacy, particularly with technologies like facial recognition, necessitate careful consideration to maintain public trust (Khan et al.).

Furthermore, while AI and IoT can enhance operational efficiency and citizen engagement, there is a risk of exacerbating social inequalities if marginalized communities do not receive equitable access to these smart technologies. Initiatives must prioritize inclusivity to avoid deepening existing divides in urban environments (Wang, Jingjing, et al.).

The integration of AI and IoT in urban design is a transformative movement that holds great promise for creating smarter, more responsive cities. By leveraging data-driven insights and enhancing community engagement, these technologies can significantly improve urban services, resource management, and overall quality of life for residents. Nevertheless, careful consideration of ethical implications, inclusivity, and security is essential for maximizing the benefits while minimizing potential drawbacks. Continued research and innovative applications of AI and IoT will be critical as urban areas evolve to meet the challenges of the future.

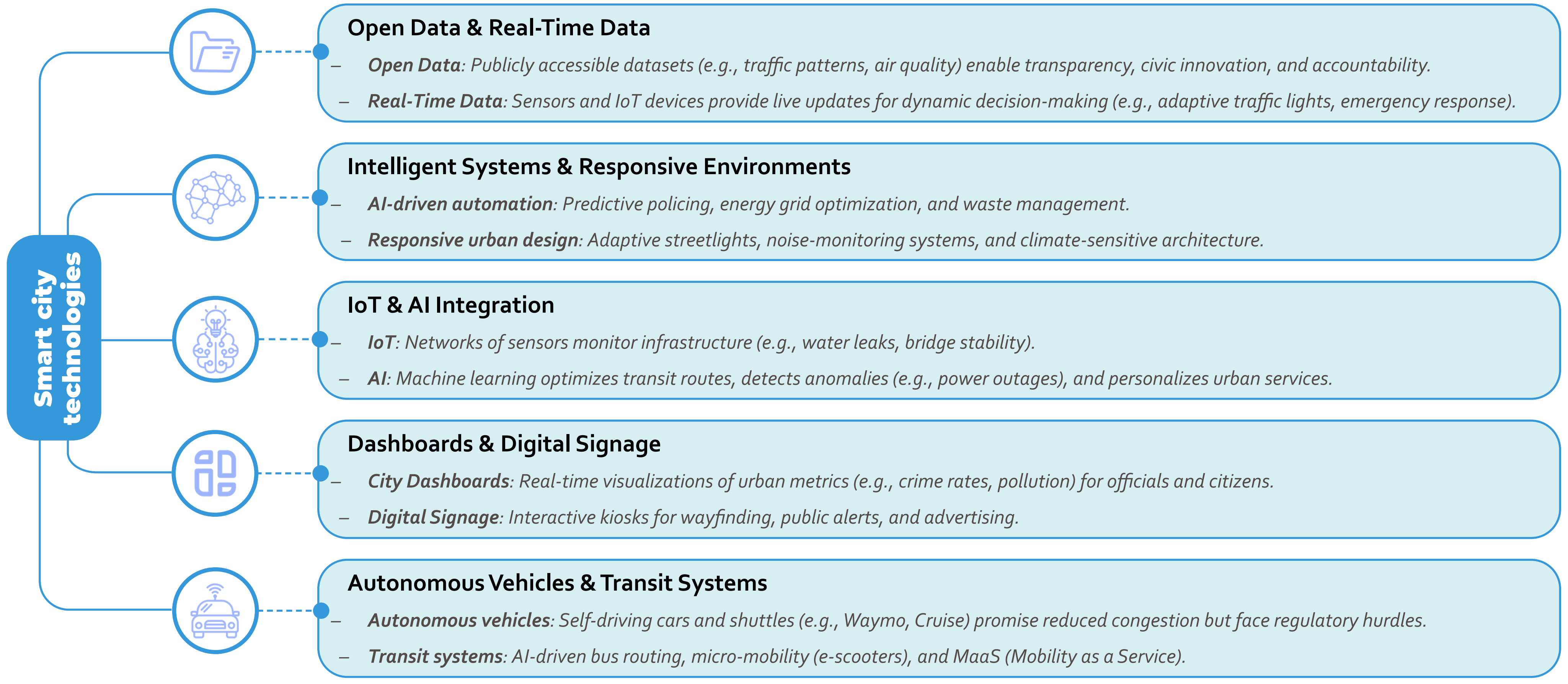


Figure 07

Smart city technologies and applications (Halegoua).
Diagram by author with retrieved icons from https://thenounproject.com/

Challenges of Smart City Technologies

Data Privacy: Big data collection and processing raise privacy concerns. Eckhoff et al. noted that smart cities' interconnected technical components make privacy management challenging because standalone privacy systems may fail. Protecting citizens' data requires integrated privacy solutions that consider system interactions.

High costs: Smaller communities with little funding may struggle to integrate smart technologies. Neupane et al. remark that smart city efforts offer many benefits, but their high initial and ongoing expenses may deter local governments. Metro areas may adopt smart technology differently due to this financial barrier.

Technical Adaptation: Urban planners and architects may struggle to integrate smart technologies into traditional practises. Li et al. remarked that urban planners' reluctance to adopt new technologies hinders collaboration and creativity Smart city solution deployment training and education to overcome acceptance barriers are growing.

Opportunities of Smart City Technologies

Community Empowerment: Smart city technology empowers citizens with participatory tools that increase trust and transparency. Involving community members in urban planning decisions boosts civic engagement. Sameer et al. say digital participatory planning technologies allow communities to voice their urban development needs and desires, boosting social cohesion and inclusivity.

Environmental Benefits: Energy savings and pollution reduction are environmental benefits of smart technology. Baltac said smart city initiatives may maximize resources, energy efficiency, and environmental management to increase sustainability. Smart traffic management reduces congestion and pollutants.

Social Equity: AI and IoT help underserved populations use metro services. Smart public transport systems optimise routes to ensure equal service delivery to all residents, encouraging social inclusion. Toli and Murtagh emphasize social issues in smart city frameworks to ensure community benefit from technological improvements.

2.2. Resilient landscape design principles

Resilience to Urbanization

Resilience to urbanization is a crucial consideration in resilient landscape design, particularly as cities face increasing pressures from rapid population growth, climate change, and associated environmental challenges. This research explores how resilient landscape design principles can mitigate urban pressures by creating flexible landscapes that adapt to changing land use demands while enhancing ecological and community resilience.

1. Mitigating Urban Pressures through Flexible Design

– **Adaptive Landscapes:** Designing landscapes that can accommodate evolving land use patterns is fundamental for resilience. According to Kwak et al., flexibility in urban design allows landscapes to adapt to changes in usage, demographics, and climate conditions. This is particularly important in urban environments where land is at a premium and the demands on land use fluctuate rapidly. By incorporating multifunctional elements such as parks, green roofs, and community gardens, urban areas can respond effectively to these pressures while maintaining ecological integrity.

– **Ecological Resilience:** Adaptive landscapes that respond to urban development can also enhance ecological resilience. Ginzarly et al. emphasize the critical need for integrating natural processes in urban planning, allowing for greater ecological function and biodiversity. By using native vegetation and creating multifunctional green spaces, urban planners can improve stormwater management, air quality, and habitat availability for various species, thus supporting urban ecosystems in the face of change.

2. Incorporating Features to Reduce Pollution and Enhance Quality

– **Green Infrastructure:** Implementing green infrastructure techniques in urban design can significantly reduce pollution while improving air and water quality. Eco-innovations such as bioswales, rain gardens, and permeable pavements absorb and filter stormwater as it permeates through the soil, reducing runoff and filtering pollutants before they enter waterways. These design features enhance the resilience of urban landscapes by mitigating flooding and improving water quality (Li, Yangfan, et al.).

– **Air Quality Improvement:** In addition to enhancing water management, resilient landscapes can incorporate vegetation that contributes to improved air quality. Trees and plants effectively sequester carbon dioxide and other pollutants, providing significant health benefits to urban populations. The design considerations for urban parks and greenways should prioritize plant species that maximize these benefits while maintaining aesthetic and recreational values.

3. Community Engagement and Social Resilience

– **Inclusive Spaces:** Resilient landscape design should also focus on creating inclusive spaces that facilitate community engagement and social interactions. Ginzarly et al. note that community involvement in the planning process fosters a sense of ownership and stewardship over public spaces, leading to increased social resilience. Such participatory approaches can improve the adaptability of urban landscapes by aligning design objectives with the needs and values of community residents.

– **Health and Well-Being:** The design of public spaces that encourage physical activity and social interaction is crucial to enhancing human well-being. Creating accessible recreational areas promotes physical health while simultaneously strengthening social bonds among community members. As illustrated in research by Li et al., green spaces can play a significant role in improving mental health and resilience, particularly in underserved populations.

In summary, resilient landscape design principles that emphasize resilience to urbanization are essential for creating sustainable urban environments that can adapt to change and improve community well-being. By incorporating flexible design strategies that mitigate urban pressures, utilizing green infrastructure, enhancing social connectivity, and promoting community engagement, cities can build landscapes that are not only functional but also resilient in the face of emerging urban challenges. Continued research and advocacy for these principles will be crucial as urban environments evolve to meet future demands.

Adaptability to Climate Change

Resilient landscape design principles are increasingly vital in the context of climate change, as they provide strategies for urban environments to withstand and adapt to climate-related challenges. Adaptability is crucial for ensuring that urban ecosystems remain functional and supportive to their communities despite the increasing frequency of extreme weather events. This research explores key climate-responsive strategies, applications to mitigate extreme weather, and the overarching significance of resilient landscape design.

Climate-Responsive Strategies

Drought-Tolerant Vegetation

Native and drought-resistant plants reduce water use, making urban landscaping sustainable. Water shortages need careful vegetation selection to ensure ecological balance and aesthetics (Janiszek and Krzysztofik).

Permeable Surfaces

Permeable pavements and surfaces in metropolitan areas reduce stormwater runoff and flooding. The designs help manage extra water after extreme precipitation (Cheng).

Green Infrastructure

Janiszek and Krzysztofik noted that green roofs, rain gardens, and bioswales improve climatic resilience in urban development. These elements provide habitat and mitigate urban heat islands while increasing community well-being through green space.

Design for Extreme Weather Events

Flood Mitigation

Bioswales and rain gardens capture and filter rainwater, reducing urban flooding. These solutions improve urban resilience, especially in flood-prone areas (Cheng). Innovative urban resilience techniques like green spaces that absorb surplus rainwater in Rotterdam (Esenarro et al.) demonstrate success.

Heat Island Reduction

Landscape design using urban woods and reflecting materials reduces urban heat islands. Greenery and heat-reflecting materials can lower urban temperatures, improving comfort and saving energy use (Li).

The role of green infrastructure in climate adaptation is supported by compelling research. For instance, Bologna and Hasanaj emphasize the need for systematic cataloging of design solutions that aid urban regeneration in the face of climate change. Furthermore, the importance of understanding the interplay between urban landscapes and changing environmental conditions to design resilient communities (La Rosa and Privitera). These studies collectively advocate for expanded green infrastructure as a strategy to minimize the adverse effects of climate change.

Adaptability to climate change through resilient landscape design is crucial in creating sustainable urban environments. By incorporating climate-responsive strategies and targeted design for extreme weather events, cities can enhance their resilience and capacity to support communities during environmental challenges. Ultimately, fostering collaboration, securing funding, and leveraging innovative design solutions will be essential for realizing the full potential of adaptable urban landscapes in the face of climate change.

2.2. Resilient landscape design principles

Ecological Functionality

Ecological functionality is a cornerstone of resilient landscape design principles, playing a vital role in ensuring that urban environments are sustainable and capable of adapting to climate change and biodiversity loss. This research explores key approaches to enhancing ecological functionality within urban landscapes, including the support for biodiversity, the restoration of degraded ecosystems, and the integration of green corridors connecting fragmented habitats.

Support for Biodiversity

Enhancing urban ecology requires designing native species habitats. Urban green areas may maintain biodiversity and provide ecosystem services if constructed properly, as Bennett and Lovell show. Development and urbanization fragment habitats, causing biodiversity loss in metropolitan areas. The use of native plants in landscaping promotes ecological balance by creating habitats for indigenous wildlife.

Aronson et al. also note that urbanization reduces species numbers in urban areas, which may house a range of species. To increase urban biological variety, urban design techniques should integrate native vegetation restoration and protection.

Restoration of Degraded Ecosystems

Restoring damaged ecosystems boosts urban resilience. Transformation of natural landscapes in cities can cause ecological deterioration. Previous research suggests that proactive restoration can improve ecological functioning and resilience (Ballare et al.). Wetland and riparian zone restoration can increase water quality, habitat connectivity, and ecosystem services.

Urban parks using ecological restoration methods can boost biodiversity and reduce urban heat, according to research. Cities may improve habitat quality and host more species that benefit urban ecosystems by enhancing ecological integrity (Ellis et al.).

Integration of Green Corridors

Urban habitat fragmentation can be addressed via green corridors. These corridors let wildlife travel between green spaces and improve urban ecology. Ballare et al. show that habitat network links boost species richness and urban ecological diversity.

By providing outdoor enjoyment and community participation, green corridors can improve public health. These linked networks provide ecological and social advantages, highlighting the link between urban green infrastructure and quality of life, according to Uchida et al.

Ecological functionality is critical to the principles of resilient landscape design. By supporting biodiversity, restoring degraded ecosystems, and integrating green corridors, urban areas can enhance their resilience to climate change while providing ecological, social, and health benefits. Although challenges exist, the successful adoption of these principles through stakeholder engagement, innovative design, and effective management can lead to more sustainable and vibrant urban environments that prioritize ecological integrity and represent a valuable resource for future generations.

Social and Community Resilience

Social and community resilience is an essential aspect of resilient landscape design, focusing on creating inclusive spaces that foster community engagement and social cohesion. As urban environments continue to evolve in response to climate change and growing populations, resilient landscape design principles have become critical for promoting human well-being and social connectivity.

Creating Inclusive Spaces

Resilient societies require inclusive public space design. Aktürk and Dastgerdi stress the need of community-building to enable locals to adapt to climate change. Landscape architects may improve social connections and community engagement by accommodating varied activities and user demographics. Accessible parks and plazas are used more by all ages and abilities.

Active engagement builds strong social networks, strengthening the community's resilience to crises.

Promoting Human Well-Being

Community health depends on accessible leisure. Liu and Zhu note that biophilic design—integrating nature into urban spaces—can reduce stress and improve physical and mental health. This strategy promotes green space pleasure, reducing urban stress.

Also important is designing green places to encourage relaxation and well-being. The Mao D., et al. article covers landscape ecology, not stress-reducing settings, however restorative landscapes are consistent with its findings. Mao D., et al. also describe how native plants, water features, and shaded seating places promote relaxation and well-being to support this assertion.

Integrating Green Corridors and Ecosystem Connectivity

Green lanes in urban areas allow wildlife and humans to circulate. This design philosophy protects biodiversity and ecological balance while allowing urban social activity. By offering walking, riding, and community gathering pathways, green corridors improve social connection, according to Xi and Wang. These corridors restore damaged ecosystems, boosting urban resilience.

Importantly, green lanes can improve urban ecology by linking fragmented ecosystems. Although not specifically about green corridors, Mao et al. highlight the link between ecological integrity and urban resilience.

Incorporating social and community resilience into resilient landscape design principles is vital for mitigating the impacts of climate change and fostering vibrant urban environments. By creating inclusive spaces, promoting well-being through accessible recreational areas, and integrating green corridors for ecological connectivity, urban areas can enhance their capacity to adapt to change while improving the quality of life for residents.

Future urban design efforts must prioritize community engagement and sustainability, ensuring a holistic approach that balances environmental needs with social inclusivity. By addressing the challenges associated with financial constraints, institutional barriers, and effective community engagement, cities can build resilient landscapes that cater to the needs of all their inhabitants.

2.2. Resilient landscape design principles

Multifunctionality

Multifunctionality is a critical principle in resilient landscape design, emphasizing the need to create landscapes that serve multiple purposes, such as recreation, stormwater management, carbon sequestration, and enhancing social cohesion. By balancing ecological, social, and economic functions, urban landscapes can meet diverse community needs while mitigating the impacts of climate change.

Designing Landscapes for Multiple Purposes

Recreation

Green spaces for recreation promote public health and well-being by providing leisure and community gathering spaces. Residents' physical and mental health improves with park and recreation access (Lohbeck et al.).

Stormwater Management

Bioswales, rain gardens, and permeable surfaces reduce runoff and flood threats. These design elements improve water quality and ecological health while improving landscape functionality (Sayer et al.).

Carbon Sequestration

Vegetation that sequesters carbon can help combat climate change in urban areas. Canopies, green roofs, and urban forests reduce greenhouse gas emissions and improve air quality (Sayer et al.).

Balancing Ecological, Social, and Economic Functions

Ecological Balance

Multifunctional landscapes must value biodiversity for ecological health. Planners may strengthen urban landscapes and maintain ecosystem services by supporting native species and rebuilding degraded ecosystems (Santos et al.).

Social Equity

Landscape design that considers social issues promotes public space access for all. Elizbarashvili et al. stress that different community voices in planning promote social cohesiveness and public space ownership. This participative approach helps alleviate recreational access disparities.

Economic Viability

Multifunctional landscapes increase property prices, attract tourism, and lower infrastructure maintenance costs. Implementing green infrastructure like urban parks can boost local economies by boosting business growth and creating maintenance and operation jobs (Botequilha-Leitão).

Incorporating multifunctionality into resilient landscape design principles is essential for creating sustainable urban environments that meet diverse community needs. By designing landscapes to serve multiple purposes and balancing ecological, social, and economic functions, cities can enhance resilience and improve quality of life for residents. While challenges in implementation exist, continued research and innovation in planning practices can help address these issues and provide valuable strategies for future urban development.

Connectivity

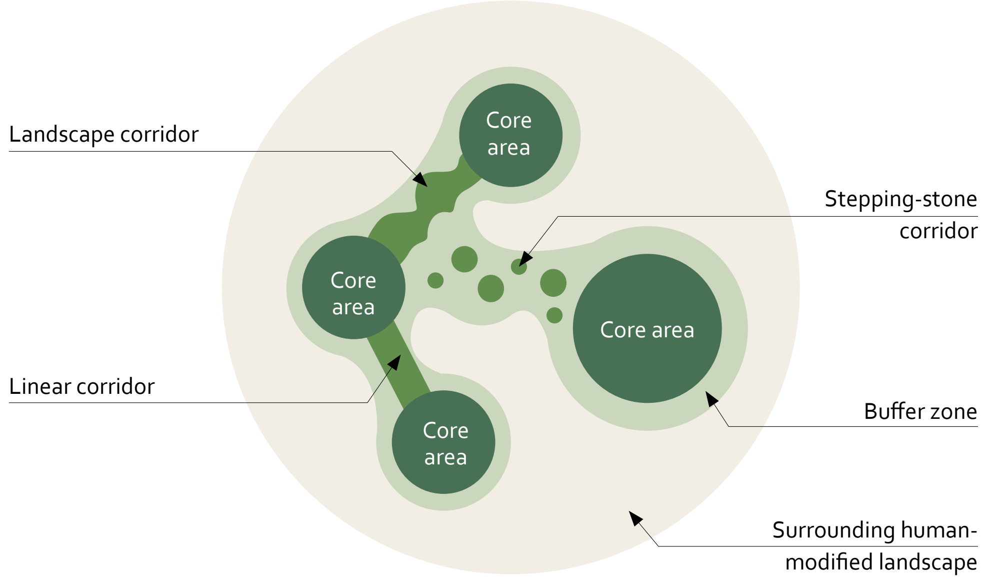


Figure 08

The Ecological corridor model (Carver, Steve)
Diagram re-drawn by author

Connectivity in landscape design is paramount for creating resilient ecosystems and promoting biodiversity in urban environments. By linking green spaces through ecological corridors (Figure 08) and networks, urban planners can foster both ecological integrity and social engagement, resulting in healthier communities. This research reviews key principles of connectivity, associated challenges, and provides insights on its importance in landscape design for resilience.

Linking Green Spaces through Ecological Corridors

Wildlife mobility and connectivity across fragmented landscapes require ecological corridors. McGuire et al. note that climatic connection can improve biodiversity conservation in urban and rural areas by helping species adapt to changing environments. Ecological corridors provide wildlife paths and green spaces for pleasure and interaction.

Urban planning with green networks improves landscape functionality. Cities may provide citizens with green spaces and promote biological processes by developing parks, gardens, and natural areas (Riggio and Caro). Riggio and Caro's Tanzanian wildlife corridor study supports green networks, which can promote wildlife connection in urban areas and reduce habitat fragmentation.

Mobility and Access for Pedestrians, Cyclists, and Wildlife

Mobility and access for users are crucial to resilient landscape design connectivity. Design must incorporate pedestrian, cyclist, and wildlife needs to create areas that encourage diverse mobility.

Urban designers can add walking and cycling trails to green corridors to make non-motorized transportation safe and accessible. Reduces urban infrastructure stress and improves public health. Beier and Noss state that wildlife corridors maintain landscape connectedness and improve species interactions, however designing wildlife crossings is difficult.

Maintaining urban ecological health requires integrating infrastructure like wildlife crossings, which allow animals to safely cross human-made boundaries. Sawyer et al. examine how conceptual models might reflect animal usage of fragmented environments, emphasizing the importance of these crossings.

Sustaining Biodiversity through Connectivity

Connecting habitats separated by urban development increases biodiversity. According to McGuire et al., Beier and Noss, a connected landscape promotes genetic diversity and ecosystem resilience, especially in light of climate change. This connection is essential because species must migrate to suitable environments.

Integrated design concepts help restore damaged habitats, as shown by studies on corridors and biodiversity in infrastructure projects (LaPoint et al.). Multifunctional landscape design allows humans and wildlife to coexist.

Connectivity is an essential principle of resilient landscape design that enhances ecological functionality and promotes human well-being. By linking green spaces through ecological corridors and ensuring mobility for all users, urban planners can create towns that are more sustainable and robust against climate change. Despite the existing challenges, fostering collaboration among stakeholders and investing in community engagement will help harness the full potential of connectivity in achieving resilient urban systems.

2.2. Resilient landscape design principles

Sustainability and Resource Efficiency

Sustainability and resource efficiency are key principles in resilient landscape design that focus on creating urban environments that minimize ecological impact while maximizing benefits for communities. This research highlights the importance of using sustainable materials and prioritizing renewable energy sources, along with optimizing water usage through innovative systems, as essential components of resilient urban landscapes.

Using Sustainable Materials and Renewable Energy Sources

Choosing sustainable landscaping materials is essential for environmental responsibility. Beatley and Newman say sustainable materials cut resource usage and preserve landscapes. Using locally sourced resources reduces transportation emissions and boosts local economies, promoting sustainability.

In addition to materials, renewable energy sources are essential for urban landscape energy efficiency. Solar panels in park structures or landscape elements can power lights, irrigation, and other facilities, reducing dependence on fossil fuels. The citation (Mborah et al.) focuses on post-mining land-use rather than renewable energy in urban environments, hence it does not support this assertion.

Optimizing Water Usage

Resilient landscape design requires efficient water management, especially in drought-prone cities. Innovative methods like rainwater collecting and greywater reuse can greatly cut potable water consumption. Al-Mefleh et al. found that using treated greywater for irrigation can reduce demand on local water resources and maintain urban landscape health.

Implementing drip irrigation or moisture sensor technology can optimize water usage by feeding plants the right amount of water depending on real-time needs. This keeps landscapes lush and conserves water. However, focuses more on indoor water use assessment than landscape irrigation optimization, making it less applicable (Pannkuk and Wolfskill).

Maximum system efficiency and public commitment to resource efficiency require community awareness and education on sustainable water practices.

Challenges to Implementing Sustainability and Resource Efficiency

While the adoption of sustainable practices in landscape design offers numerous advantages, several challenges persist:

– **Cost Barriers:** Municipalities and private developers may struggle to afford sustainable technologies and materials. This is especially true compared to standard practises with lesser upfront expenditures (Sekban and Acar).

– **Public Perception and Engagement:** Community buy-in for sustainable programs sometimes involves extensive education and outreach. Educating residents about sustainable practices can boost involvement and support (Markidis).

– **Technical Expertise:** Integrating modern water management or energy efficiency solutions demands expertise. Technical knowledge and experience are essential for implementation and maintenance (Cai).

Benefits Beyond Sustainability

Implementing sustainability and resource efficiency principles in resilient landscape design provides various benefits beyond ecological preservation:

– **Enhanced Community Welfare:** Urban landscapes can promote citizens' mental and physical health by supporting accessible recreational places and green infrastructure. Byrne et al. found that nature reduces stress and improves quality of life.

– **Increased Resilience:** Sustainable landscapes provide ecosystem services including air purification, heat mitigation, and stormwater management, increasing urban resilience. These services grow more vital as cities adjust to climate change and address environmental challenges (Yan et al.).

Sustainability and resource efficiency are fundamental principles in resilient landscape design, offering a pathway toward urban environments that are ecologically sound, socially inclusive, and economically viable. By using sustainable materials, prioritizing renewable energy, and optimizing water usage through innovative management practices, urban planners can create vibrant landscapes that enhance community resilience. Despite the challenges that may arise in implementing these principles, the long-term benefits of sustainable landscape design are significant, contributing to a more sustainable future for urban areas.

This research highlights the necessity of landscape design strategies that adapt to various environmental conditions while ensuring ecological restoration. Appropriate increases in green infrastructure can efficiently reduce the risk of non-point source pollution to water bodies and offer critical ecosystem services. The practical application of sustainable water use in landscape design education can introduce future professionals to the significance of resource-efficient practices. Understanding the implications of greywater use in the design of resilient landscapes is crucial for ensuring sustainability.

Photo's source:
https://www.tempelhoferfeld.de/en/discoveries-experiences/civic-engagement-projects/community-garden-allmende-kontor/

2.3. Human-Centered Design and Social well-being

Human-Centered Design

HCD is a framework that prioritizes the needs, preferences, and experiences of people in the design process. This approach is essential for landscape architecture, particularly in enhancing social and ecological resilience in urban environments. By focusing on empathy, inclusivity, iteration, collaboration, and sustainability, HCD principles can lead to the creation of more functional, accessible, and enjoyable public spaces. This research explores the key principles of HCD, its applications in landscape architecture, and relevant case studies to illustrate its impact.

Key Principles of HCD

Empathy: Effective design requires empathy for people's needs, feelings, and behaviors. User interviews, ethnographic investigations, and participatory workshops help designers understand the context in which design occurs. Binnington and Russo stress that landscape architects should make decisions based on empathy to create community-serving settings.

Inclusivity: HCD must serve underrepresented and underserved communities. Integrating accessibility and cultural awareness ensures that public spaces are inclusive. Universal design principles, which accommodate different age groups and skills, are essential for inclusive landscapes (Kempenaar).

Iteration: Prototyping, testing, and refining designs with feedback helps create responsive and adaptive solutions. Landscape designers can improve design results and user happiness by iterating based on community feedback and observational data.

Collaboration: Involving consumers, community members, and experts in the design process creates ownership and accountability. Collective methods can produce new, community-focused design solutions (Kempenaar).

Sustainability: HCD designs aim to reconcile human demands with environmental and social responsibilities. Designers should consider the long-term effects of their work on the environment and community (Tzortzi et al.).

Applications in Landscape Architecture

Photo's source: https://why-site.com/in-praise-of-crowds/

Photo's source: https://www.dpem.com/blog/insights/trends-in-digital-placemaking-and-building-brand-community-online

Photo's source: https://www.re-thinkingthefuture.com/designing-for-typologies/a11274-designing-accessible-and-inclusive-landscapes-for-children-of-diverse-abilities/

Interactive Public Spaces

Designing parks and plazas as interactive spaces fosters community engagement and cultural activities. By incorporating features such as art installations, performances, and collaborative gathering areas, landscapes can strengthen social ties and encourage diverse forms of community interaction.

Engagement Platforms

The use of digital tools, such as apps and AR, enhances user participation in the planning and utilization of urban landscapes. These technologies facilitate communication between stakeholders, allowing communities to express their needs and preferences easily.

Inclusive Design

Creating landscapes that are accessible to all ages and abilities is essential in promoting equity in public spaces. Strategies such as ensuring barrier-free access and designing sensory gardens that cater to various user experiences enhance physical and psychological engagement with the environment (Kurjenoja et al.).

Research Examples and Implications

Several studies illustrate the impact of HCD principles in landscape architecture. For example, research on participatory design highlights how involving indigenous cultures in the planning process fosters landscape identity and enhances community connections (Marques et al.). By using participatory approaches and responsiveness to local needs, designers can create more resilient and meaningful urban environments.

Moreover, the implementation of climate-resilient designs in conjunction with HCD principles can lead to more sustainable urban landscapes. Emphasizing community involvement ensures that ecological considerations align with social values, enhancing both ecological and social resilience (Tzortzi et al.).

In summary, HCD offers a powerful framework for creating resilient landscapes that prioritize the community's needs and well-being. By fostering empathy, inclusivity, and collaboration while incorporating sustainable principles, landscape architects can develop public spaces that enhance social cohesion, environmental stewardship, and quality of life. The continued integration of HCD principles in landscape architecture will be critical as urban environments face increasing challenges from climate change and population growth.

2.3. Human-Centered Design and Social well-being

Social Well-Being

Social well-being encompasses various aspects of community life, including social interaction, mental health, physical activity, community identity, and resilience. Integrating social well-being considerations into urban design is crucial for fostering vibrant, inclusive communities that enhance the quality of life for residents. This research explores key components of social well-being in urban design, emphasizing the importance of accessible spaces, nature integration, and active community engagement.

Key Components of Social Well-Being

Social Interaction

Parks, public squares, and community centers foster communal bonds. Socially engaged urban places improve community cohesion and quality of life. Flexible areas for group activities, events, and leisure can promote community relations (Carlson et al.). Flexible and adaptable public spaces can foster spontaneous social interactions and structured events, boosting community life.

Mental Health and Stress Reduction

Integrating nature into urban spaces reduces stress and improves mental health. According to Zhu et al. and other studies, green environments promote mood and cognitive development. Parks, green roofs, and gardens connect residents to nature, decreasing stress and improving mental health.

Physical Activity

Walkable neighbourhoods, bike routes, and recreational facilities promote physical activity and health. Murillo et al. found that neighborhood walkability increases resident physical activity. To promote healthy lives, urban planners must prioritize active transportation infrastructure, especially in areas without recreational facilities.

Community Identity and Belonging

Urban settings that represent local history, culture, and values generate community pride and connectedness. Culturally responsive design can strengthen community identity and encourage public space maintenance (Adams et al.). Urban design that emphasizes local tradition fosters a sense of belonging, which is essential for social cohesion.

Resilience and Safety

Social vulnerabilities must be addressed in safe, inclusive, and adaptive contexts to build community resilience. Well-lit paths and monitoring systems give inhabitants a sense of security, encouraging them to use public spaces. According to King et al., walkable and safe neighborhoods boost residents' trust in their surroundings.

Research Examples and Applications

Various studies highlight the impact of urban design on social well-being. For example, Yen and Li explore the changes in residents' physical activities and social interactions after moving to a walkable community, illustrating the profound effect of well-designed urban environments on communal health. Similarly, research by Carlson et al. shows that perceived neighborhood walkability is positively associated with physical activity levels, reinforcing the importance of accessible urban design.

Challenges in Promoting Social Well-Being

Economic Barriers

Municipalities may lack funds to create inclusive and accessible public areas. Infrastructure demands sometimes take precedence over community investment in budgets (Tao et al.). Strategic planning is needed to match community objectives with funds.

Community Engagement

Promoting social well-being requires varied community voices in design. Insufficient public participation can result in underutilized spaces and lower community satisfaction (Van Holle et al.).

Interdisciplinary Approaches

Integrating urban design knowledge to improve social well-being may be difficult. Urban planners, social scientists, and community organizations must work together to find holistic, community-focused solutions (Sallis et al.).

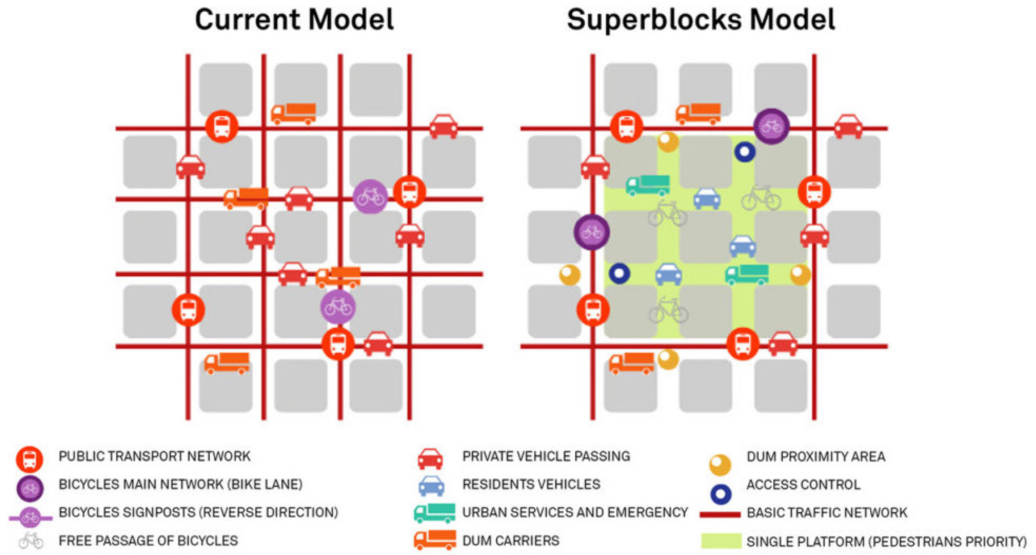
2.4. Case Study

Barcelona's Superblocks, Barcelona, Spain

Barcelona's Superblocks initiative is a pioneering urban redesign strategy that uses IoT and smart city technologies to reclaim streets from cars, reduce pollution, and enhance public space usability. The project transforms clusters of city blocks into pedestrian-priority zones, integrating IoT for real-time monitoring and adaptive management.

Key IoT Applications

	Deployed	Purpose	Outcome
Environmental Sensing	Air quality (NO_2, $PM_{2.5}$), noise, and temperature sensors.	Monitor pollution and microclimate changes after traffic reduction.	25% drop in NO_2 levels in Superblock zones (Barcelona City Council)
Smart Mobility	Vehicle counters with RFID tags to enforce traffic restrictions. Dynamic LED signage redirecting cars in real time.	Prioritize pedestrians/cyclists while allowing limited local vehicle access.	58% reduction in traffic volume (Rueda et al.)
Adaptive Public Spaces	Smart benches with solar-powered Wi-Fi/USB charging. Irrigation systems using soil moisture sensors in green zones.	Enhance usability and sustainability of reclaimed spaces.	40% increase in time spent outdoors by residents (Barcelona Urban Lab)
Participatory Data Platforms	"Sentilo" IoT platform aggregating sensor data for public dashboards. Citizen reporting apps for maintenance requests (e.g., broken benches).	Foster transparency and community engagement.	30% faster response to infrastructure issues (Ajuntament de Barcelona)



Superblocks Model
Picture's source: Ajuntament de Barcelona

Barcelona Superblock : Blueprint for the Green City of the Future?
Picture's source: https://www.theoverview.art/superblocks-barcelona-blueprint-for-the-livable-city-of-the-future/

Lessons for TF

Prove Impact with Data: *Barcelona's sensors provided measurable evidence of pollution/traffic reductions – critical for public and political buy-in.*

Modular IoT Systems: *Start small (e.g., air quality sensors) before scaling to complex integrations (e.g., adaptive lighting).*

Design for Equity: *Ensure IoT tools serve all demographics (e.g., non-smartphone users can access data via kiosks).*

2.4. Case Study

Singapore's Smart Green Networks

Singapore's Smart Nation Initiative aims to leverage technology, including AI and IoT, to improve urban living, sustainability, and resilience. A key component of this initiative is the development of smart green networks, which integrate digital technologies into parks, gardens, and green corridors to enhance their functionality, accessibility, and ecological value.

Key Features of Singapore's Smart Green Networks

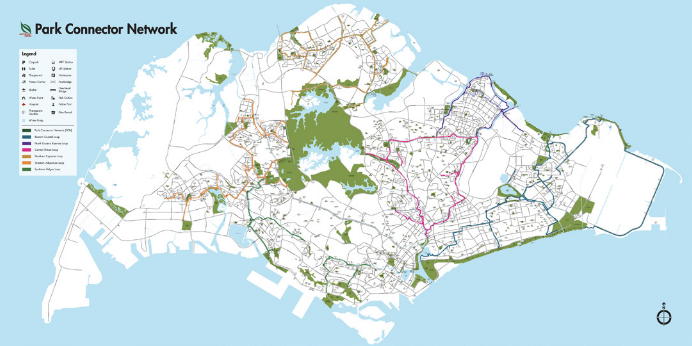
1. **Smart Parks and Gardens:** **Bishan-Ang Mo Kio Park** is a flagship project that combines green infrastructure with smart technologies.

– The park features ***IoT sensors*** to monitor environmental conditions such as air quality, temperature, and humidity.
– ***Smart irrigation systems*** use real-time data to optimize water usage, ensuring efficient resource management.
– Interactive elements, such as ***AR displays and mobile apps***, provide visitors with educational content about the park's biodiversity and history.

Bishan Park
Source: https://www.dreiseitlconsulting.com/bishan-ang-mo-kio-park

2. **Green Corridors and Connectivity:** **The Park Connector Network (PCN)** is a series of green corridors that link parks, nature reserves, and urban areas across Singapore.

– The PCN is equipped with ***smart lighting systems*** that adjust brightness based on time of day and foot traffic, reducing energy consumption.
– ***Fitness stations*** and ***cycling paths*** along the corridors encourage physical activity and social interaction.
– ***Real-time data dashboards*** provide information on trail conditions, weather, and user density, enhancing the visitor experience.



The Park Connector Network
Source: https://pcn.nparks.gov.sg/the-pcn-experience/pcnloops/

3. **Biodiversity and Ecological Resilience:** The **Southern Ridges**, a 10-kilometer green network, integrates smart technologies to support biodiversity and ecological resilience.

– ***AI-powered cameras and acoustic sensors*** monitor wildlife activity, helping conservationists track species populations and habitat health.
– ***Smart waste bins*** with compaction technology reduce litter and improve waste management efficiency.
– ***Educational kiosks and QR codes*** provide visitors with information about local flora and fauna, fostering environmental awareness.

The Southern Ridges
Source: https://honeykidsasia.com/pram-friendly-walks-singapore-southern-ridges/

4. **Community Engagement and Inclusivity:** **The Jurong Lake Gardens** incorporate smart technologies to engage diverse user groups.
– ***Interactive play areas*** for children use sensors and AR to create immersive learning experiences.
– ***Accessible pathways and smart benches*** with charging stations cater to elderly visitors and people with disabilities.
– ***Community gardening plots*** equipped with IoT sensors allow residents to monitor soil conditions and plant health, promoting urban agriculture and community stewardship.

The grasslands of Jurong Lake Gardens
Source: https://henninglarsen.com/projects/jurong-lake-gardens

5. **Climate Resilience and Sustainability:** The **Marina Barrage** is a multifunctional green space that combines flood control, water storage, and recreational activities.
– ***IoT sensors*** monitor water levels and quality, enabling real-time flood management and water resource optimization.
– ***Solar panels and green roofs*** reduce the site's carbon footprint and enhance energy efficiency.
– The space is designed to adapt to rising sea levels and extreme weather events, demonstrating the integration of climate resilience into urban green networks.

The Marina Darrage
Source: https://www.channelnewsasia.com/commentary/singapore-water-marina-barrage-lee-kuan-yew-challenge-visitors-917841

Lessons for TF

Technology as an Enabler	Biodiversity and Ecological Health	Community Engagement	Climate Resilience	Data-Driven Decision-Making
Use IoT and AI to enhance the functionality and accessibility of green spaces without compromising their natural character. Implement smart systems for resource management (e.g., water, energy) to improve sustainability.	Integrate smart technologies to monitor and support local ecosystems, ensuring that green networks contribute to biodiversity conservation.	Design interactive and inclusive spaces that cater to diverse user groups, fostering a sense of ownership and stewardship among local communities.	Incorporate adaptive design features that address climate risks, such as flooding and heatwaves, while maintaining the recreational and ecological value of green spaces.	Use real-time data to optimize maintenance, improve user experiences, and inform future design iterations.

03

Harmonics of Progress
A Symphony of Ideas

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"The ***heart*** *may be*

strong,

but

the ***brain*** *is*

wise."

- Unknown

The Role of IoT in Landscape Design

IoT connects various sensors and devices within urban landscapes, facilitating the collection of real-time data and allowing for seamless communication between urban infrastructure and stakeholders (Figure 09). By implementing IoT solutions, landscape architects and urban planners can gain valuable insights into environmental conditions, usage patterns, and community preferences, ultimately leading to more data-informed decision-making (Kang et al.).

Applications of IoT in Landscape Design

Public Spaces Monitoring

IoT sensors can be strategically installed in parks, plazas, and public spaces to measure foot traffic, air quality, and noise levels. This information allows urban planners to assess the usability of these areas and identify opportunities for improvement (Rashid et al.). For instance, cities can adjust maintenance schedules, enhance safety measures, and develop programs that cater to community needs based on real-time data.

Energy Efficiency

IoT applications include smart lighting systems equipped with sensors that adjust illumination based on occupancy and environmental conditions. This reduces energy consumption and operational costs while enhancing user comfort. Deploying IoT technology in landscape design thus not only promotes energy efficiency but also aligns with sustainability goals (Zhou and Liu).

Waste Management

The integration of IoT in waste management systems, such as smart bins that monitor fill levels, can streamline collection routes and optimize resources. This innovation reduces operational costs and ensures more efficient waste management processes, enhancing the sustainability of urban environments (Javed et al.).

Well-Being Metrics

Wearable devices and environmental sensors can gather data related to public health, allowing city planners and landscape designers to implement informed interventions that promote mental and physical well-being among residents (Mashal and Alsaryrah). By considering community health data, urban spaces can be tailored to foster healthier lifestyles and encourage community engagement (Olorunsogo).

Research Example

A good example of IoT in landscape design is smart irrigation systems. These devices optimize water utilization using real-time data from IoT soil sensors and AI algorithms. Successful adoption of such systems shows how IoT may improve water management and environmental sustainability. These data-driven models help planners adapt quickly to changing conditions, creating resilient landscapes (Kang et al.).

Sensor networks monitor water flow in bioswales and soil moisture levels in green infrastructure projects to optimize green space performance. Real-time monitoring improves the landscape's ecological function and reassures populations of its health and sustainability (Adam et al.).

The integration of IoT in landscape design offers significant opportunities for enhancing urban functionality, sustainability, and community well-being. By leveraging real-time data collection and analysis, urban planners can create responsive landscapes that adapt to changing needs and challenges. However, addressing challenges related to data privacy, interoperability, and funding is crucial for the successful implementation of IoT technologies in urban environments. As cities continue to evolve, ongoing research into best practices and innovative applications of IoT will be essential for fostering resilient landscapes that serve both ecological and social functions.

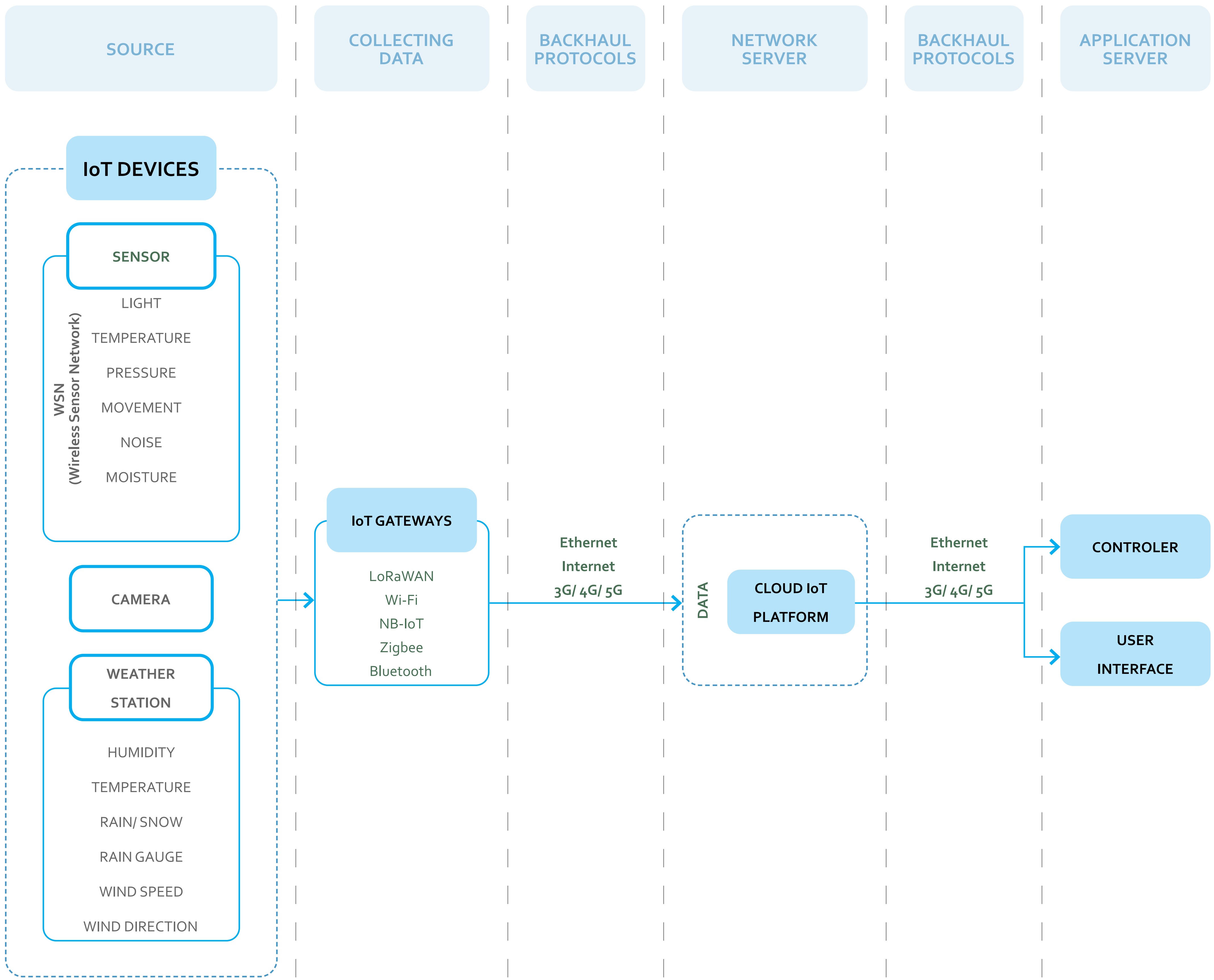

Figure 09

Common IoT Data Flow Architecture Framework
Diagram re-drawn by author, adapted from https://www.iiconsortium.org/IIRA/

The Role of AI in Public Space Design

AI is critical in controlling and improving urban landscapes through real-time data analysis and predictive modeling (Figure 10). Wirtz et al. observe that AI may improve comprehension in a variety of public sector applications, adding enormous value and enhancing functioning in urban settings. This technology enables architects and city planners to create more responsive public areas that adapt to the changing demands of city residents.

Applications of AI in Public Space Design

Interactive Public Spaces

AI technology can help to create interactive public places that respond to user demands. For example, AI-powered platforms may evaluate pedestrian movement and preferences, allowing urban planners to adjust space allocation accordingly. This data-driven strategy encourages community involvement and guarantees that public areas fulfill many purposes, ranging from social contact to leisure activities.

Environmental Monitoring

Combining AI with IoT sensors in public settings allows for continuous monitoring of environmental factors such as air quality, noise levels, and temperature. Public parks connected with environmental sensors may provide real-time data to properly manage the space, improving visitor experiences while addressing public health problems.

Traffic and Mobility Optimization

AI can evaluate traffic patterns and public transit data to optimize routes and increase accessibility in cities. Cities can estimate peak usage periods and make data-driven decisions to improve mobility for all citizens, including those with impairments.

HCD and Community Engagement

AI's application in public space design aligns closely with the principles of HCD. By utilizing AI-driven engagement platforms, designers can foster community participation in the planning process. Residents can share preferences and feedback through digital tools, enabling designers to understand the specific needs and aspirations of communities. This participatory approach enhances social equity and promotes a sense of ownership among citizens.

Examples of AI Integration in Public Space Design

Smart Irrigation Systems

One practical application of AI in landscape design is the development of smart irrigation systems. These systems use IoT soil moisture sensors combined with AI algorithms to optimize water usage based on current weather forecasts and soil conditions, thus ensuring efficient resource utilization and sustainable landscape management.

AR Platforms

Implementing AR platforms allows for real-time visualization of proposed changes to public spaces, facilitating informed community input during design processes. By interacting with proposed designs in an immersive way, community members can better understand and engage with the planning process.

The integration of AI applications in public space design has the potential to reshape urban landscapes, making them more adaptive, responsive, and inclusive. By utilizing real-time data analysis and fostering community engagement, designers can create spaces that enhance quality of life and reflect the needs of diverse populations. Despite challenges related to privacy, equity, and technical literacy, the pathway towards incorporating AI in public space design is promising, leading to innovative solutions that contribute positively to urban environments.

As cities evolve in response to changing demographics, environmental pressures, and technological advancements, continued exploration of the intersections between AI, public space design, and community engagement will be critical for ensuring vibrant, resilient urban futures.

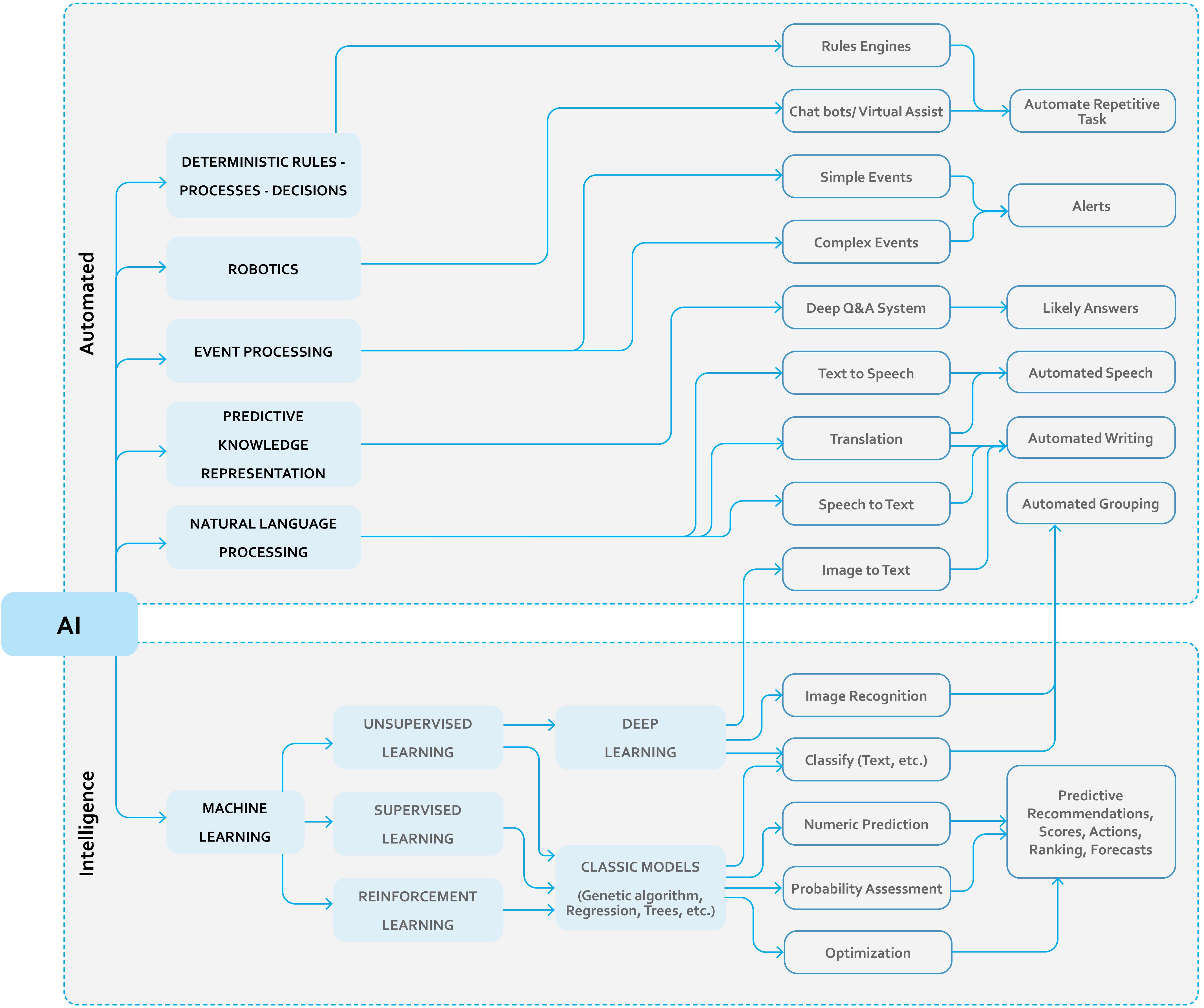

Figure 10

Type of Classification Algorithms in AI
Diagram re-drawn by author, adapted from https://www.ibm.com/think/topics/artificial-intelligence

3.1. Technologies enhancing social activities

Relationship of IoT and AI

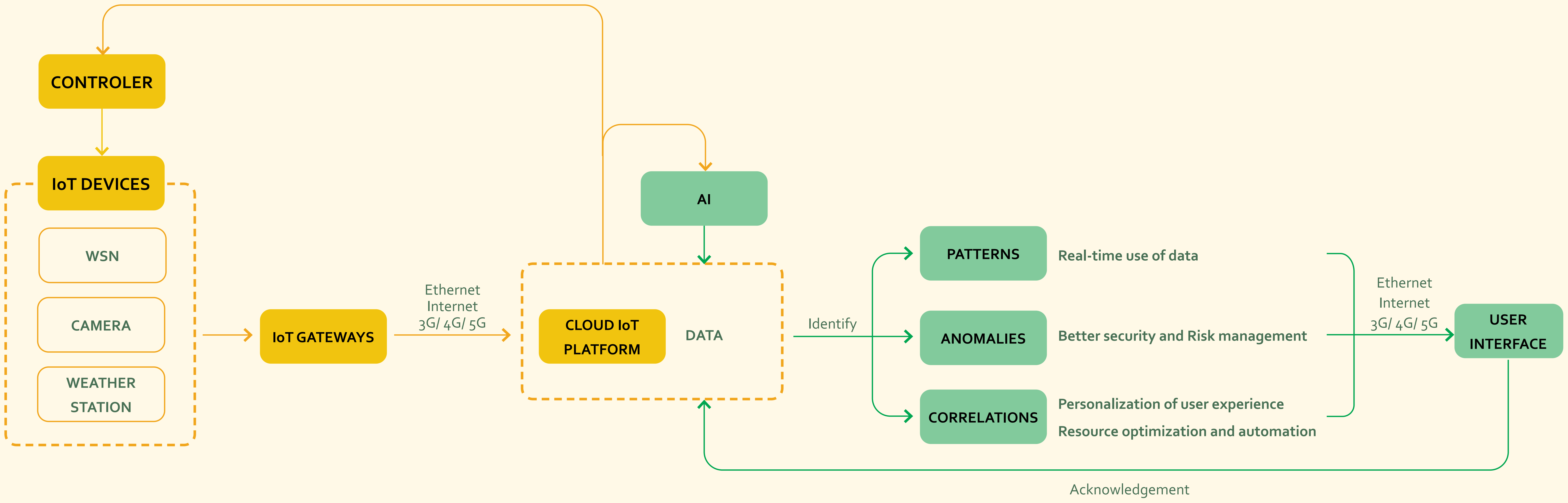

Figure 11

Relationship of IoT and AI
Diagram re-drawn by author, adapted from https://www.ibm.com/think/topics/artificial-intelligence

Challenges in Implementation IoT

IoT in landscape design has several benefits, but implementation is difficult:

– ***Data Privacy and Security:*** Privacy and security of data IoT applications capture a lot of data, raising privacy and security concerns. Ethical data management practices are crucial for maintaining public trust and support for IoT efforts (Turkmanović et al.).

– ***Interoperability Issues:*** The diversity of IoT devices and systems may make interoperability problematic, making it hard for systems to communicate. Standardised protocols and frameworks are needed to improve device compatibility (Feng et al.).

– ***Funding and Resources:*** IoT technology installation can be expensive, limiting access for smaller governments or communities with limited budgets. Funding and cooperation with private companies can help underserved areas acquire IoT technologies (Blanco-Novoa et al.).

Challenges and Considerations AI

AI in public space design has many benefits but also limitations. Key concerns include:

– ***Data Privacy and Security:*** AI requires massive data collecting, making user privacy and security crucial. Concerns about monitoring and data misuse can slow AI adoption.

– ***Equitable Access:*** AI technology may not benefit all communities equally. Promoting social fairness requires providing AI-enhanced public services to all citizens, especially marginalized groups.

– ***Technical Literacy:*** AI platforms require digital literacy to engage communities. Training and education are necessary for all inhabitants to engage meaningfully in design.

The integration of IoT and AI in urban and landscape design **enhances sustainability, efficiency, and livability.** IoT sensors collect real-time data on environmental conditions (air quality, noise, temperature), traffic flow, and water usage, while AI processes this data to optimize designs (Figure 11). For example:

– ***Smart Cities:*** AI analyzes IoT data to improve traffic management (adaptive traffic lights), energy-efficient street lighting, and waste collection routes.

– ***Landscape Design:*** IoT monitors soil moisture and plant health, while AI suggests optimal irrigation schedules or adaptive green spaces based on climate trends.

– ***Urban Planning:*** AI simulates population growth and infrastructure needs using IoT-collected data, enabling dynamic zoning and resilient designs.

Together, they enable **data-driven, responsive environments** that **balance ecological health** and **human needs.**

(Smart City initiatives (e.g., Barcelona, Singapore), IEEE IoT Journal, and AI in urban resilience studies.)

3.2. Resilient landscape design theories

The evolution of resilient landscape design theories is crucial for addressing the increasingly complex challenges posed by rapid urbanization, climate change, and the need for sustainable development. By integrating ecological principles with innovative design strategies, landscape architecture can effectively contribute to creating urban environments that are resilient, adaptable, and supportive of biodiversity. The following sections detail key theories, principles, and applications of resilient landscape design.

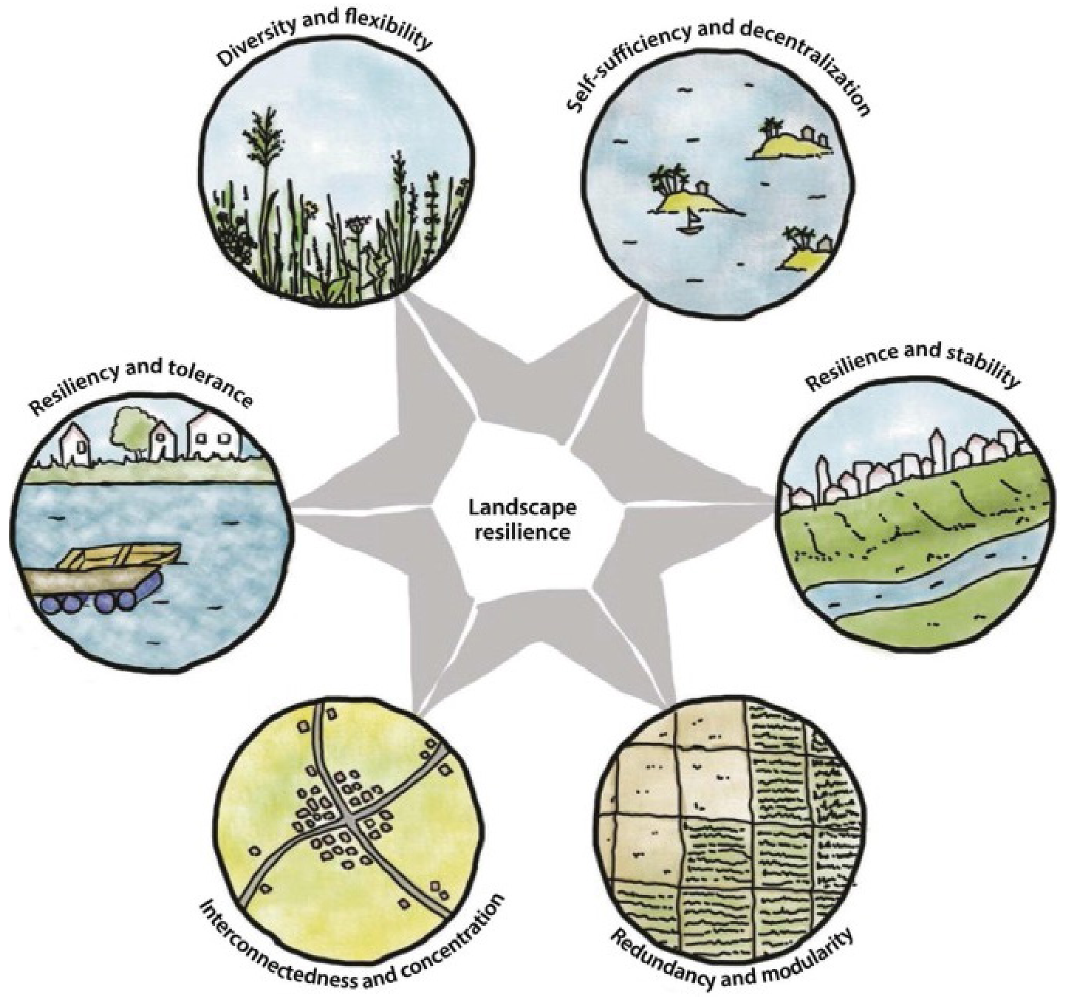

Figure 12

Factors Influencing Landscape Resilience (Schmidt)

Key Theories in Resilient Landscape Design

Ecological Resilience Theory

This theory emphasizes the ability of landscape systems to absorb disturbances while maintaining their fundamental functions. As highlighted by Mitrović et al., landscapes that are designed with ecological resilience in mind can recover from environmental stresses, promoting biodiversity and ecosystem function. Understanding these dynamics is vital for urban planning, as resilient landscapes can support both human activities and wildlife habitats.

Landscape Connectivity

Connectivity is a fundamental concept in land use planning, focusing on how different habitats are linked to facilitate species movement and genetic exchange. Tambosi et al. advocate for maintaining and enhancing landscape connectivity to ensure ecological resilience. This involves designing features such as corridors and stepping stones that connect habitats in urban areas, thus allowing wildlife access and preserving biodiversity.

The integration of resilient landscape design theories into urban planning offers significant potential for creating sustainable, adaptable environments that support ecological integrity and human well-being. By prioritizing ecological resilience, connectivity, and community engagement, landscape architects can design urban areas that effectively respond to challenges posed by urbanization and climate change. Continued research into innovative practices and collaborative frameworks will be essential for advancing the principles of resilient landscape design and fostering truly sustainable urban environments.

3.3. Existing research on TF and Berlin's green network

TF, a unique urban park situated on a former airport site in Berlin, exemplifies the city's commitment to integrating green spaces into its urban framework. This research examines how TF serves as a central element of Berlin's green network, showcasing its ecological, social, and community significance. Recent studies have highlighted its multifaceted role and the broader implications for urban green infrastructure.

Ecological and Environmental Functions

TF contributes significantly to urban biodiversity and environmental health. Rost et al. discuss how urban allotment gardens within Berlin, including areas like TF, function as biodiversity hotspots and help regulate the urban heat island effect. By providing habitats for native species and promoting ecological connectivity, such spaces are crucial in maintaining the city's ecological balance.

Furthermore, Knaus and Haase highlight the importance of green infrastructure in Berlin's urban climate strategies, particularly in response to increasing heat loads. The characteristics of TF, such as its extensive green areas and open space, exemplify the opportunities provided by integrating green infrastructure into urban design, enhancing the city's climate resilience.

Social and Community Engagement

TF promotes community and social cohesiveness as well as ecology. Through public spaces where inhabitants can pick edible plants, Landor-Yamagata et al. describe how the site promotes urban foraging and community participation, boosting social relationships and health. Participatory spaces like community-supported agriculture and social interaction strengthen the link between green spaces and urban well-being.

TF talks emphasize urban green space social justice. According to Rosol, the site's use and preservation discussions show how public participation and community engagement are important in urban green space governance. Berlin inhabitants value inclusive and accessible public places, as shown by their strong opposition to reconstruction.

Sustainability and Resource Efficiency

As Berlin aims to enhance its sustainability and resource efficiency goals, TF advocates for the multifunctionality of urban green spaces. Chen et al. discuss how the park serves multiple purposes, including recreation and ecological restoration, while also facilitating urban resilience against climate change impacts. The site's design incorporates features that promote stormwater management and reduce heat, showcasing its potential as a model for sustainability in urban planning.

Moreover, Carver and Gardner emphasize how urban green spaces like TF contribute positively to ecological preservation efforts, highlighting its multifaceted role in supporting urban biodiversity and its relevance in discussions about ecological governance.

Biodiversity and Urban Green Space Provision

Various studies reinforce the importance of urban green spaces in Berlin for biodiversity conservation. Beninde et al. emphasize that the presence of green spaces correlates with higher urban species richness, thereby underscoring the need for effective green space integration. TF's extensive green area supports a variety of plant and animal species, contributing to the overall biodiversity of the urban landscape.

In addition, Kabisch and Haase explore the equitable provision of urban green spaces, discussing the significance of accessible and well-distributed green areas for promoting social justice. Their findings indicate that urban green spaces play a crucial role in advancing environmental justice, considering factors such as accessibility for marginalized communities.

TF serves as an exemplary case of how urban parks can fulfill ecological, social, and community functions, impacting Berlin's broader green network. The existing research literature emphasizes the multifaceted role of this significant green space in supporting biodiversity, fostering community engagement, and promoting sustainability. Understanding these dynamics is crucial for future urban planning initiatives aimed at enhancing community resilience and addressing the evolving challenges of urbanization.

This body of research highlights the importance of integrating ecological and social considerations into urban landscape design, ensuring that public spaces like TF contribute meaningfully to the well-being of urban residents and the environment.

04

Crafting the Methodology
Tracing the Melody

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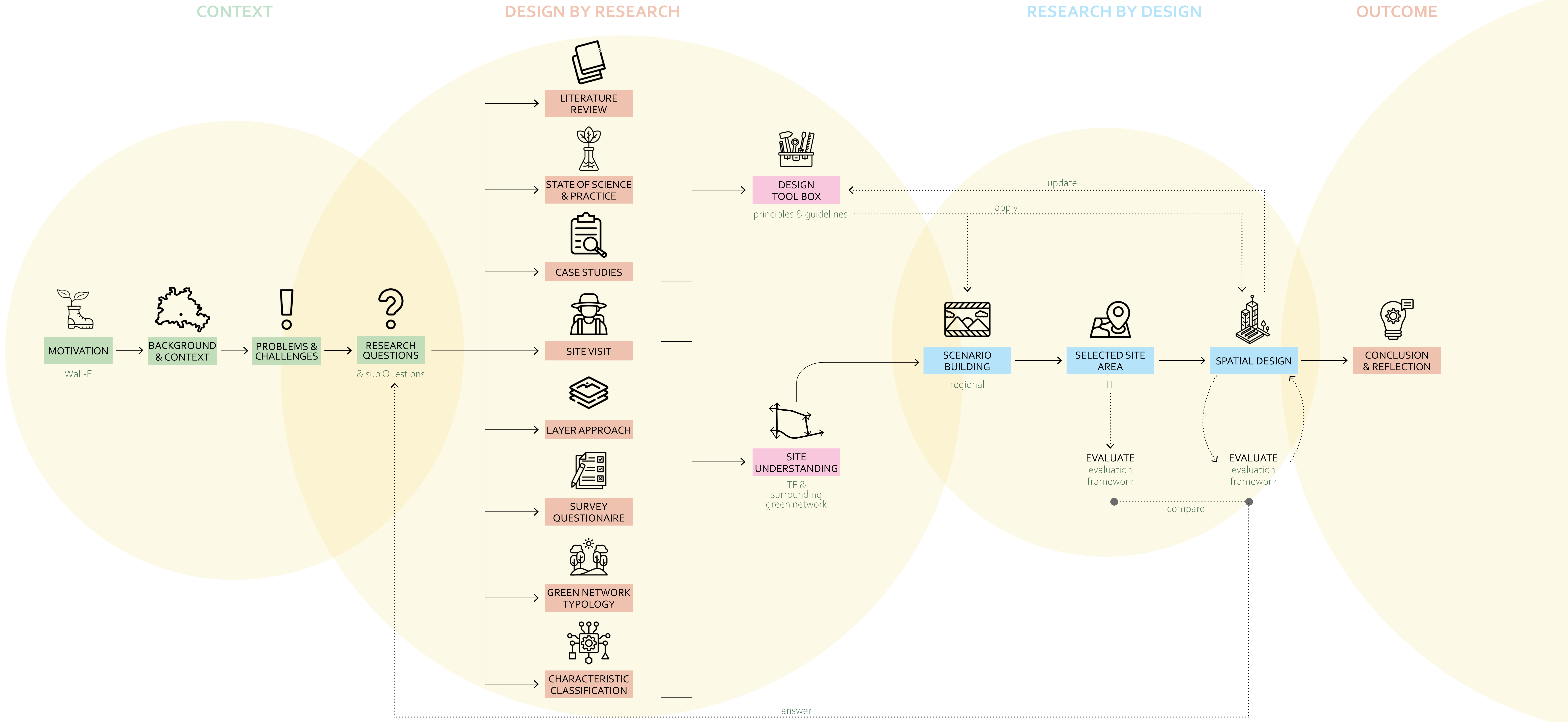
"**We shape our landscape**,
and afterwards
our **landscape shape us**"

- Winston Churchill

Methodology



4.1. Research approach and design

This thesis adopts a ***research-through-design*** methodology (Figure 13), blending theoretical inquiry with spatial and technological interventions. It operates at the intersection of landscape architecture, urban technology, and social sustainability. The methodology is inherently interdisciplinary, integrating knowledge from urban studies, environmental design, smart technologies, and human-centered research.

The research is structured through a mixed-methods approach, combining:

– ***Qualitative methods*** (literature reviews, interviews, surveys, user observation),
– ***Spatial analysis*** (site mapping, GIS data, usage patterns),
– and ***Design-based scenarios*** that explore future possibilities.

By applying a ***theory-to-practice*** cycle, the study iteratively moves between analytical phases and creative synthesis. The final output is a speculative yet grounded design proposal for TF's surrounding green network, embedded with smart technologies and resilient landscape strategies aimed at enhancing human well-being.

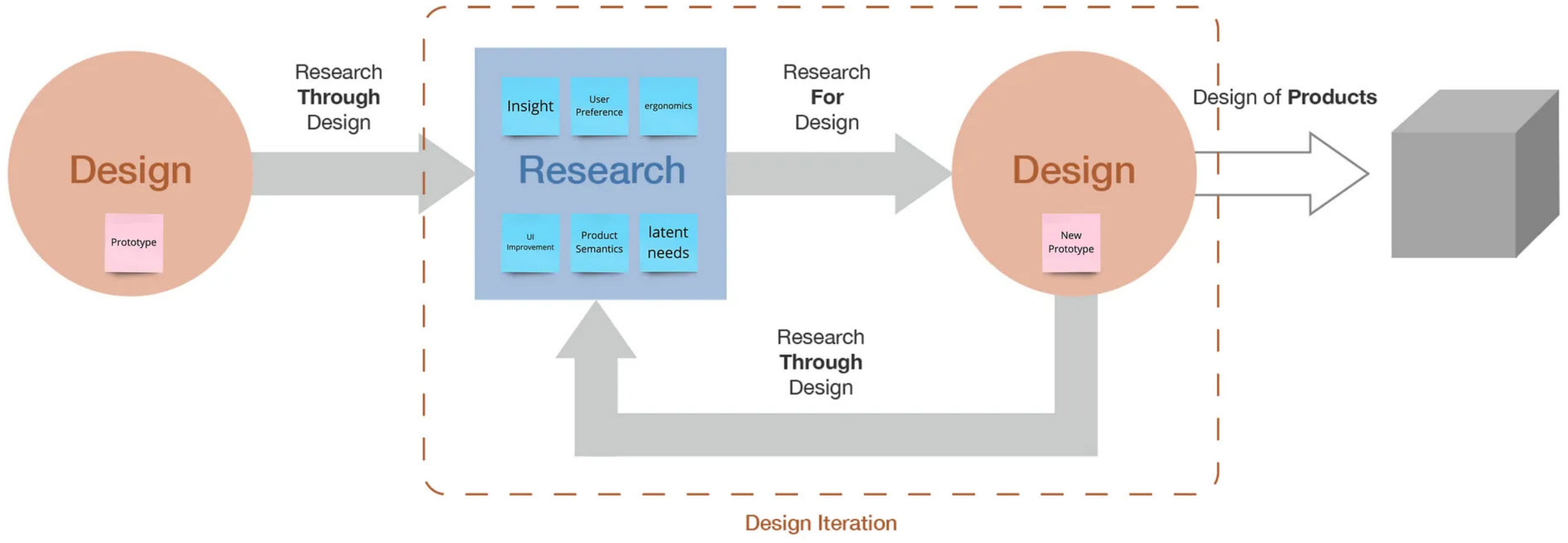


Figure 13

The General Design Process of Research and Design (Adapted from Soegaard et al.)
Source: https://medium.com/design-bootcamp/research-through-design-the-spirit-of-iteration-7af98ee546b7

4.2. Site Selection and Justification

The selected site, TF, and its connected green corridors and public spaces in Berlin serve as a unique experimental ground due to several reasons:

– ***Historical and cultural relevance***: Former airfield turned into one of Europe's largest urban parks, symbolizing freedom, openness, and civic transformation.
– ***Spatial capacity***: Offers vast open areas with strong potential for multi-functional landscapes and integration of digital technologies.
– ***Ecological potential***: Part of Berlin's green infrastructure network, linking several major parks and biodiversity corridors.
– ***Social value***: Acts as a magnet for diverse user groups and social activities.
– ***Connectivity***: Centrality within the urban transport network, metaphorically described as the "heart" with public transit as the "veins."

This site provides a platform to test how AI, IoT, and resilient landscape principles can shape more inclusive and responsive urban green spaces.

4.3. Data Collection Methods

Literature Review

A comprehensive literature review frames the theoretical foundation of the thesis. Key areas include:

– Smart cities and technological integration in public space.
– Resilient landscape design theory and practice.
– HCD and urban well-being.
– Landscape development and urban transformation of TF and surrounding area.

Sources include academic journals, books (e.g., Halegoua's Smart Cities), municipal reports, and design precedents.

Site Analysis

In-depth spatial and environmental assessment of TF and adjacent parks involves:

– GIS mapping of green connectivity, land use, and ecological data.
– Behavioral observation to analyze how people use space (sitting, gathering, moving).
– Sensory mapping to assess comfort zones, noise, microclimates, and aesthetics.
– Infrastructure audit of existing tech elements, mobility patterns, and access points.

Tools: GIS, behavioral observation, sketch mapping, etc.

Survey

Survey with visitors, residents, and park users on perceptions of safety, comfort, social interaction, and openness to digital features in public space.

4.4. Design Strategy and Scenario Development, Ethical considerations

Data collection emphasizes qualitative richness and context sensitivity.

Design Strategy and Scenario Development

The design process is driven by insights gathered through research and grounded in the realities of the site. The thesis develops three future-oriented design scenarios for TF's green network:

– Current State Plus (Minimal intervention with low-tech upgrades)
– Augmented Landscape (Integration of IoT and responsive design elements)
– Symbiotic Ecosystem (AI-embedded, highly adaptive, and user-centered landscape system)

Each scenario explores varying levels of tech integration, ecological sensitivity, and user interaction. Design principles include:

– Modular green infrastructure,
– Interactive furniture and lighting (IoT sensors),
– Data-informed spatial reconfigurations using AI,
– Seasonal adaptability and flood-resilient planting schemes.

Ethical considerations

Ethical awareness is embedded in every stage:

– Informed consent for surveys and interviews.
– Transparency around data collection and storage.
– Equity and accessibility in design outcomes.
– Mindful integration of AI and IoT to avoid surveillance or exclusion.
– Reflections on tech's limits and unintended consequences in public space.

05

Mapping Green Arteries of Berlin
The Heartbeat's Echo

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"Everything in Life
is ***Vibration.***"

- Albert Einstein

5.1. Historical and Contextual Analysis

Landscape architecture

Landscape architecture in Berlin began in the late 19th and early 20th century, with an emphasis on aesthetic and practical design. However, with the introduction of contemporary technology such as Geographic Information Systems (GIS) and Building Information Modeling (BIM), landscape design started to adopt more data-driven techniques. The combination of GIS and Historic Building Information Modeling has become critical for maintaining and protecting cultural heritage assets in Berlin, enabling informed decision-making based on extensive spatial data. This technological synergy makes it easier to visualize and maintain cultural assets, which is especially significant in a city as rich in history as Berlin (Dionizio and Dezen-Kempter).

Solar roof on the apartments
Picture's source: Thomas Rosenthal, SolarZentrum

Solar roof on the Reichstag in Berlin
Picture's source: Deutscher Bundestag / Lichtblick/Achim Melde

As the 20th century progressed, the introduction of digital technologies altered landscape architectural methods. The development of remote sensing technologies and digital terrain modeling enabled more exact landscape planning and design. For example, the use of remote sensing in landscape architecture education has been promoted as a way to improve spatial information quantification and design processes. This integration not only enhances the educational framework, but it also encourages a methodical approach to landscape study, which is critical in modern urban planning (Zhang and Zhang).

The late 20th and early 21st centuries witnessed a further trend toward sustainability and ecological issues in landscape design. In Berlin, architects and planners are increasingly focused on incorporating renewable energy technology, such as solar systems, into landscape design. This integration seeks to strike a balance between historical aesthetic preservation and current sustainability objectives, ensuring that new technologies do not jeopardize heritage sites' cultural identities (Medici; Rocco et al.). The difficulty is to integrate these technologies with the existing architectural fabric, which requires careful planning and new design solutions (Rocco et al.).

Furthermore, the emergence of computational design tools has transformed the way landscape architects plan and carry out their projects. Parametric design and computational techniques have made it possible to create complex geometries and adaptable landscapes that react to environmental conditions and human requirements. This transition toward computational approaches mirrors a larger trend in architecture and urban design, where technology plays an important role in increasing creativity and efficiency (Na). In Berlin, this has resulted in initiatives that use sophisticated modeling methods to create dynamic and interactive public spaces (Zhang and Chen).

The use of technology into landscape design also tackles major urban issues like climate change and urban congestion. Landscape architects may use sophisticated modeling and simulation techniques to create resilient green areas that reduce urban heat and increase biodiversity (Nikologianni and Albans). The use of virtual reality and AR in landscape design creates more immersive experiences, allowing stakeholders to view and interact with suggested ideas prior to execution. This participatory approach is critical in a city like Berlin, where community engagement in urban planning is increasingly acknowledged as necessary for effective results (Ye et al.).

Photo's source:
https://futurelandscapes.ca/tempelhofer-feld

The history of TF is rich and multi-layered, reflecting Berlin's political, social, and urban transformations.

1. Early History (Middle Ages – 18th Century)

- The name ***"Tempelhof"*** derives from the ***Knights Templar***, who were granted the land in the 13th century.
- After the dissolution of the Templar order, the area remained largely agricultural and open for centuries.
- By the 18th century, the field served as a parade and drill ground for Prussian troops, due to its vast open space.

2. Aviation Milestone (19th – Early 20th Century)

In the late 19th and early 20th century, Tempelhofer Feld became a hub for aviation pioneers.

Notably:

- Orville Wright demonstrated flight here in 1909.
- The field evolved into one of the world's first airports, Berlin Tempelhof Airport, officially opened in 1923.
- In the 1930s, the Nazi regime initiated construction of a massive airport terminal under architect Ernst Sagebiel, designed to represent the regime's power. It was one of the largest buildings in the world at the time.

3. World War II and Cold War Era

During World War II, the site was used for military purposes and aircraft production, with forced labor involved.

After the war, Tempelhof Airport became a symbol of freedom during the Berlin Airlift (1948–49):

- As Soviet forces blockaded West Berlin, U.S. and British forces used Tempelhof to fly in vital supplies.
- Over 270,000 flights landed, delivering food, fuel, and essentials.
- This event cemented the airport's legacy in Cold War history.

Figure 14

Historical development of TF
1928 - 1943 - 1945 - 1953 - 2000 - 2024
Picture's source: Google Earth Online, https://earth.google.com/

4. Cold War to Closure (1950s – 2008)

- Throughout the Cold War, Tempelhof remained a military and commercial airport, primarily used by U.S. forces and then for short-haul civilian flights.
- The airport's operations gradually declined with the growth of Tegel and Schönefeld Airports.
- ***Tempelhof Airport officially closed in 2008***, sparking debates about the site's future.

5. Rebirth as a Public Space (2009 – Today)

After its closure, the field was temporarily opened to the public and became a massive urban open space, the largest of its kind in Berlin.

In 2010, the city officially opened it as "Tempelhofer Feld", a public park.

In 2014, a citizen-led referendum stopped development plans that would have introduced housing and commercial buildings on the site.

The result preserved the open nature of the field.

It marked a milestone in participatory urban planning in Berlin.

6. Current Use and Symbolism

Tempelhofer Feld today serves as:

- A recreational space for biking, skating, kite flying, urban gardening.
- A climate buffer and part of Berlin's ecological green network.
- A testing ground for experimental and participatory urban practices.
- A location for refugee shelters, events, and public dialogue.

It is also featured in broader strategies like Berlin Strategie 3.0 and StEP Klima/Stadtgrün, reflecting its role in sustainability and urban resilience.

Surrounding area Topography

Zone	Elevation (ASL)	Key Features	Ecological Linkages
North (Kreuzberg)	36–40m	Urban density; Landwehrkanal (32m)	Connects to Gleisdreieck Park
East (Tempelhof)	37–42m	Glacial sand deposits	Groundwater recharge zone
South (Britz)	40–45m	Gradual rise to Britzer Garten	Wildlife corridor to rural Berlin
West (Schöneberg)	39–43m	Rail embankments (Gleisdreieck Park)	Heat island mitigation

Drainage:

Poor infiltration in central fields of research area; runoff flows South-East toward Teltow Canal and North-West to Landwehrkanal.

Data Sources: asset GIS Berlin, https://www.asset-gis.de/

Legend

- -7 - 24 m
- 24 - 28 m
- 28 - 32 m
- 32 - 36 m
- 36 - 40 m
- 40 - 44 m
- 44 - 48 m
- 48 - 52 m
- 52 - 56 m
- 56 - 60 m
- 60 - 64 m
- 64 - 68 m
- 68 - 72 m
- 72 - 76 m
- 76 - 80 m
- Water runoff

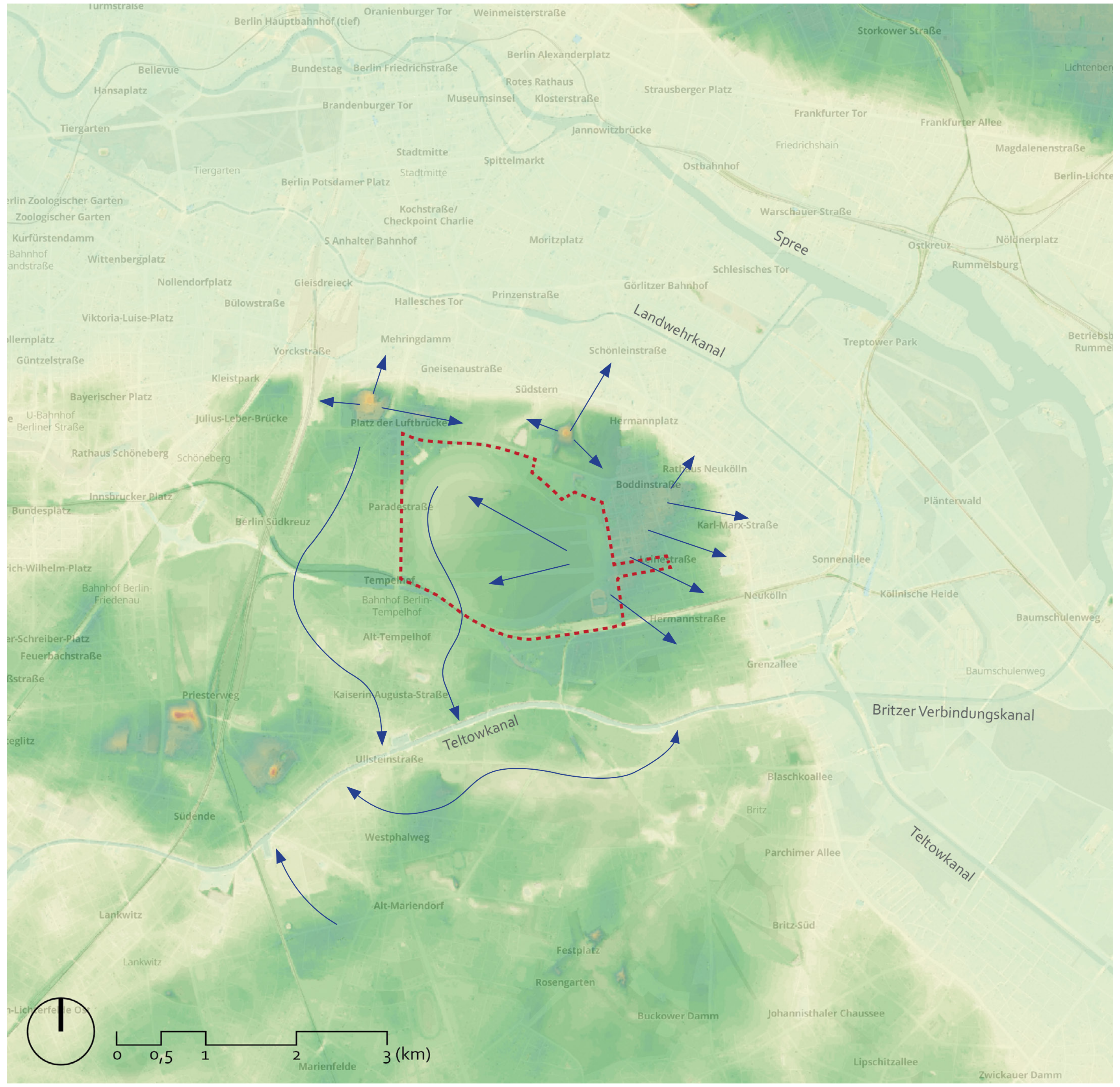


Figure 15

Topography of area surrounding TF

Picture's source: asset GIS Berlin, https://app.asset-gis.de/

TF area Topography

Elevation and Slope:

– ***Runways***: Nearly flat (slope 0.5–1%), 34–38m above sea level (ASL), with impermeable tarmac causing rapid runoff.

– ***Grasslands***: Gentle undulations (slope 1–3%), depressions prone to temporary flooding (clay subsoil).

– ***Artificial mounds***: 2–4m high landscaped hills (e.g., viewing mounds) acting as windbreaks.

Key Takeaways:

– ***Flat + Compacted***: Runways need green infrastructure to manage water/heat.

– ***Ecological Gradients***: Elevation changes support biodiversity corridors.

– ***Sustainable Drainage solution:*** naturally lower elevation area, ideal locations for water catch basins.

– ***Data-Driven Design***: Topography guides sensor placement for climate adaptation.

Legend

- 24 - 28 m
- 28 - 32 m
- 32 - 36 m
- 36 - 40 m
- 40 - 44 m
- 44 - 48 m
- 48 - 52 m
- 52 - 56 m
- 56 - 60 m
- 60 - 64 m
- 64 - 68 m
- Water runoff
- Catch basin

Figure 16

Topography of TF

Picture's source: asset GIS Berlin, https://app.asset-gis.de/

5.2. Current Physical and Spatial Analysis

Urban structure and Land use

Surrounding area

Area	Zoning (Berlin FNP)	Dominant Uses	Interface with TF
North (Kreuzberg/ Neukölln)	Mixed-Use	High-density housing, nightlife	Noise spillover; demand for evening access
East (Tempelhof)	Residential + Light Industries	Apartments, startups	Pressure for commercial encroachment
South (Britz)	Suburban + Greenbelt	Single-family homes, Britzer Garten	Wildlife corridor potential
West (Schöneberg)	Mixed-Use + Parks	Offices, Gleisdreieck Park, Viktoria-park, Natur Park Südgelände	Shared cycling infrastruc-ture

TF area

Primary Use:

Public park/ recreation (designated "*Freifläche im Außenbereich*" under Berlin zoning).

Subzones:

– ***Runways***: Active recreation (cycling, skating, running, walking), multifunctional events.
– ***Grasslands***: Protected habitats (Natura 2000_ Skylar and Sand Lizard).
– ***Community Gardens***: Allotments and urban farming.

Regulations:

– No permanent structures (per 2014 public ref-erendum).
– Limited commercial use (e.g., seasonal cafés).

Conflicts:

– ***Tarmac vs. ecology***: Heat islands vs. grassland restoration.
– ***Crowd pressure***: Sports areas degrade soil biodi-versity.

Key Takeaways:

– ***Frozen by Democracy***: Referendum protections make Tempelhofer a rare anti-gentrification model.
– ***Edge Dynamics***: Surrounding mixed-use zones demand creative interfaces (e.g., "green tech" cor-ridors).
– ***Data Gaps***: Need updated noise/ light pollution studies to guide IoT/ AI deployment.

Legend

Primarily residential structures

- Wilhelminian block structure with rear and side wings
- Wilhelminian block perimeter structure with few side and rear constructions
- Wilhelminian block perimeter structure with major changes
- Block perimeter and row building in the 1920s and 1930s
- Row building in the 1950s
- Postwar high-rises
- Housing structure in the 1990s and subsequent
- Low-rise structure with private gardens
- Villas with park-like landscape
- Structure with gardens and semi-private green spaces
- Village

Retail, service, commercial, and industrial structures

- Retail and service structure
- Low-rise commercial and industrial structure
- Dense commercial and industrial structure

Other structures

- Building sites, traffic zones, and largely public and special use structure (excluding land for road)
- Lightly developed public and special purpose areas, including green and open spaces
- Water bodies

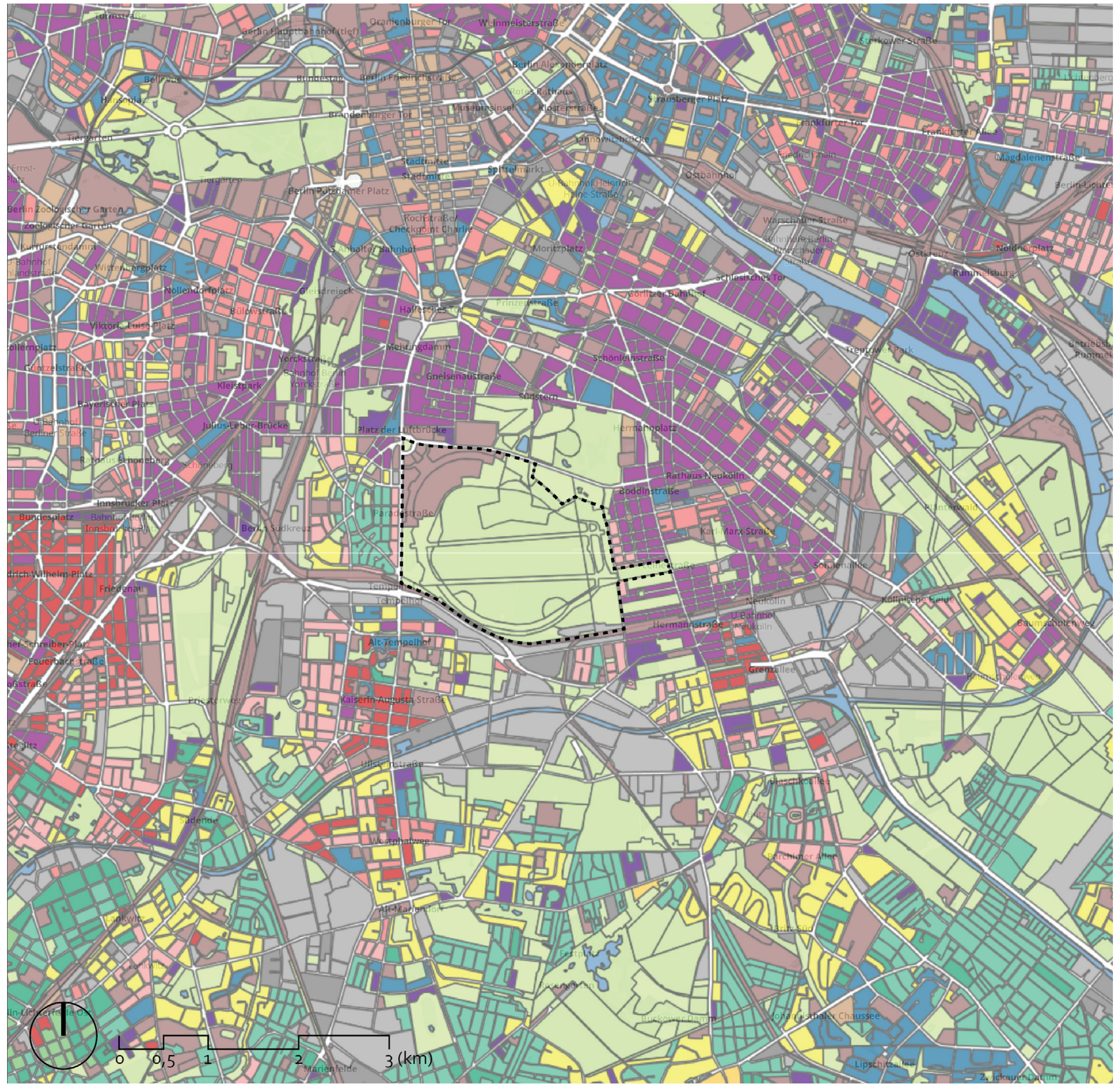


Figure 17

Urban structure of area surrounding TF
Picture's source: asset GIS Berlin, https://app.asset-gis.de/

Legend

Other structures

- Residential use
- Mixed use
- Commercial and Industrial area, large-scale retail
- Public and Special use
- Supply and Disposal
- Traffic area
- Construction site
- Park/ Green area
- Cementary
- Allotment garden
- Fallow land, mixed meadows, bushes and trees
- Sport use
- Water surface

Figure 18

TF Land-use
Picture's source: asset GIS Berlin, https://app.asset-gis.de/

5.2. Current Physical and Spatial Analysis

Connectivity and Accessibilty

Transportation Networks

1. Public Transit:

– ***U-Bahn***: Lines U6 (Tempelhof station) & U8 (Boddinstraße and Leinestraße station) – 10-15 min walks to park entrances.

– ***S-Bahn***: Ringbahn (S41/42) at Südkreuz (15 min walk) and Tempelhof (12 min walk), 2 planned stations on South.

– ***Buses***: routes stop at park edges
- 140, 184, N6, N84 (Tempelhofer Damm)
- 248, M43 (Platz der Luftbrücke, Columbiadamm)
- 166, M43, N8 (Hermannstraße)
- 246, 277, N77 (Oberlandstraße, Silbersteinstraße)

– ***Gaps:***
- No direct tram links; poor South-North connectivity, difficult to find East access.
- Last-mile challenges for elderly/ disabled visitors.

2. Active Mobility:

– ***Car:*** Access to the parking lot from Tempelhofer Damm (E-mobil charging station), Platz der Lufbrücke and Columbiadamm.

– ***Cycling***: Dedicated lanes on Columbiadamm/ Oderstraße; around 3,500 bike parking spots.

– ***Pedestrian***: 12 entrances, but uneven paving in historic sections.

Equity Hotspots

– ***West and North Entrances:*** Best served by transit (U6 and U8, Bus).

– ***East Entrances:*** Fewer amenities, higher accessibility barriers.

– ***South Entrances***: in the future with 2 new S-bahn stations

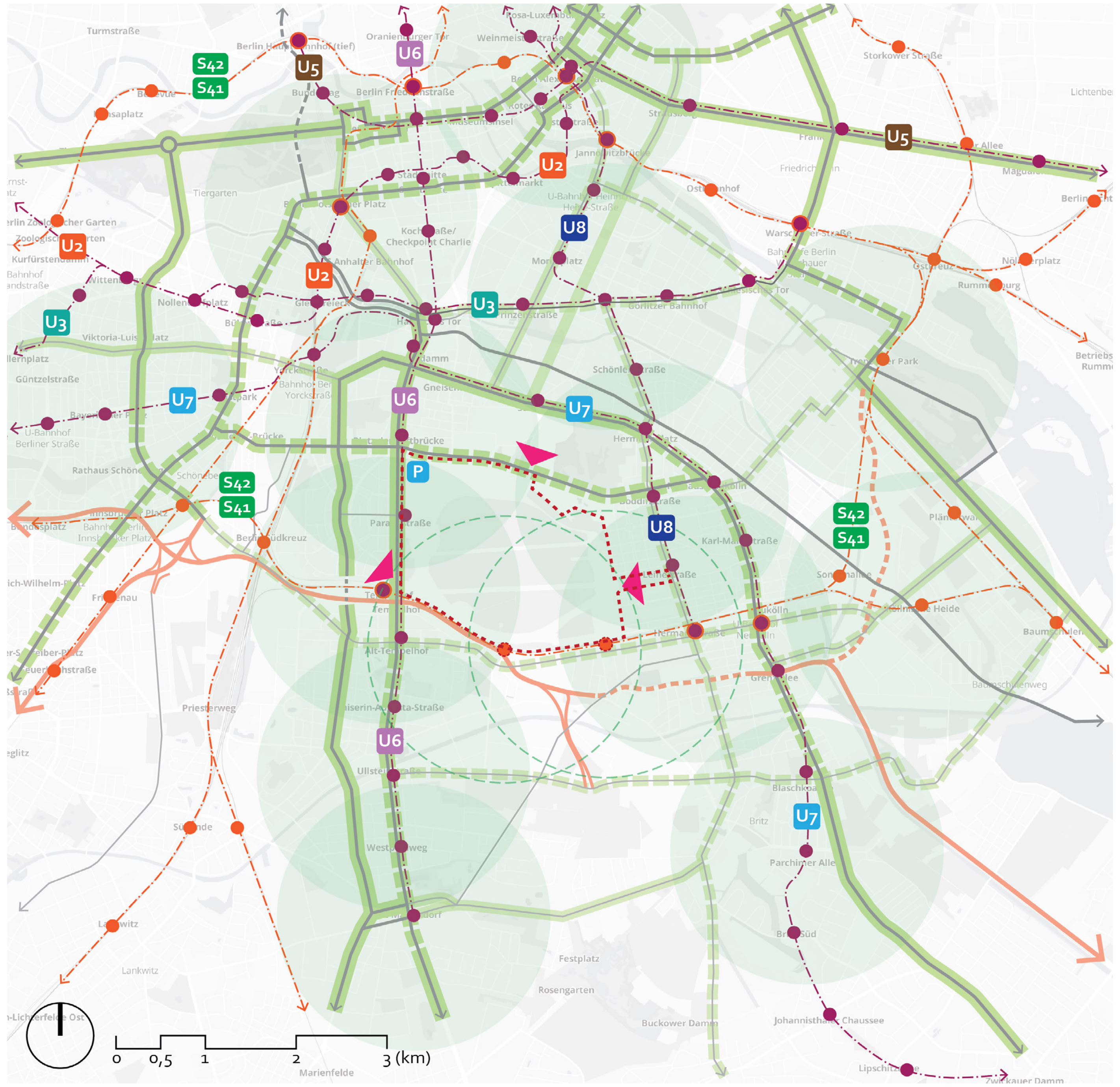
Accessibility Barriers

User Group	Challenges	Smart Tech Opportunities
Wheelchair Users	Cobblestones at old gates; lack of tactile paths	IoT surface sensors to alert maintenance
Elderly	Long walks from transit; few rest spots	App-based shaded bench locator
Families	Narrow gates clogged with strollers	AI crowd flow optimization
Tourists	Poor multilingual signage	AR wayfinding via park app, AR historical trail

Data Sources:

– *BVG 2023 Network Maps*

– *asset GIS Berlin*



Legend

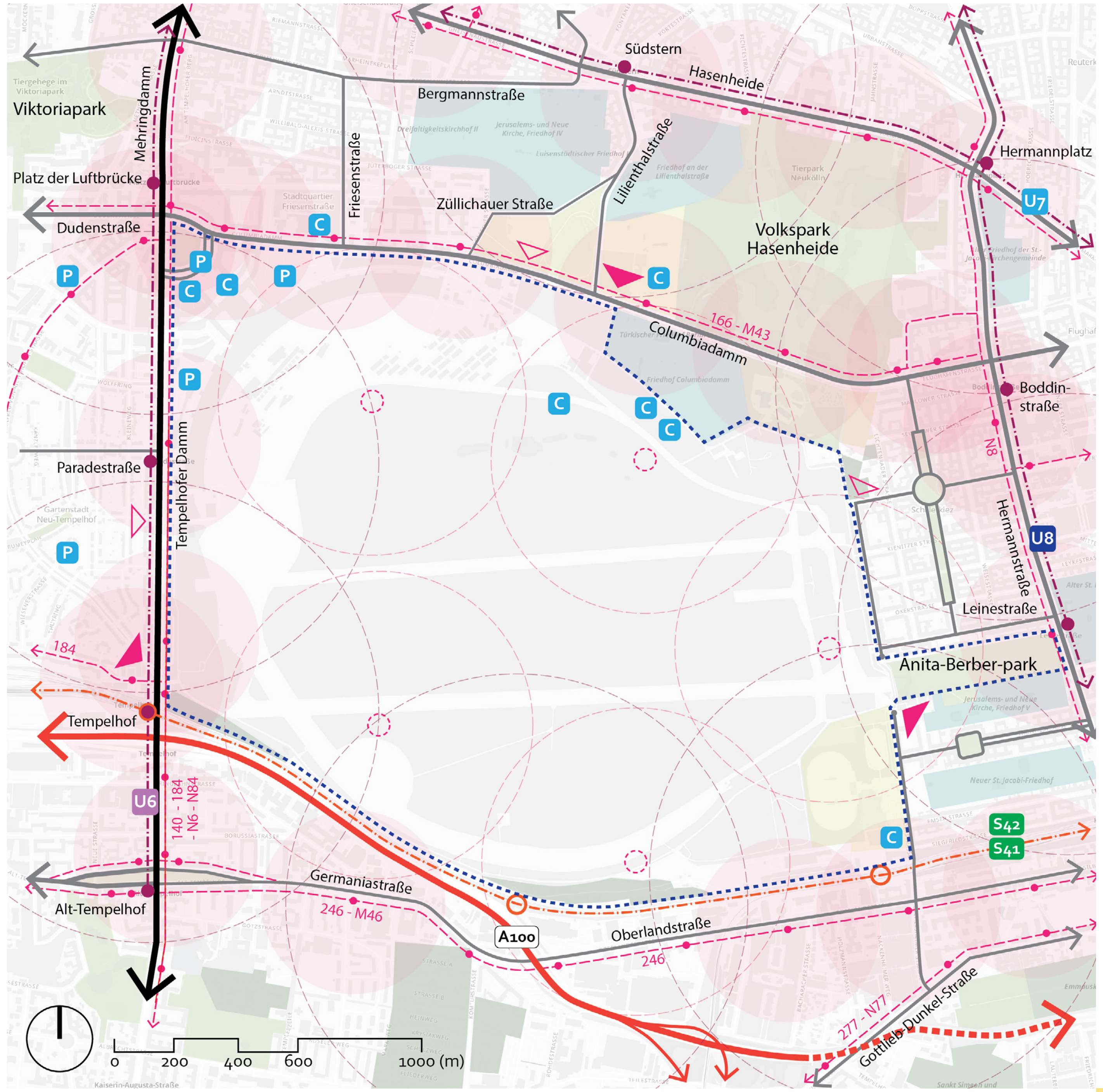
Site area
Highway
Primary road
Main road
U-bahn
S-bahn

750 m walking radius from U-/S-bahn station
750 m walking radius from planning S-bahn station

Main access
Parking lot

Figure 19

Connectivity and Accessibility of surrounding area
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/



Legend

Site area
Sport area
Park/ Green area
Cementary
Allotment garden
Highway
Primary road
Main road
U-bahn
S-bahn

750 m walking radius from U-/S-bahn station

250 m walking radius from Bus stop

500 m walking radius from potential POI

Main Access
Secondary Access
Parking lot
Bicycle parking

Figure 20

Connectivity and Accessibility of TF
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

5.2. Current Physical and Spatial Analysis

Spatial Configuration and Pathways

1. Macro-Scale Structure

Radial-Concentric Network:

– ***Radial***: Historic axis from Mehringdamm funnel users toward the park, links to other parks via Green axes.

– ***Concentric***: Ringbahn (S41/42) creates a 3km-radius catchment area.

Green Corridors:

– ***North***: connect to Großer Tiergarten via Mehringdamm and Stresemannstraße, to Volkspark Friedrichshain via Skalitzer Straße, Stralauer Platz and Lichtenberger Straße.

– ***North West***: Links to Gleisdreieck Park via Columbiadamm.

– ***East***: Links to Treptower Park and Spreepark via Columbiadamm - Karl Marx Straße - Grenzallee.

– ***South***: Fragmented connection to Britzer Garten due to autobahn (A100) barriers.

Legend

Site area

Park/ Green area

Cementary

Allotment garden

Highway

Primary road

Main road

U-bahn

S-bahn

Main Green axis_Current

Secondary Green axis_Current

Main Green axis_Potential

Secondary Green axis_Potential

Main Green node_Potential

Secondary Green node_Potential

Main Access

Historical place

Historical trail_Potential

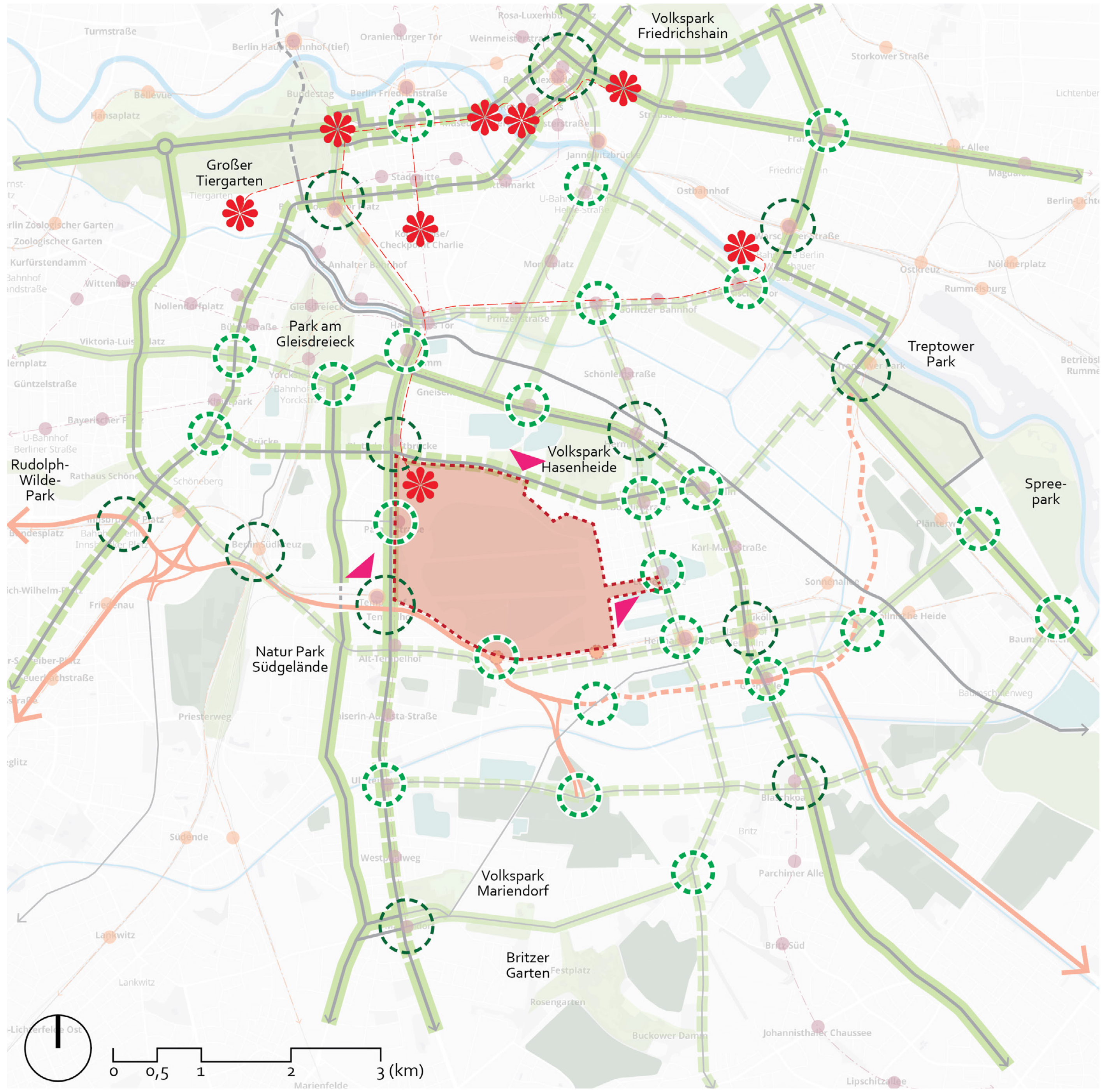


Figure 21

Spatial configuration of TF and Green network surrounding

Drawn by author

Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

2. Meso-Scale Pathway System

A. Formal Circulation

Primary Paths:

– ***Runways***: 3.3km straightaways (asphalt, 10m wide) for high-speed cycling/skating.

– ***Perimeter Loop***: 6km crushed stone trail (accessible, 4m wide).

Secondary Paths:

– Grassland trails (2m wide, mown biweekly).

– Community garden access lanes.

B. Informal Networks

Desire Lines:

– Diagonal footpaths across grasslands (soil compaction issues).

– Nighttime shortcuts linking to transit.

Materiality & Performance:

Path Type	Material	Flood Resilience	Maintenance Needs
Asphalt runways	Sealed pavement	Poor (runoff)	Low
Gravel perimeter	Permeable aggregate	Good	Moderate
Grass trails	Compacted soil	Fair (erosion)	High

Legend

Site area

Sport area

Park/ Green area

Cementary

Allotment garden

Highway

Primary road

Main road

U-bahn

S-bahn

Main Green axis_Current

Secondary Green axis_Current

Main Green axis_Potential

Secondary Green axis_Potential

Main Green node_Potential

Secondary Green node_Potential

Main Access

Secondary Access

Berlin Historical Point

Berlin Historical trail_Potential

Tempelhof Historical Point

Tempelhof Historical trail

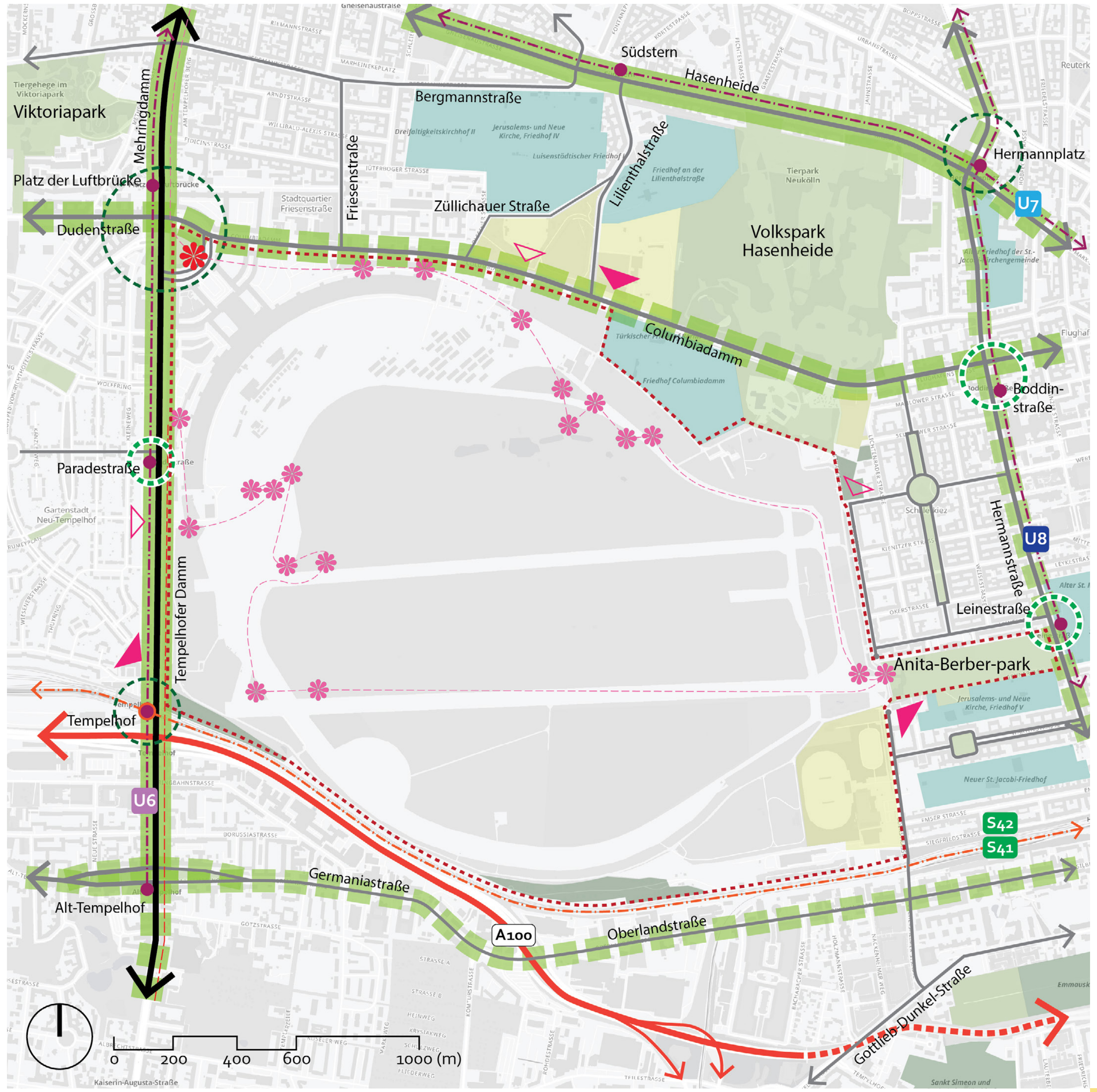


Figure 22

Spatial configuration of TF and Green network surrounding

Drawn by author

Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

5.2. Current Physical and Spatial Analysis

Spatial Configuration and Pathways

3. Micro-Scale Spatial Experience

A. Activity Zones

– ***Dynamic Open Fields***: 50+ ha for unstructured play/ sports.

– ***Contemplative Spaces***: Mounded areas with sightline buffers.

– ***Social Nodes***: Picnic clusters near entrances (80% within 5m of paths).

B. Wayfinding

Deficiencies:

– Minimal signage (relies on landmark navigation).

– No tactile guides for visually impaired.

Opportunities:

– AR markers at decision points (e.g., fork in runways).

– Solar-powered LED edge lighting for nighttime clarity.

4. Mobility & Conflict Analysis

User Conflicts:

– ***Cyclists vs. Pedestrians***: 22% of accidents occur at runway crossings (Polizei Berlin, 2023).

– ***Event Crowds***: 500k+ visitors during festivals overwhelm eastern paths.

Integration:

– Runways score highest attraction through-movement.

– Southern grasslands are secluded but underused.

5. Monument area

– **Green area of Platz de Luftbrücke:** with the iconic structure Airlift Memorial.

– **Hangar constrtuction:** preserve for multifunctional gathering point.

– **Runways:** concrete pavements with good preserved quality.

Challenges in the Monument Zone

– ***Heat & Hardscape***: Large paved areas (e.g., runways, hangar area) intensify urban heat.

– ***Flood Risk***: Impermeable surfaces cause runoff, threatening nearby green spaces.

– ***Underused Spaces***: The monumental architecture is iconic but lacks interactive functions.

– ***Biodiversity Loss***: Limited vegetation reduces habitat for urban wildlife.

Key Takeaways

– ***Dual-Speed Network***: Formal fast paths + informal slow paths require material differentiation.

– ***Legibility Deficit***: Poor wayfinding reduces equitable access to secluded areas.

– ***Adaptive Materials***: Permeable surfaces can reconcile flood resilience with heavy use.

Legend

- Site area
- Mixed use area
- Sport area
- Green area
- Community garden
- Allotment garden
- Argriculture area
- Leisure area
- Tempohomes
- Dog park
- BBQ area
- Windsport area
- Skylark Protection Zone
- Highway
- Primary road
- Main road
- U-bahn
- S-bahn
- Main Access
- Secondary Access
- Berlin Historical Point
- Tempelhof Historical Point
- 'Fast' pathway
- 'Slow' pathway
- Info-Box
- Info-Pavillon

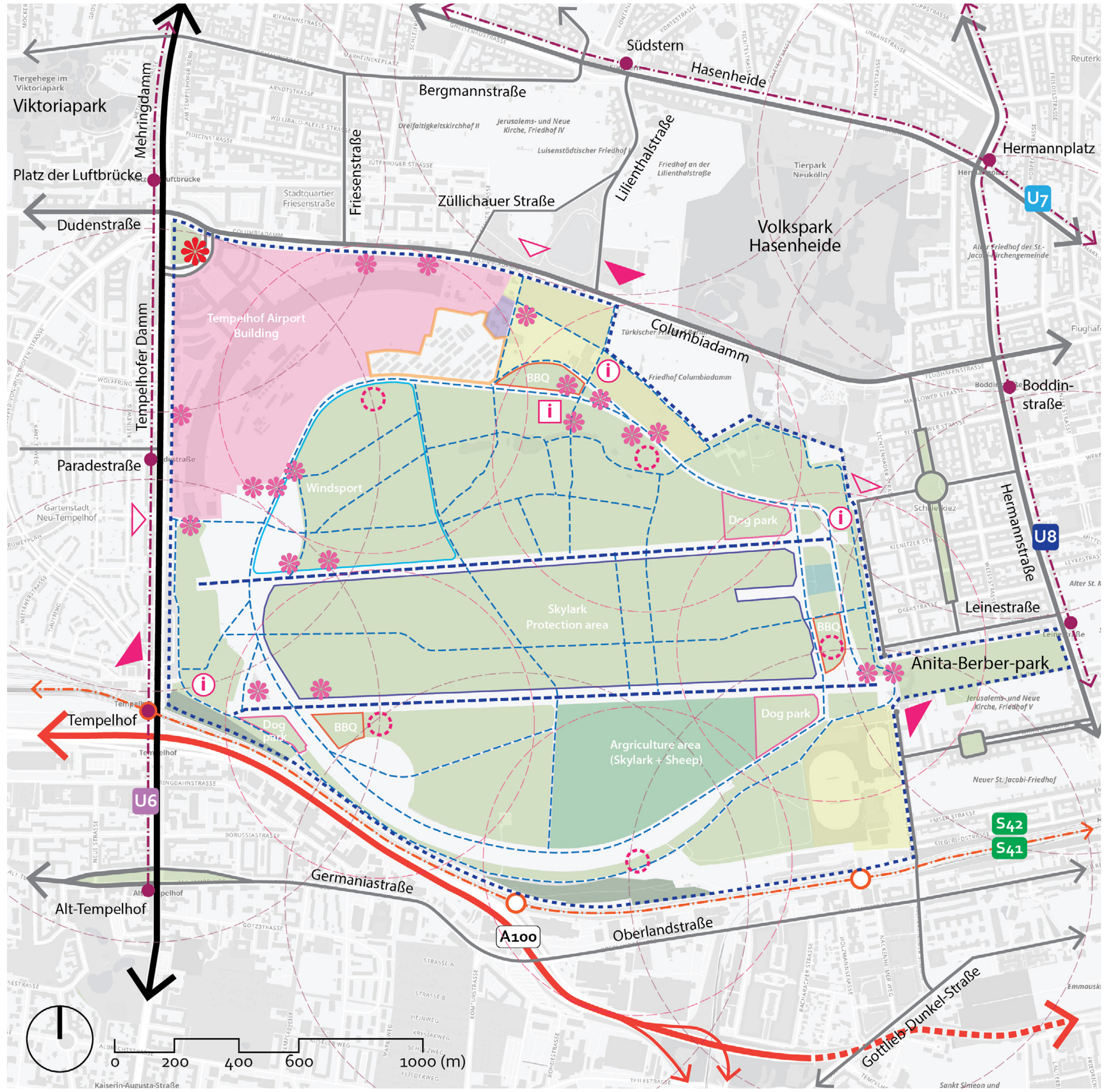


Figure 23

Pathway network of TF
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Legend

- Site area
- Architectural monument
- Monument area entire complex
- Monument area ensemble
- Garden monument
- Natural monument tree

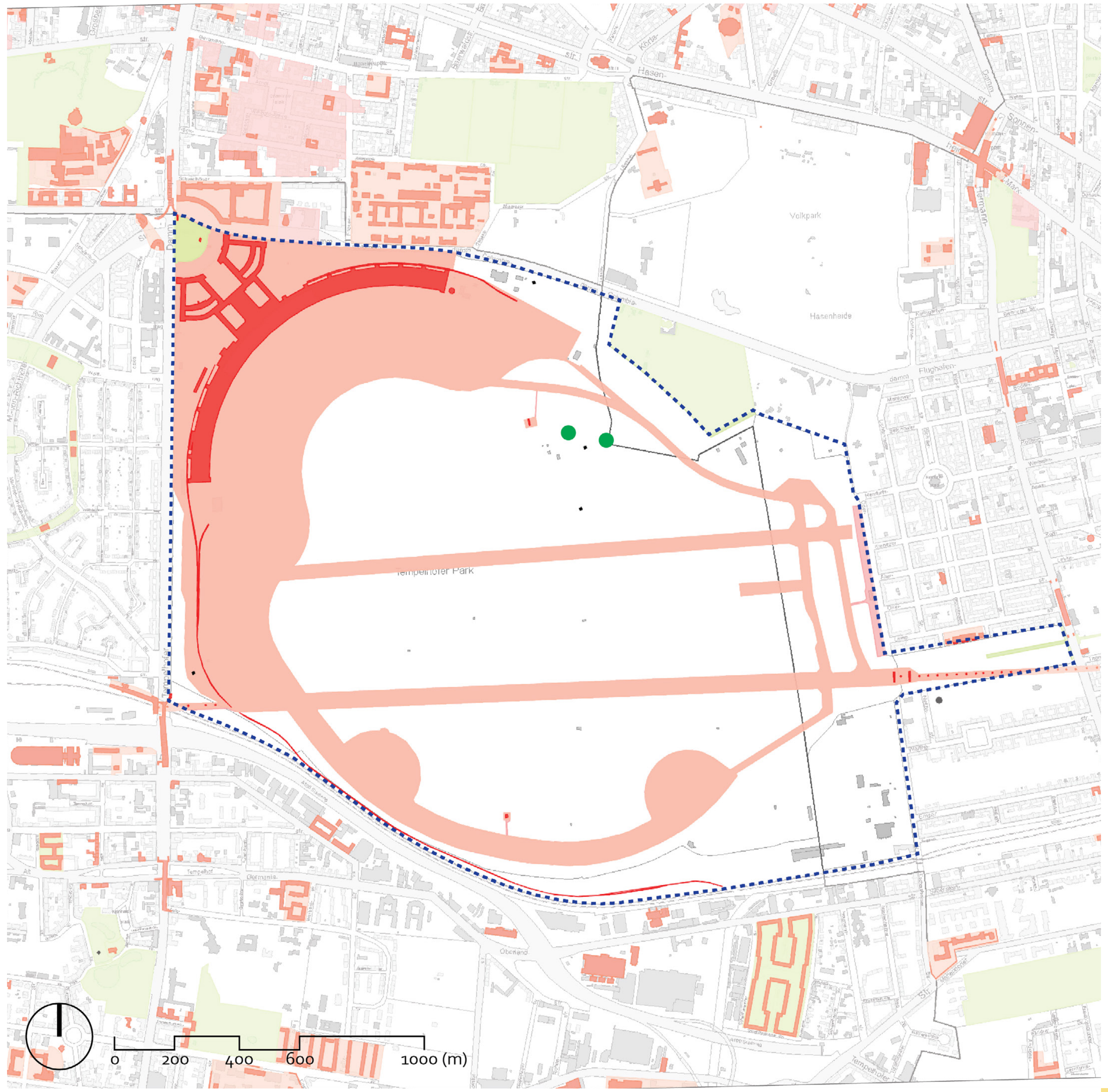


Figure 24

Monument area
Picture's source: asset GIS Berlin, https://app.asset-gis.de/

Climate and microclimate

1. Berlin's Macroclimate Context

Temperature:

– +1.5°C since 1950 (SenStadt, 2023).
– More frequent heatwaves (e.g., 38°C in 2022).

Precipitation:

– Wetter winters, drier summers (increased drought-flood cycles).
– 20% more heavy rain events since 2000 (German Weather Service).

Wind: Persistent North-West, gustier near open areas.

2. TF's Microclimate Context

Heat island (daytime)

Zone	Summer Peak Temp.	Compared to Berlin Avg.	Primary Drivers
Runway tarmac	48°C	+12°C	Low albedo, no shade
Grasslands	32°C	-4°C	Evapotranspiration
Mounded areas	35°C	-1°C	Elevated airflow

Data Sources:
Berlin Climate Atlas, 2022 IR drone surveys (TU Berlin, Aug 2023)

Cold air drainage (nighttime)

– ***Grassland depressions***: 2–3°C cooler than surroundings (radiational cooling).
– ***Risk***: Late frosts damage early-blooming plants.

Wind Patterns

– ***Channeling***: Unobstructed runways accelerate NW winds (20% faster than urban canyons).
– ***Shelter***: South-East edges near buildings have lower wind speeds.

Microclimate Variability

– ***Winter:*** Wind chill makes central runways unusable; peripheral tree belts provide shelter.
– ***Summer:*** South edges (near Neukölln) are hottest due to asphalt + lack of shade.

Current microclimate features of TF

Factor	Characteristics	Implications
Heat Islands	Runways absorb heat (up to 10°C hotter than shaded zones).	Heat stress for users; biodiversity loss.
Wind Tunnels	Flat, open terrain accelerates winds (problematic for events/cyclists).	Erosion, discomfort.
Rainwater Runoff	Impermeable tarmac causes flooding at edges (e.g., Columbiadamm entrance).	Damages soil, disrupts use.
Biodiversity Zones	Wildflower meadows and wetlands mitigate local temps (+2°C cooler than runways).	Model for climate adaptation.

Climate risks for TF

Risk	Impact	Vulnerable Groups
Extreme Heat	Heatstroke, reduced park use	Elderly, children, homeless
Urban Flooding	Runway pooling, garden damage	Cyclists, urban farmers
Soil Degradation	Compacted earth from overcrowding	Biodiversity, gardeners
Wind Erosion	Dust storms, poor air quality	Event organizers, athletes

3. Hydrological Extremes

Flood Risks

– ***Hotspots***: Southern fields (clay subsoil, 30% slower infiltration).
– ***2022 Event***: 40mm rain in 2 hours caused 15cm-deep pooling.

Drought Vulnerability

– ***Grasslands***: Sandy soils lose moisture faster than loamy areas.
– ***Stress Signs***: 25% of park trees show early leaf drop (Grün Berlin, 2023).

Key Takeaways

– ***Extreme Gradients***: 16°C intra-park temp differences demand zoned design strategies.
– ***Precision Adaptation***: IoT networks can target microclimates (e.g., dry zones get 20% more irrigation).
– ***Conflicting Needs***: Windbreaks for comfort may reduce pollination corridors – require AI-balanced planning.

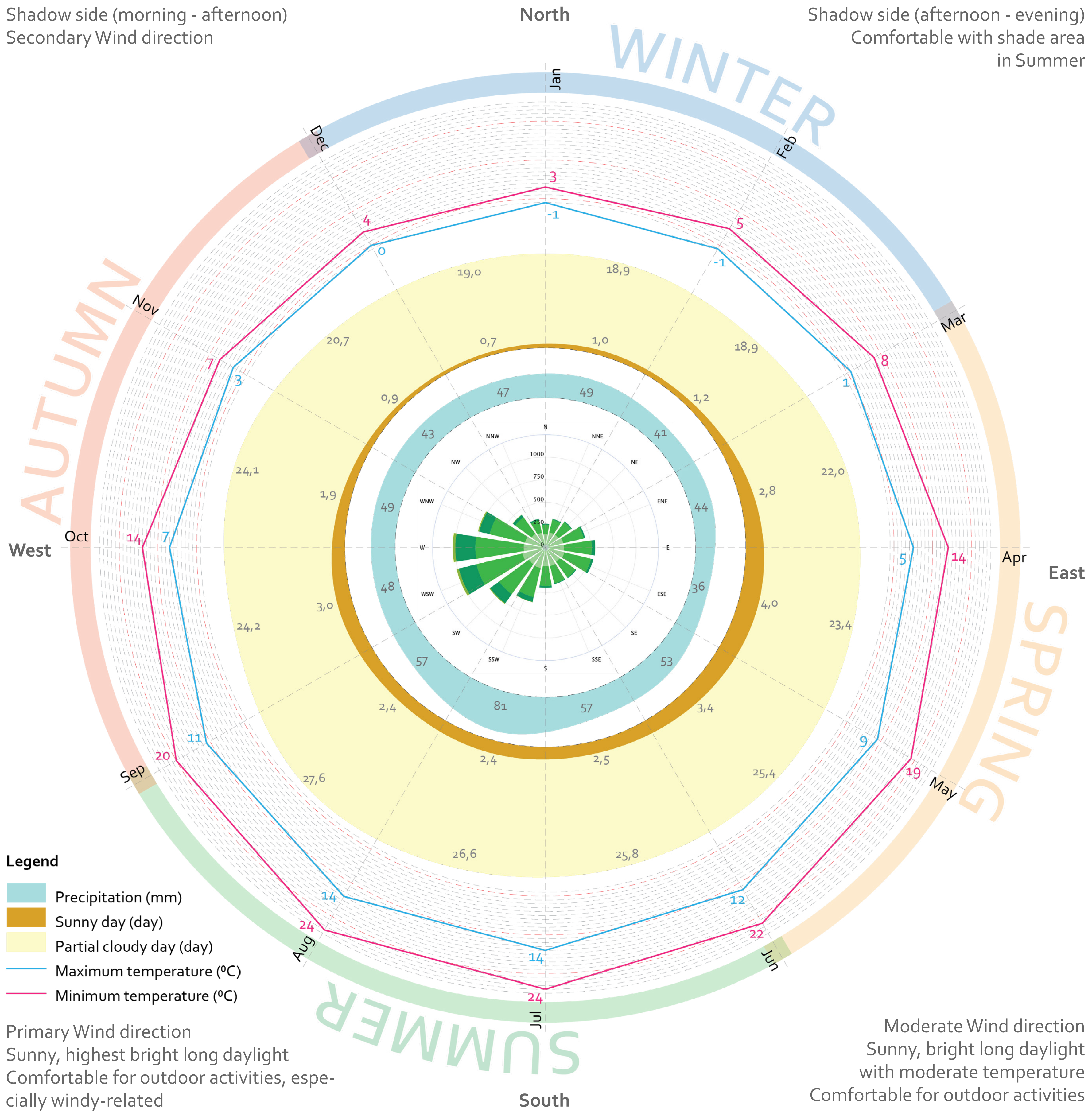


Figure 25

Climate diagram
Drawn by author
Source: meteoblue, https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/berlin_germany_2950159

5.3. Current Environmental and Ecological Analysis

Green and Blue Infrastructure

Green Infrastructure

A. Core Vegetation Systems

Type	Ecological Function	Challenges
Native Grasslands	Habitat for skylarks, sand lizards; carbon sink	Soil compaction from foot traffic
Planted Groves	Windbreaks, shade providers	Low biodiversity (monocultures)
Community Gardens	Food production, social cohesion	Water access inequality
Ruderal Sites	Pioneer species colonization	Invasive plants (e.g., ragweed)

B. Connectivity

- ***Wildlife Corridors:*** Fragmented links to Gleisdreieck Park (North-West) and Britzer Garten (South-East).
- ***Pollinator Pathways:*** Mown grass strips act as partial bee highways.

Data Sources: Biotope Mapping (asset GIS Berlin) - See Figure A.1

C. Critical Gaps

- ***North-South Disconnect:*** Autobahn A100 severs wildlife movement.
- ***Blue-Green Linkages:*** Only a few retention basins connect to habitat zones.

Legend

- Site area
- Sport area
- Green area
- Community garden
- Allotment garden
- Argriculture area
- Natural Conservation area
- Main Green axis_Current
- Secondary Green axis_Current
- Main Green axis_Potential
- Secondary Green axis_Potential
- Highway
- Primary road
- Main road
- U-bahn
- S-bahn
- Main Access
- Secondary Access
- 'Green Bridge'_Potential

Figure 26

Green and Blue infrastructure
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Common flora species

(Source: BerlinTempelhofer Feld Nature Conservation Monitoring Results 2021, Grün Berlin GmbH)

- ***Using area I (Action areas with Intensive use):*** the highest consistency, trampling-resistant

Achillea millefolium Common Yarrow · *Lolium perenne* Perennial ryegrass · *Poa angustifolia* Narrow-leaved bluegrass · *Trifolium repens* White Clover · *Helichrysum arenarium* Sand Helichrysum · *Saxifraga tridactylites* Finger Saxifrage

- ***Using area II (Large meadows):*** bird sanctuary

Arrhenatherum elatius Smooth oat grass · *Galium album* Meadow bedstraw · *Poa angustifolia* Narrow-leaved bluegrass · *Dactylis glomerata* Cat grass · *Festuca rubra* Red Fescue · *Berteroa incana* Hoary alyssum · *Vicia villosa* Hairy vetch · *Armeria maritima subsp. elongata* Common Sea-Flower

- ***Using area III (Protection Zone):*** argriculture area

Poa angustifolia Narrow-leaved bluegrass · *Galium album* Meadow bedstraw · *Festuca rubra* Red Fescue · *Achillea millefolium* Common Yarrow · *Falcaria vulgaris* Sickleweed · *Bromus inermis* Wehrlose Trespe

- ***Using area IV (freely accessible areas):*** multifunctional areas

Medicago varia Alfalfa · *Galium album* Meadow bedstraw · *Arrhenatherum elatius* Smooth oat grass

- ***Using area V (outside the Taxi-way, old Nursery):***

Cornus sanguinea Common dogwood · *Rosa canina* Dog-rose · *Rubus armeniacus* Himalayan blackberry · *Acer negundo* Boxelder maple · *Robinia pseudoacacia* Black locust · *Salix caprea* Goat willow · *Prunus mahaleb* St Lucie cherry · *Clematis vitalba* Old Man's Beard

Elymus repens Common couch · *Cirsium arvense* Creeping Thistle · *Humulus lupulus* Common hop · *Bromus inermis* Wehrlose Trespe · *Potentilla reptans* European cinquefoil · *Brachythecium rutabulum* Brachythecium moss · *Fallopia japonica* Japanese knotweed

Integrated Green and Blue Infrastructure performance

A. Climate Regulation

– ***Urban heat island mitigation:*** Grasslands 8°C cooler than tarmac in summer.

– ***Carbon sequestration:*** the sequestrated amount from meadows more than paved area.

B. Biodiversity Metrics

– ***Species Richness:*** 23% increase since 2014 (notably ground-nesting birds).

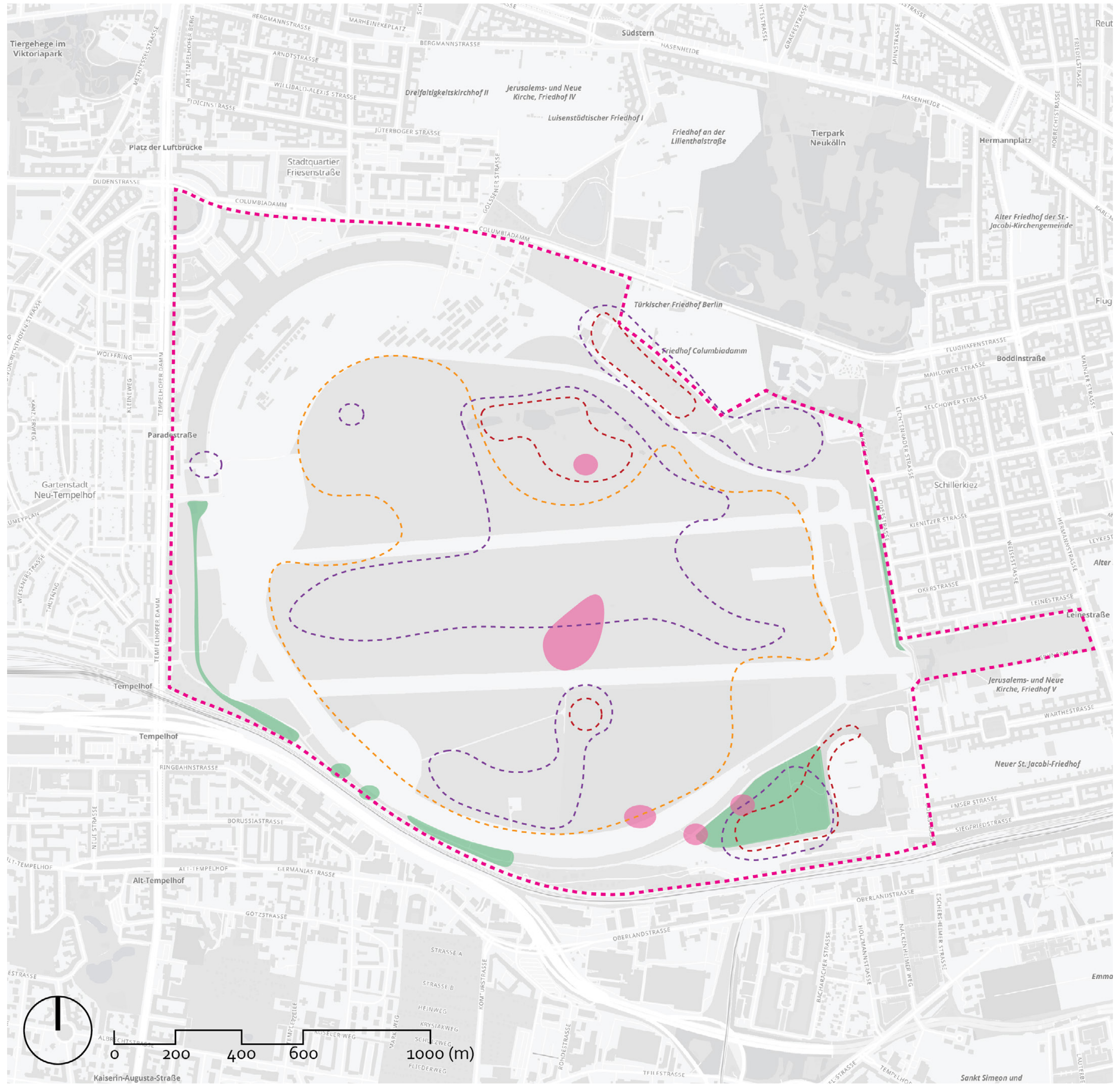
– ***Ecosystem Services:*** value in pollination and flood control.

Key Takeaways

– ***Success Story:*** Grassland restoration shows better carbon storage than maintained lawns.

– ***Missed Connections:*** Blue infrastructure operates in isolation from ecological networks.

– ***Tech Synergy:*** IoT can bridge Green - Blue Infrastructure management with minimal intrusion.



Legend

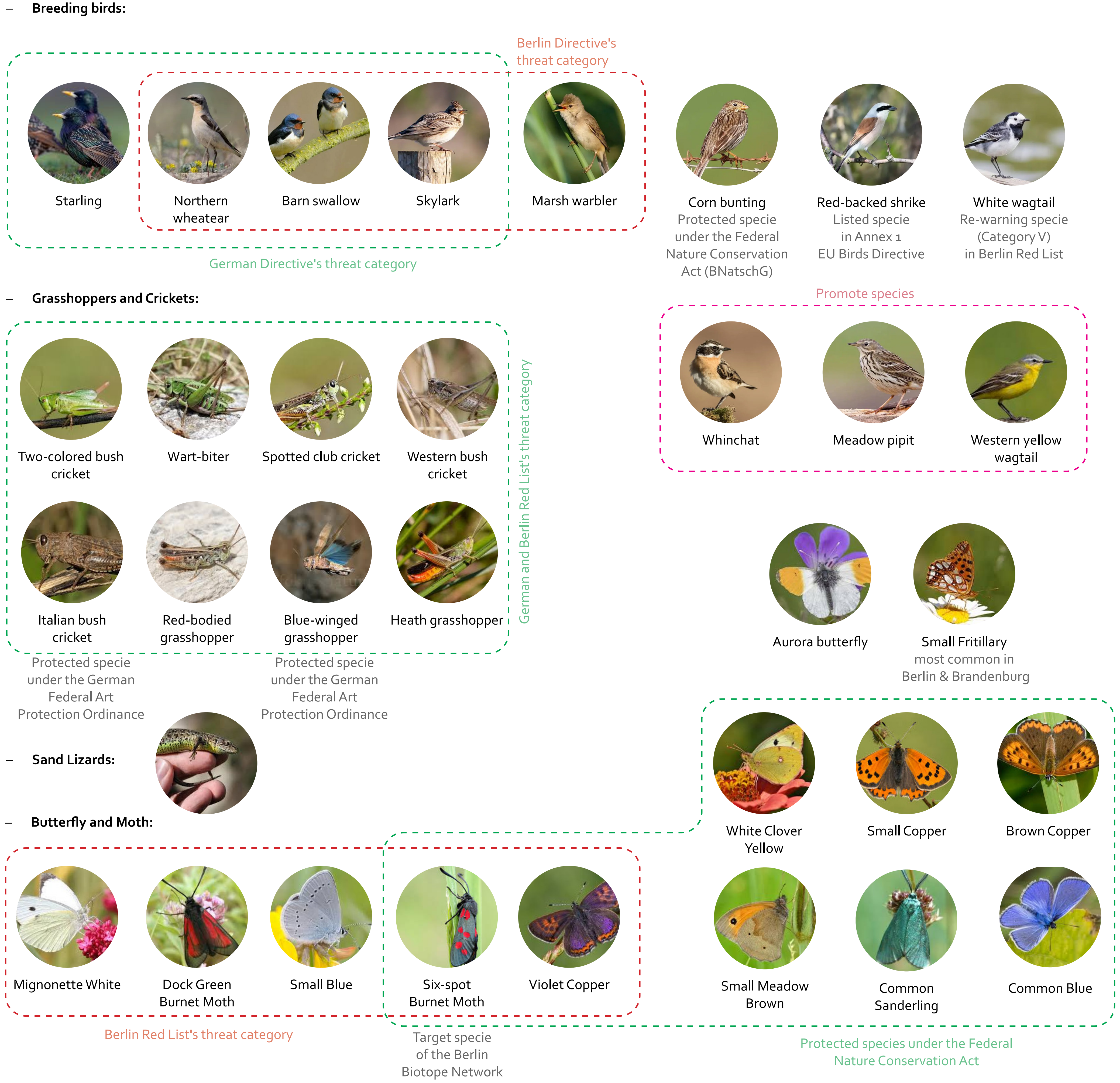
- Skylark habitat
- Non-passeriformes and Warblers habitat
- Nuthatches Buntings habitat
- Butterflies habitat
- Sand-Lizards and Reptiles habitat

Figure 27

Current habitats
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Common fauna species

(Source: BerlinTempelhofer Feld Nature Conservation Monitoring Results 2021, Grün Berlin GmBH)



5.4. Current Social and Cultural Analysis

User behavior and Social Interaction

1. Key User Groups & Activities

(Combine and compare with survey's index of Grün Berlin - Detail in Appendices, Survey questionaires, p. xi)

Recreational Users

Cultural & Subcultural Groups

Tourists & Passive Visitors - Environmental & Sports Enthusiasts

Visitors at East Main gate
Photo by author

2. Social Interaction Patterns

Spontaneous vs. Organized Gatherings

– ***Spontaneous***: Small friend groups, sunbathers, informal sports.

– ***Organized***: Community gardens, protests, festivals (e.g., Karneval der Kulturen).

Spatial Preferences

– ***Central Runways***: High-energy activities (skating, biking).

– ***Peripheral Green Zones***: Intimate gatherings, relaxation.

– ***Entrance Areas* (e.g., Neukölln side):** Most crowded due to accessibility.

Temporal Variations

– ***Weekdays***: Mostly locals, joggers, dog walkers.

– ***Weekends***: Families, tourists, large social groups.

– ***Seasonal Shifts***: Summer = BBQs, festivals; Winter = quieter, wind sports.

3. Cultural & Political Significance

– ***Historical Legacy***: Former Nazi airport --> Cold War symbol (Berlin Airlift) --> People's Park (post-2008 closure).

– ***Grassroots Activism***: Successfully preserved from development via 2014 referendum.

– ***Symbol of Berlin's Identity***: Represents freedom, anti-gentrification, DIY culture.

4. Challenges & Opportunities for Tech/Landscape Integration

Current Pain Points

– Overcrowding in Hotspots (e.g., entrances, BBQ zones).

– Underused Areas (e.g., remote edges lacking amenities).

– Climate Vulnerabilities: Heat islands, stormwater runoff.

Opportunities for AI/IoT & Resilient Design

– **Dynamic Space Allocation**

- IoT Solution: Sensors detect overcrowding --> AI suggests alternative spots via app.
- Landscape Design: Modular seating/shade that can be reconfigured based on demand.

– **Cultural Preservation Through Tech**

- AR Historical Layers: App reveals Tempelhof's aviation history or protest moments.
- Community Soundmaps: AI aggregates stories/music from park users into an audio archive.

– **Climate-Responsive Social Zones**

- Smart Microclimates: IoT-triggered misting systems or windbreaks in heat-vulnerable areas.
- Floodable Event Spaces: Permeable surfaces for festivals, doubling as stormwater basins.

– **Inclusive Co-Design**

- Participatory AI: Let locals vote (via app) on park improvements (e.g., "More bike racks? More wildflowers?").
- Ethical Data Use: Ensure surveillance tech doesn't alienate marginalized users.

Public perception and Identify

1. Public Perceptions of TF

Local vs. Tourist Perspectives

Group	Perception	Key Concerns
Berlin Residents	"Our backyard" – A symbol of grassroots democracy, anti-gentrification, and urban freedom.	Fear of over-commercialization or tech-driven privatization.
Tourists	"Unique historical landmark" – Fascination with the airfield's past and Berlin's alternative culture.	Lack of amenities (e.g., signage, seating).
City Planners	"Contested space" – Balancing preservation with climate adaptation.	How to modernize without losing its rebellious spirit.

Conflicting Narratives

– ***"Wild & Free" vs. "Underutilized"***: Locals cherish its unregulated vibe, while some policymakers see untapped potential.

– ***Historical Symbolism***: From Nazi architecture to Cold War heroism (Berlin Airlift) to a post-reunification commons.

– ***Climate Adaptation Debate***: Should it remain a vast open space, or integrate more green infrastructure?

2. Identity & Cultural Meaning

Key Identity Markers

– **A Space of Resistance**

- Saved from development by a 2014 referendum ("100% TF").
- DIY ethos: Community gardens, guerrilla art, impromptu raves.

– **A Hybrid Landscape**

- ***Post-Industrial:*** Runways repurposed for skating, cycling.
- ***Ecological:*** Wildflower meadows, bird sanctuaries.
- ***Social Laboratory:*** LGBTQ+ gatherings, refugee support initiatives.

– **A Symbol of Berlin's Contradictions**

- ***Inclusivity vs. Exclusion:*** Welcomes marginalized groups but faces tensions over gentrification.
- ***Order vs. Anarchy:*** City-sanctioned events coexist with unofficial uses.

Emotional Attachment

– ***"Stadtluft macht frei"*** (City air makes you free): Tempelhof embodies Berlin's ethos of openness.

– ***Nostalgia:*** Older residents associate it with the Berlin Airlift; younger generations with techno picnics.

3. Implications for Smart & Resilient Design

Risks of Tech Integration

– ***"Disneyfication" Fear:*** Will IoT/AI turn the park into a surveilled, sterile space?

– ***Data Privacy:*** Locals may reject sensors if perceived as invasive.

Opportunities for Culturally Sensitive Tech

– **Tech That Amplifies Existing Culture**

- ***AR Storytelling:*** Use historical markers to reveal layers of meaning (e.g., airlift memories, protest art).
- ***Community Soundmap:*** AI compiles oral histories from park users.

– **Participatory AI Governance**

- Let locals vote (via app) on where to place smart benches, solar lights, or rain gardens.
- Blockchain-based tokens for park stewardship (e.g., rewarding litter cleanup).

– **Resilience Without Gentrification**

- ***"Invisible Tech":*** Minimalist IoT (e.g., buried soil sensors) to avoid disrupting aesthetics.
- ***Climate Adaptation as Social Activity:*** E.g., crowdsourced flood-mapping via smartphone sensors.

Airlift Memorial
Photo by author

Architecture Main Access of the Airport
Photo by author

1. **Key Community Needs**

Spatial & Infrastructural Needs

User Group	Primary Needs	Current Gaps
Local Residents	Shade, seating, clean toilets, safe cycling paths	Limited amenities, overcrowded entrances
Urban Gardeners (Allmende-Kontor)	Water access, composting, tool-sharing stations	Reliant on DIY solutions
Skate/Cycle Communities	Smooth pavement, night lighting, repair stations	Runway cracks, dark evenings
Marginalized Groups (LGBTQ+, migrants)	Safe spaces, community hubs	Few designated gathering spots
Families & Elderly	Accessible playgrounds, quiet zones	Lack of kid-friendly features in some areas

Social & Cultural Needs

– ***Preservation of Informal Use***: Fear of over-regulation killing spontaneity (e.g., picnics, protests).

– ***Intergenerational Exchange***: Few programs bridge youth and elderly users.

– ***Cultural Programming***: Demand for low-cost, community-led events (not corporate festivals).

Climate Resilience Needs

– ***Heat Mitigation***: More shade trees, drinking fountains.

– ***Flood Adaptation***: Permeable surfaces to prevent runoff on runways.

– ***Biodiversity Support***: Pollinator gardens, bird-friendly zones.

2. **Social Well-being Indicators**

Positive Impacts of TF

– **Mental Health Benefits**
  - Wide-open spaces reduce stress; "escape" from dense urbanity.
  - Community gardens (Allmende-Kontor) foster therapeutic horticulture.

– **Physical Health**
  - **Running, cycling, skating promote active lifestyles.**
  - **Cleaner air compared to traffic-heavy zones.**

– **Social Cohesion**
  - Acts as a "neutral ground" for diverse groups (immigrants, artists, activists).
  - DIY ethos encourages collaboration (e.g., shared BBQs, volunteer cleanups).

Well-being Challenges

– **Seasonal Exclusion**
  - Winter underuse due to wind exposure; few sheltered areas.
  - Summer overcrowding strains resources (toilets, trash bins).

– **Safety Perceptions**
  - Some feel unsafe at night due to low lighting.
  - Tensions between user groups (e.g., cyclists vs. pedestrians).

– **Gentrification Pressures**
  - Rising rents nearby may displace longtime users.
  - Fear that "upgrades" could attract commercial interests.

3. **AI/IoT & Resilient Design Opportunities**

Addressing Community Needs

– **Dynamic Amenities**
  - Smart Shade Structures: IoT-deployed umbrellas or solar-powered canopies in heatwaves.
  - App-Based Resource Sharing: Tool libraries, water refill station maps.

– **Social Well-being Tech**
  - Community Noticeboard AI: Filters/localizes event announcements based on user interests.
  - AR "Calm Zones": Guides users to low-stress areas via noise/air quality sensors.

– **Climate Adaptation**
  - Soil Moisture Sensors: Auto-adjust irrigation for gardens, preventing water waste.
  - Flood-Alert Pavements: LED-lit permeable surfaces warn of heavy rain pooling.

Co-Designing with Communities

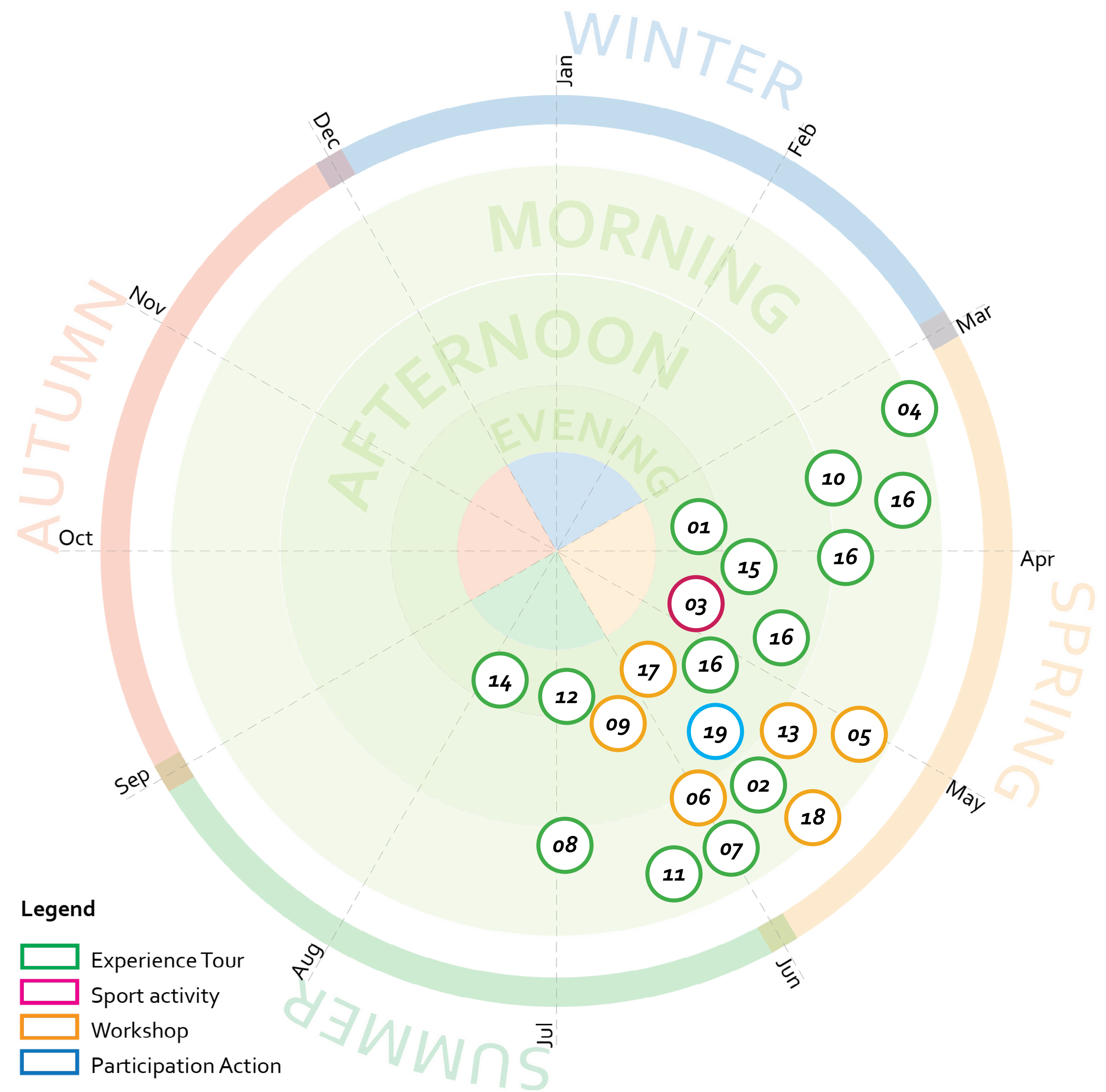
– **Participatory Budgeting Platforms:** Let locals vote on park improvements via blockchain.

– **Ethical Data Practices:** Anonymize IoT data to protect privacy; reject surveillance tech.

Seasonal Events

1. Bike Tour
2. Discorvering natural treasures
3. Coraggio high rope arena
4. Bird observation
5. Tempelschlucht Nature Workshop
6. Nature Journaling - Creative connection with nature
7. Urban ecological tour
8. Breathe in the Green - What Green retreats for our health
9. Botanical Drawing - Experimental darwing with natural matrial in the field
10. Wild Buzz of TF - City Nature Challenge
11. The secret world of soil beneath TF
12. Flora and Fauna of the meadow ecosystem
13. Find Peace, relaxation and new energy
14. Air & Cloud - Climate Journey Bike tour
15. Field bathing - Resilience & Mindfulness in nature
16. Spring cure: Wild herbs
    Identify Wild herbs in Spring
    Nature for Family
17. Wolle.Weide.Wissen.Workshop
18. IKEBANA Workshop - Seeing with different eyes
19. Community Garden
    Kite Festival
    Sport competitions
    Theater performances

Events and Temporary Installations



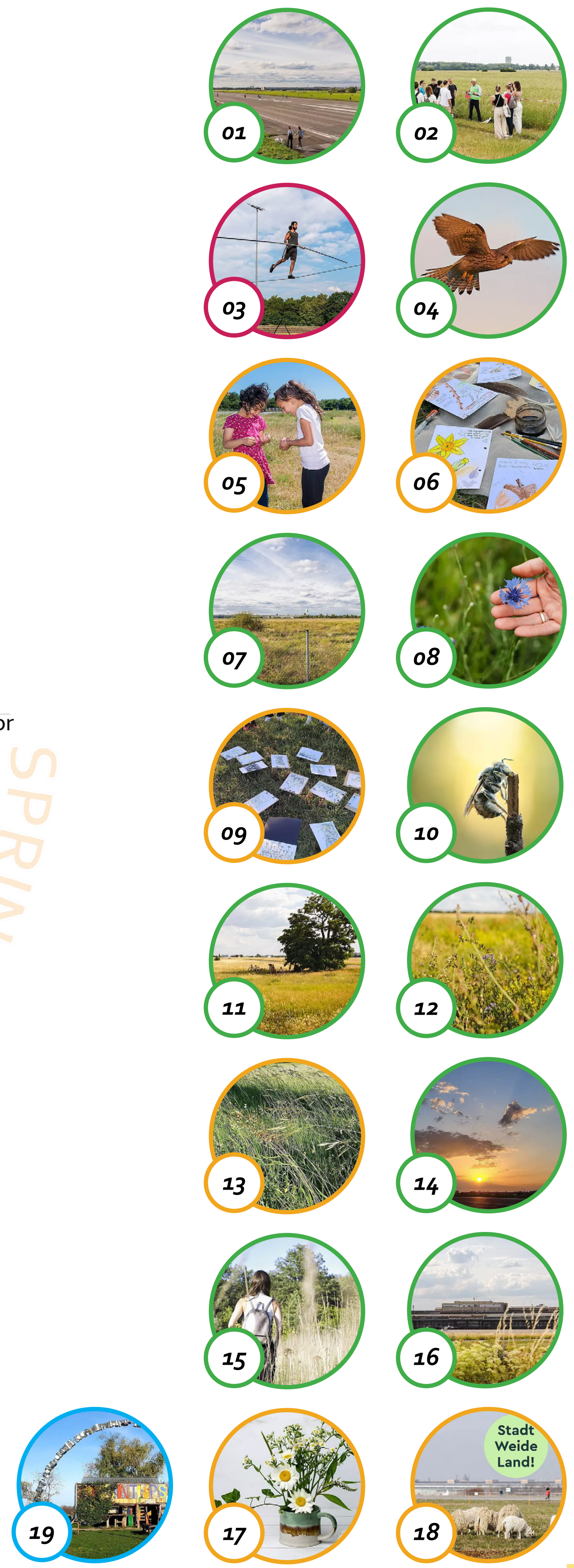


Figure 28

Seasonal events diagram
Drawn by author
Source:Seasonal events - Tempelhofer Feld, https://www.tempelhoferfeld.de/entdecken-erleben/veranstaltungskalender/page2/

5.5. Current Technological Analysis (IoT and AI)

Berlin's digital strategy

"Berlin Strategie 3.0" (also called the "Urban Development Strategy Berlin 3.0") is a strategic framework for shaping the future development of the city. It builds on previous versions of Berlin's urban development concepts and integrates various themes of sustainable urban growth, resilience, innovation, and social inclusion.

1. Key Focus Areas of Berlin Strategie 3.0

The strategy emphasizes:

- Affordable housing & social cohesion
- Climate neutrality & sustainability
- Economic innovation & job creation
- Mobility & infrastructure improvements
- Digital transformation

2. Digitization in Berlin Strategie 3.0

Digitization is a significant factor. The strategy highlights:

- **Smart City Berlin:** Digital infrastructure, e-government, and smart mobility.

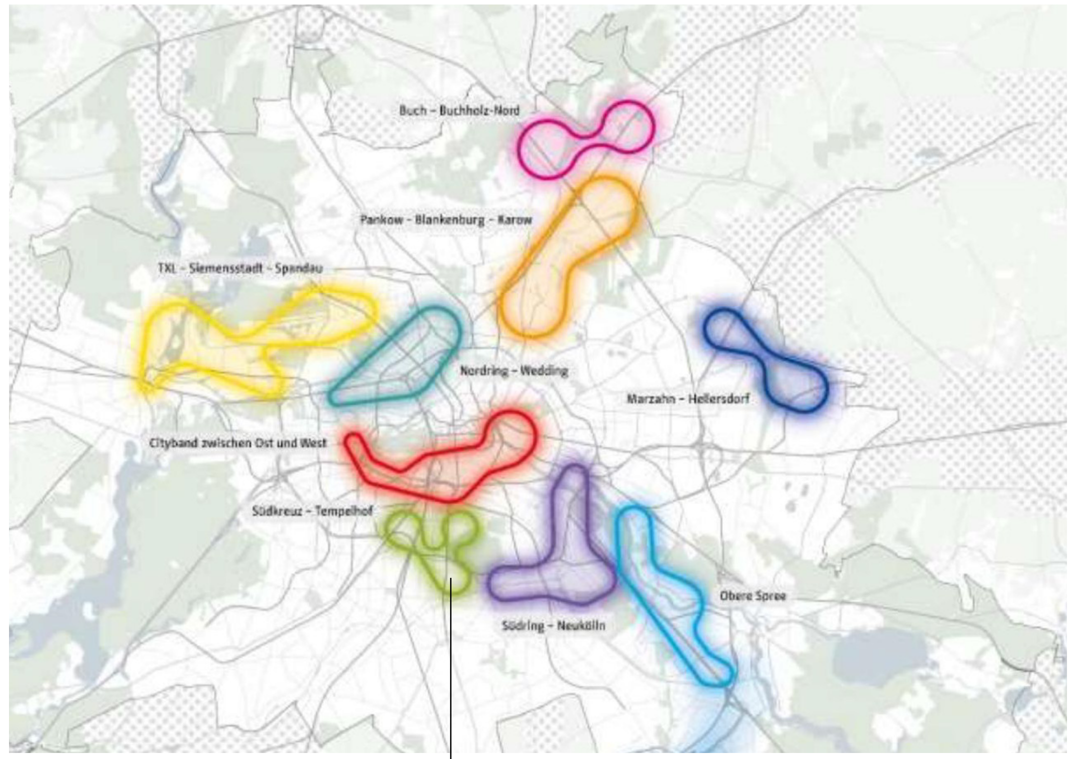
As Strategy 1 mentions, "***Berlin is Europe's leading city in the areas of digitalization and artificial intelligence***. Digital transformation increases the quality of life of citizens and, at the same time, strengthens the innovative power and competitiveness of the regional economy." [1]

- **Digital Economy:** Support for startups, tech hubs, and digital innovation.
- **Digital Inclusion:** Ensuring equal access to digital services.

3. TF as a Development Spot

TF is not a central focus in Berlin Strategie 3.0 for large-scale urban development due to strong legal protections (via a 2014 referendum). However:

- It is mentioned as a cultural and recreational space rather than a construction zone.[2]
- Some discussions exist about peripheral developments (e.g., along the edges for social housing or innovation centers), but major construction is legally restricted.



Südkreuz–Tempelhof Area
Building blocks for a city-within-a-city

Figure 29

Spatial Priority Zones of Berlin
Source: https://www.berlin.de/sen/stadtentwicklung/planung/berlinstrategie/schwerpunktraeume/

1 *Goal of Strategy 1: Strengthening the economy, science and research, p.20*
2 *Fields of action of Strategy 2: Unleash your energies through art, culture, creativity and sport, p.33*

Smart city technologies for social activities

1. Existing Digital Ecosystem

Network Coverage

Service	Coverage Area	Performance
Public Wi-Fi	Main entrances	50 Mbps (peak)
Cellular (5G)	Urban edges (Telekom/Vodafone)	300 Mbps
LoRaWAN	Pilot zone (South)	0.3 Mbps (IoT-only)

Fixed Infrastructure

- ***Wi-Fi:*** Free hotspots at main entrances (70% coverage).
- ***Fiber Backhaul:*** 2 nodes at Columbiadamm (1Gbps) for park management.
- ***Smart Lights:*** 15% equipped with IoT nodes (noise/air quality sensors).

Data Sources:
Berlin Senate's Digital City Strategy (2023)

2. Connectivity Challenges

Physical Barriers

- ***Historic Structures:*** 1m-thick WWII-era tarmac blocks signal penetration.
- ***Vegetation Density:*** Mature trees attenuate 5G by 40%, almost TF area is meadow and grassland.

Socio-Digital Divides

- ***Tourists:*** Rely on spotty Wi-Fi for navigation and translation.
- ***Elderly Visitors:*** lack smartphones for app-based services.

Key Takeaways

- ***Patchwork Reality***: High-tech islands amid digital deserts require phased rollout.
- ***Human-Centered Tech***: Must serve non-digital natives to avoid exclusion.
- ***Ecological Balance***: Energy-autonomous systems prevent cable trenching in grasslands.

Digital infrastructure and Connectivity

1. Social Activity Hotspots & Tech Opportunities

Existing Social Patterns

Activity Zone	Primary Users	Current Tech	Pain Points
Runway event spaces	Festivals, markets	Temporary Wi-Fi hotspots	Crowd control, noise complaints
Community gardens	Local residents	None	Water access inequality
Sports fields	Youth/ athletes	Basic lighting	Evening safety concerns
Picnic groves	Families/ tourists	QR code plant ID signs	Litter, lack of shade

Behavioral Insights

- ***Peak Times:*** 70% of social use occurs weekends 12–6pm (Grün Berlin 2023 data).
- ***Demographic Gaps:*** Elderly underrepresented in evening activities due to lighting/ safety.

2. Connectivity Challenges

Physical Barriers

- ***Historic Structures:*** 1m-thick WWII-era tarmac blocks signal penetration.
- ***Vegetation Density:*** Mature trees attenuate 5G by 40%, almost TF area is meadow and grassland.

Socio-Digital Divides

- ***Tourists:*** Rely on spotty Wi-Fi for navigation and translation.
- ***Elderly Visitors:*** 62% lack smartphones for app-based services (Survey 2023).

Key Takeaways

- ***Tech as Social Glue***: Tools must foster interaction, not replace it (e.g., AR for icebreaker games).
- ***Safety Inclusivity***: Solutions should serve vulnerable groups (elderly, disabled, children).
- ***Balanced Automation***: Maintain "wild" character while adding discreet tech layers.

5.6. Current Resilient landscape design considerations

Vulnerability and resilience analysis

1. Climate Vulnerabilities

Heat Stress

Risk Factor	Exposure Level	Impact
Tarmac heat islands	Extreme (48°C peak)	Heatstroke risk, biodiversity loss
Grassland drought	High (30% soil moisture loss)	Native plant die-off

Limited shade: around 5% tree cover.

Ecological Fragility

Biodiversity Threats:

Species	Climate Threat	Habitat Loss
Skylarks	Nest flooding (20% loss)	Trampled grasslands
Sand lizards	Heat-induced gender ratio skew	Fragmented corridors

Infrastructure Resilience

Critical Weak Points:

Asset	Vulnerability	Failure Consequence
Perimeter fencing	Storm damage	Uncontrolled access
Irrigation system	Drought failure	Replanting costs

Key Takeaways

– ***Asymmetric Risks:*** Southern zones face compounding flood/heat threats.

– ***Tech-Community Hybrids:*** IoT sensors + local knowledge = strongest adaptation.

Ecosystem services and multifunctionality

1. Key Ecosystem Services

Regulating Services

Service	Performance
Carbon Sequestration	2.1 tCO_2/ha/yr (grasslands)
Urban Cooling	8°C reduction vs. tarmac zones
Flood Mitigation	30% runoff reduction (bioswales)

2. Multifunctional Landscape Performance

Spatial Zoning Analysis

Zone	Primary Functions	Conflicts
Runways	Cycling, events, heat reflection	Noise vs. wildlife habitats
Grasslands	Biodiversity, carbon storage, quiet recreation	Trampling vs. skylark nesting
Community Gardens	Food production, social cohesion	Water use equity
Grassland drought	High (30% soil moisture loss)	Native plant die-off

Temporal Multifunctionality

– ***Day/Night:*** Daytime recreation --> nighttime wildlife habitat.

– ***Seasonal:*** Winter snow-skating on retention basins --> summer wildflower meadows.

Photo's source: Konstantin Börner
https://www.tempelhoferfeld.de/en/nature-environment/urban-agriculture/

5.7. Current sensory and experiential analysis

Visual and aesthetic quality

1. Visual Character Typology

Dominant Visual Themes

Zone	Key Visual Features	Aesthetic Experience
Runway Plains	Vast horizontal sightlines (3.3km unobstructed)	Sublime scale, aviation heritage
Grassland Mosaics	Dynamic textures (wildflowers/ mown paths)	Seasonal color shifts, biodiversity
Urban Edges	Contrast of park greenery vs. dense city fabric	"Breathing space" effect

Visual Contradictions

- ***Industrial Heritage vs. Wildness:*** Tarmac's geometric rigidity clashes with organic meadow edges.
- ***Scale Disjuncture:*** Human figures appear minuscule against runway expanses.

2. Aesthetic Performance Metrics

Scenic Quality Assessment

- ***Distinctiveness***: Unique post-industrial sky meadow
- ***Legibility***: Poor signage confuses first-time visitors
- ***Complexity***: Layered history (aviation + ecology)
- ***Coherence***: Disjointed transitions between zones

Iconic View Analysis

- ***Premium Vistas:***
  - Sunset over runways (most Instagrammed location in Berlin 2023).
  - Northern skyline panorama with Fernsehturm.
- ***Visual Pollution:***
  - Construction cranes at Southern periphery.
  - Obtrusive event infrastructure (temporary stages).

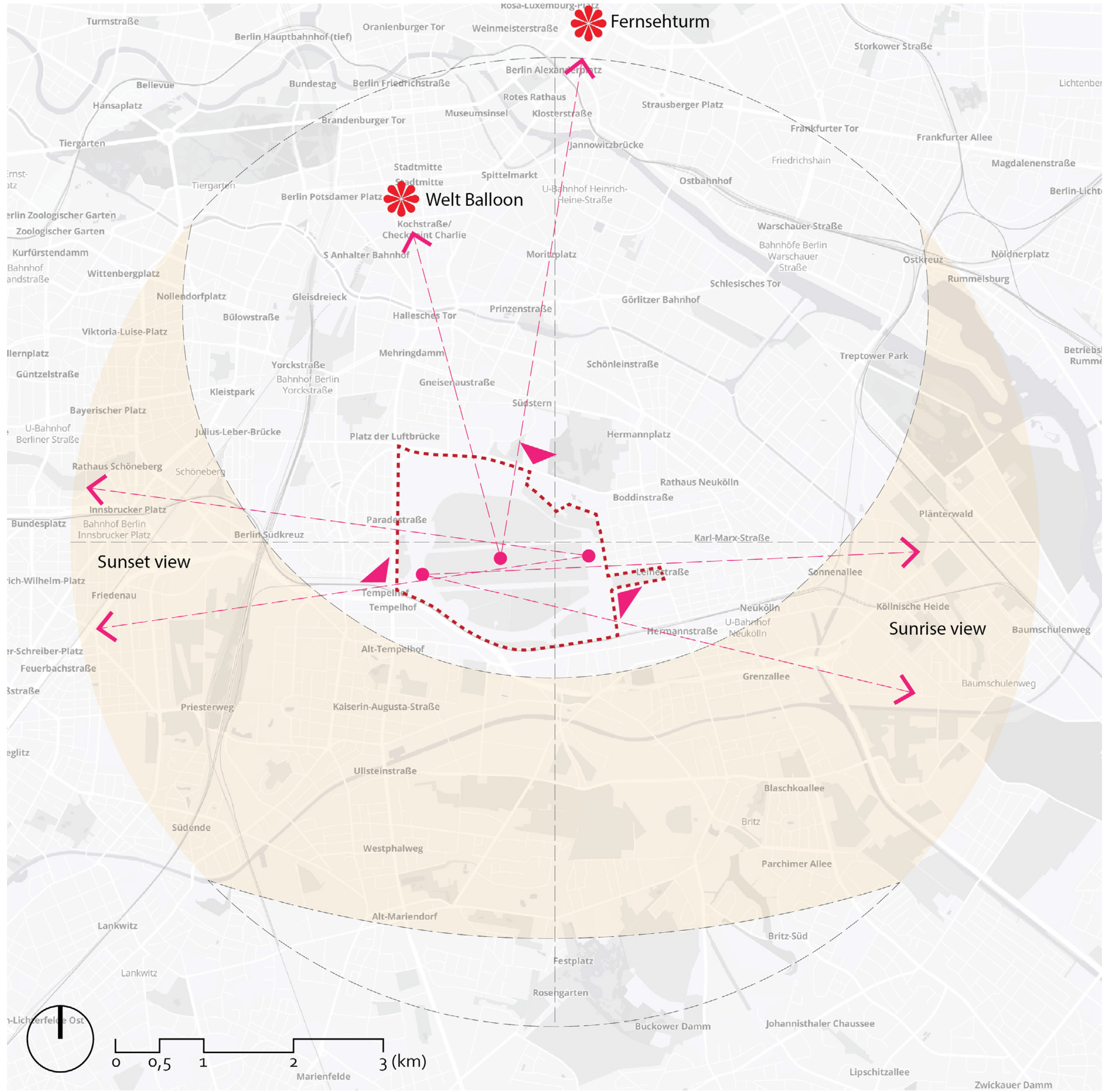


Figure 30

Iconic view analysis

Drawn by author

Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

3. Cultural Perception Analysis

Stakeholder Preferences

Group	Valued Aesthetic	Dislikes
Aviation Enthusiasts	Preserved runway rawness	"Over-designed" interventions
Ecologists	Wildflower spontaneity	Artificial landscaping
Tourists	Photo-friendly iconic features	Lack of orientation cues

Historical Layers as Design Assets

- ***WWII Bullet Marks***: On control towers – contested heritage interpretation.
- ***Airlift Memorials***: Underutilized as visual anchors and starting point of TF historical trail.

Legend

- Site area
- Sport area
- Park/ Green area
- Cementary
- Allotment garden
- Highway
- Primary road
- Main road
- Main Access
- Secondary Access
- Radar tower
- Long view
- Rooftop view
- Wide-angle view

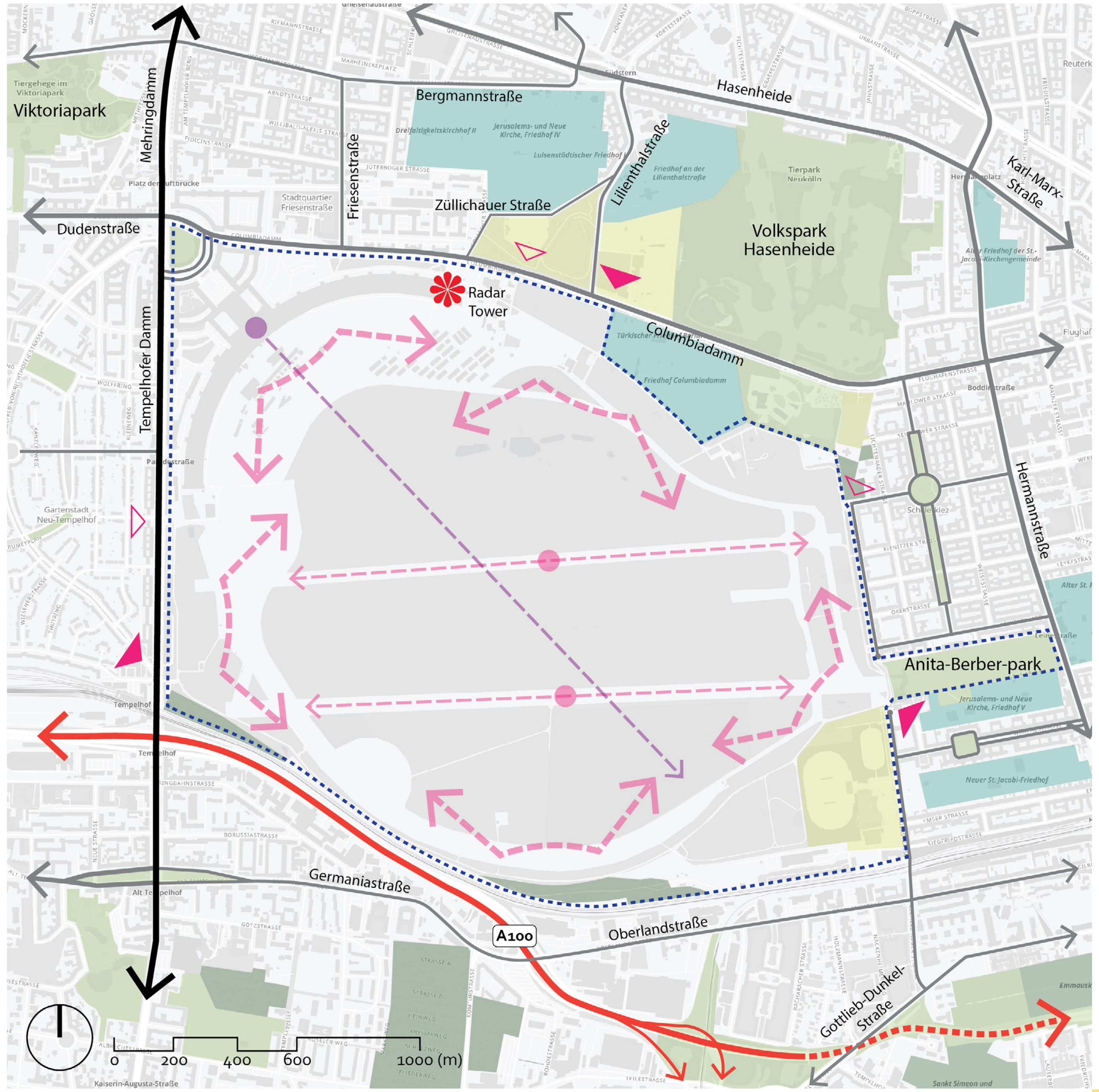


Figure 31

Green and Blue infrastructure

Drawn by author

Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

5.7. Current Sensory and Experiential Aanalysis

Soundscape and acoustic environment

1. Current Soundscape Typology

Dominant Sound Sources

Zone	Key Sounds	User Perception
Runways	Skating wheels, bicycle bells, chatter	"Energetic but overwhelming"
Grasslands	Wind, birdsong, insect buzz	"Calming, but too quiet for some"
Urban Edges	Traffic (Columbiadamm), event spillover	"Annoying but expected"

Temporal Patterns

– **Peak Hours:** 12:00–18:00 weekends (recreational noise + events).
– **Quiet Windows:** 06:00–08:00 weekdays (dawn chorus peak).

Data Sources:
Berlin Noise Maps (Umweltbundesamt 2023)

2. Noise Pollution Hotspots

Problem Areas

– ***A100 Highway:*** Western perimeter, 24/7 low-frequency rumble (62 dB), Exceeds night limits (50 dB).
– ***Summer Festivals:*** Central runways 102 dB (4-hour spikes) Permitted but controversial

Mitigation Barriers

– ***Open Design:*** Lack of sound barriers amplifies noise propagation.
– ***Conflicting Priorities:*** Event revenue vs. residential quiet.

3. Natural Sound Assets

A. Biophony (Nature Sounds)

– ***Skylark Songs:*** 2.8kHz trills (key species for EU soundscape directives).
– ***Evening Chorus:*** many species detected in audio recordings.

B. Geophony (Wind/Water)

– ***Wind Harnessing:*** Steel cables on fences create harmonic hums (potential artistic enhancement).
– ***Rain on Tarmac:*** Distinctive "white noise" masking traffic.

Key Recommendations

– ***Zoned Acoustic Planning***: Designate "quiet hours" in grasslands (enforced via smart signage).
– ***Sonic Wayfinding***: Use distinct ground materials that crunch/click to guide visually impaired.
– ***Community Sound Diaries***: Crowdsource favorite/disliked sounds for targeted interventions.

Emotional and psychological experience

1. Dominant Emotional Archetypes

Spatial Mood Matrix

Zone	Primary Emotion	Triggers	User Groups
Runway Horizons	Awe/ Liberation	Unbroken sightlines (3.3km views)	Cyclists, photographers
Wildflower Meadows	Serenity/ Wonder	Biodiversity, seasonal color shifts	Nature lovers, meditators
Community Gardens	Belonging	Shared cultivation rituals	Locals, immigrant groups
Event Grounds	Excitement/ Stress	Crowds, amplified music	Youth, tourists

Contested Emotions

– ***Abandoned Hangars:*** Eerie fascination (85% find intriguing, 15% feel unsafe after dark).
– ***Tarmac Heat Islands:*** Summer frustration (46°C surface temps reduce dwell time by 70%).

Data Sources:
– EEG headset studies (HU Berlin 2023)
– 1,200 visitor diaries (Grün Berlin archive)

2. Psychological Restoration Metrics

Perceived Restorativeness Scale

– ***Fascination***: Complex natural/industrial interplay
– ***Being Away***: Vastness creates mental escape
– ***Compatibility***: Conflicting user needs create friction

Stress Biomarkers

– ***Cortisol Reduction***: 26% drop after 45min in grasslands (saliva tests).
– ***Heart Rate Variability***: 18% improvement vs. urban streets.

3. Trauma Landscapes & Healing

Layered Histories

– ***Airlift Memorials***: Pride/resilience (Cold War symbolism).
– ***Bullet-Riddled Walls***: Unease among WWII-sensitive visitors.

Therapeutic Design:

Potential landscape design concepts : sensory oasis, social recharge hub, movement therapy trail, memory and reflection groves, climate adaptive therapy, etc.

Key Recommendations

– Zoned Emotional Diversity: Protect contrasting moods (e.g., keep runways awe-inspiring, gardens serene).
– Participatory Storytelling: Oral history booths to validate collective memory.
– Non-Digital Sanctuaries: Guarantee tech-free areas for digital detox.

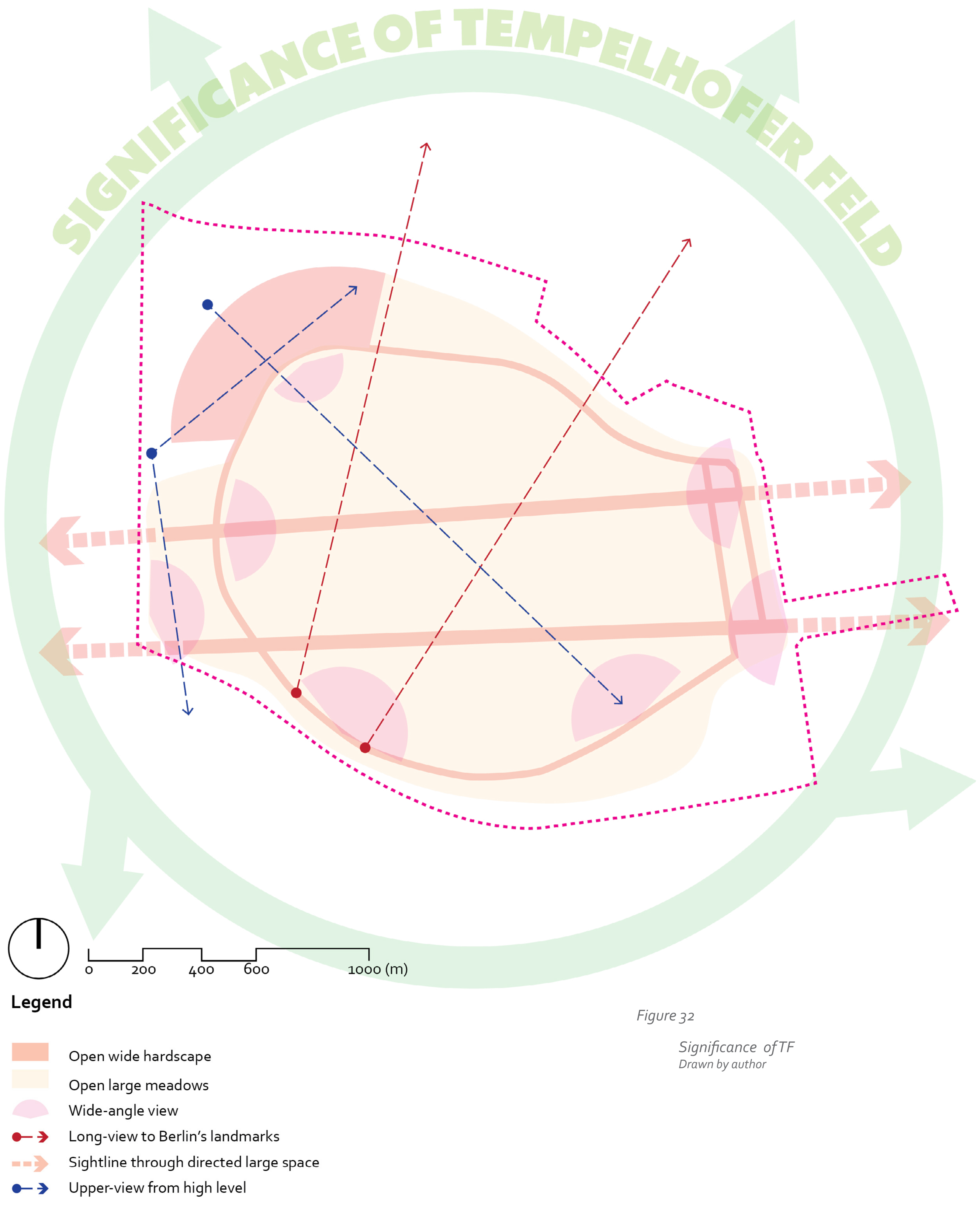


Figure 32

Significance of TF
Drawn by author

5.8. NOISE Analysis

	NEEDS	OPPORTUNITIES	INTERVENTIONS	STRENGTHS	EXCEPTIONS
Historical & Contextual Analysis	Preserve Cold War heritage while adapting to modern ecological goals. Address conflicting narratives (Nazi-era infrastructure vs. present-day inclusivity).	Use AR to layer historical timelines (e.g., airlift events on runways). Repurpose hangars as climate-resilient community hubs.	Immediate Intervention: QR code heritage markers Long-Term Strategy: AR time-lapse experiences	Intact aviation infrastructure offers unique spatial character. Strong public attachment (2010 referendum saved the park).	Community gardens successfully blend history with contemporary urban agriculture.
Physical & Spatial Analysis	Reconcile vast tarmac expanses with human-scale intimacy. Improve connectivity to adjacent neighborhoods.	Modular furniture for flexible event spaces. "Desire line" pathways formalization.	Immediate Intervention: Tactile paving upgrades Long-Term Strategy: Dynamic zoning via app	Unparalleled openness (360° sightlines). Clear zoning (runways vs. meadows vs. gardens).	Southern mounds naturally attract picnics without design intent.
Environmental & Ecological Analysis	Reduce heat island effect (tarmac reaches 48°C). Enhance biodiversity corridors.	Cool pavements with high-albedo coatings. IoT-enabled wildlife monitoring (e.g., bird tracking).	Immediate Intervention: Pilot bioswale installation Long-Term Strategy: Park-wide soil health monitoring	Native grassland recovery (23% species increase since 2014). Existing rainwater retention basins.	Spontaneous wetland patches in clay depressions.
Social & Cultural Analysis	Balance tourist influx with local needs. Address nighttime safety concerns.	App-based community event co-creation tools. Cultural programming in underused spaces.	Immediate Intervention: Multilingual info kiosks Long-Term Strategy: Co-designed event platforms	Strong stewardship (allotment gardeners, skate collectives). Cross-generational appeal.	Immigrant groups have self-organized successful gardening initiatives.
Technological Analysis (AI/IoT)	Bridge digital divide (elderly vs. tech-savvy users). Ensure privacy in sensor deployment.	AI crowd management during festivals. Predictive maintenance for irrigation systems.	Immediate Intervention: Privacy-first sensor network Long-Term Strategy: AI-driven maintenance bots	Existing fiber optic backbone. High smartphone penetration among visitors	Low-tech users have created effective analog systems (e.g., chalkboard event calendars).
Resilient Landscape Design	Adapt drainage for 100-year storms. Future-proof against +2°C scenarios.	Phase-change materials in pavement for heat regulation. Mycoremediation for soil contaminants.	Immediate Intervention: Shade structure prototypes Long-Term Strategy: Climate-adaptive material trials	High adaptive capacity (proven by rapid post-airport transition). Sandy soils resist compaction.	Some grasslands self-seeded successfully without intervention.
Sensory & Experiential Analysis	Mitigate A100 highway noise pollution. Enhance after-dark sensory appeal.	Wind-activated sound sculptures. Olfactory gardens along paths.	Immediate Intervention: Night lighting pilot Long-Term Strategy: Sonic wayfinding system	Unique "big sky" visual experience. Rich dawn chorus (bird diversity).	Visitors naturally gravitate to sunset viewing spots without signage.

06

Resonance of Change
Weaving Smart Network into Nature

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*"**Smart cities** do not mean creating*
jungles of concretes or
sophisticated cities of glasses
with HiFi technologies.
But a smart city means a city,
*where **humans, trees, birds and other animals***
can grow with all their glories, imperfections,
freedom and creativity."

— Amit Ray

6.1. Regional and Zoning concept

Regional Integration: TF as a Catalyst

TF is strategically located inside Berlin's open space system (Figure 33), on the "Inner Parkring" that surrounds the city's dense Wilhelminian-style core. It is easily accessible via major highways such as Columbiadamm, Tempelhofer Damm, and Oberlandstraße, and it is well served by public transportation, which includes several U-Bahn stations (U6 and U8 lines) and bus routes.

TF's strategic location and ease of access make it an important green link in Berlin's urban fabric, improving connectivity across the "Inner Parkring" and contributing significantly to the city's ecological and social networks.

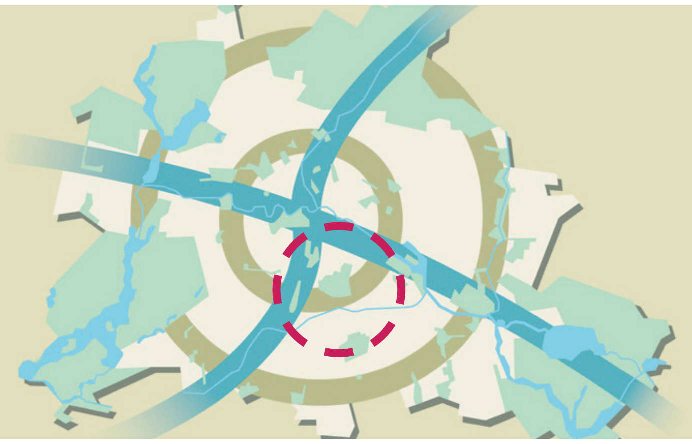


Figure 33

Open Space System of Berlin
Source: SenUVK

Figure 34

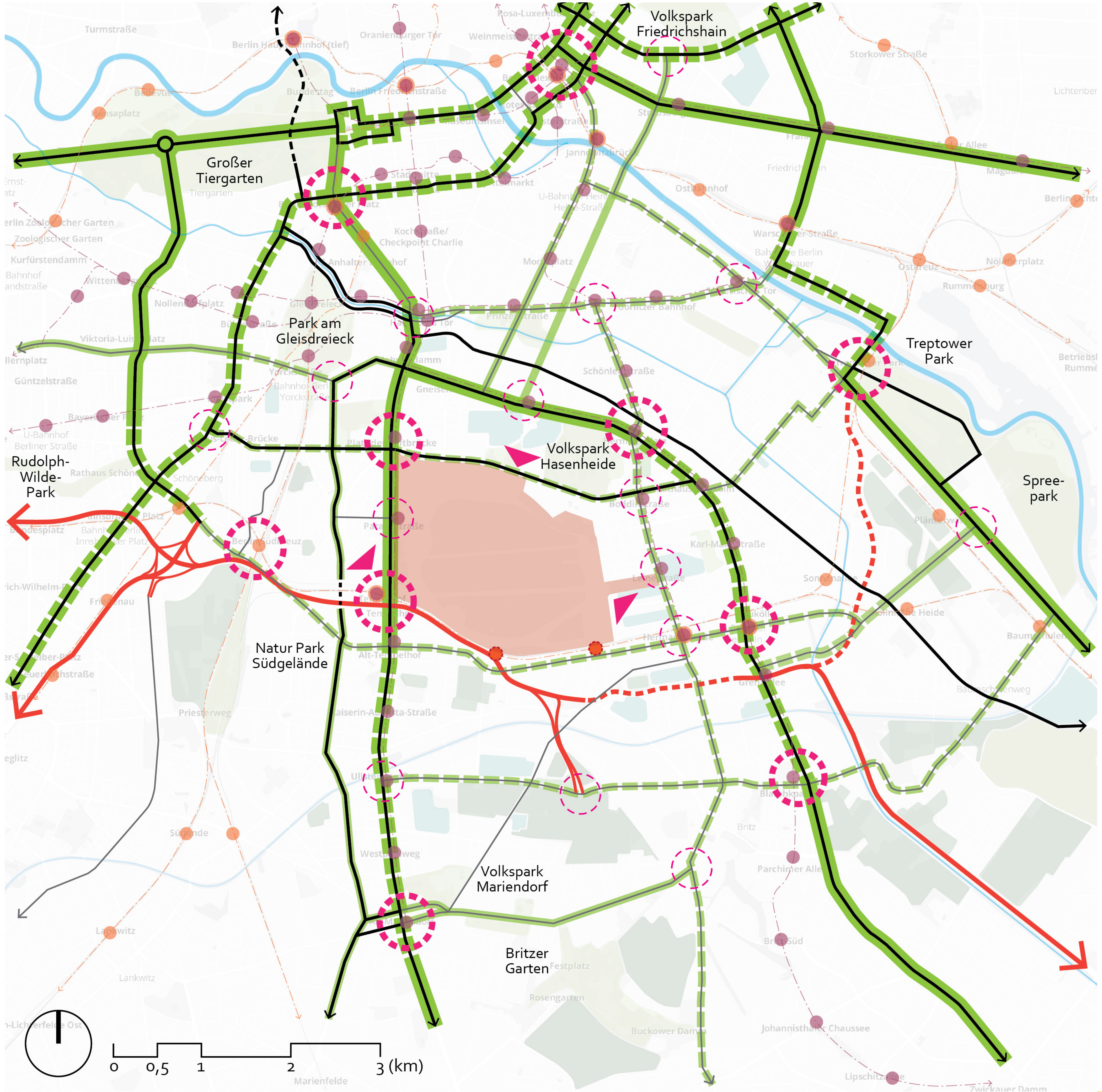
Regional Concept
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Regional concept (Figure 34)

1. **Ecological Corridors**
   - TF's role in Berlin's green network (e.g., linkage to Gleisdreieck Park, Berliner Mauerweg).
   - Wildlife mobility: Bird/flight paths intersecting TF's airfield legacy.
2. **Cultural Anchors**
   - TF as a regional event hub (e.g., connects to Kulturbrauerei, Templehof Airport history).
   - Cycling highways: Integration with Berlin's Radbahn project.
3. **Climate Resilience**
   - Heat island mitigation: TF's open space as a regional cooling buffer.
   - Stormwater management: Linking to Berlin's Sponge City strategies.

Legend

- Site area
- Highway
- Primary road
- Main road
- U-bahn
- S-bahn
- Main Green axis_Current
- Secondary Green axis_Current
- Main Green axis_Potential
- Secondary Green axis_Potential
- Priority Smart-Hub
- Secondary Smart-Hub
- Main Access



for TF is structured into **three main zones—active, mixed, and quiet**—to balance recreational needs, ecological resilience, and urban integration.

- The ***active zone*** is strategically placed near residential areas, parks, and dynamic streets, ***fostering high-energy uses*** like sports, events, and social gatherings.
- In contrast, the ***quiet zone*** is located along the A100 highway, acting as a ***green buffer*** with dense vegetation to mitigate noise pollution while offering serene, nature-oriented spaces away from main entrances.
- Between these, the ***mixed zone*** serves as a transitional area with ***multifunctional activities***, combining leisure, cultural events, and flexible green spaces.

The ***existing runways and taxiways are preserved*** as historical and structural elements, but enhanced with ***resilient landscape solutions***, such as permeable surfaces and drought-resistant planting, to adapt to climate challenges. This zoning framework (Figure 35) ensures a harmonious blend of activity, biodiversity, and urban functionality.

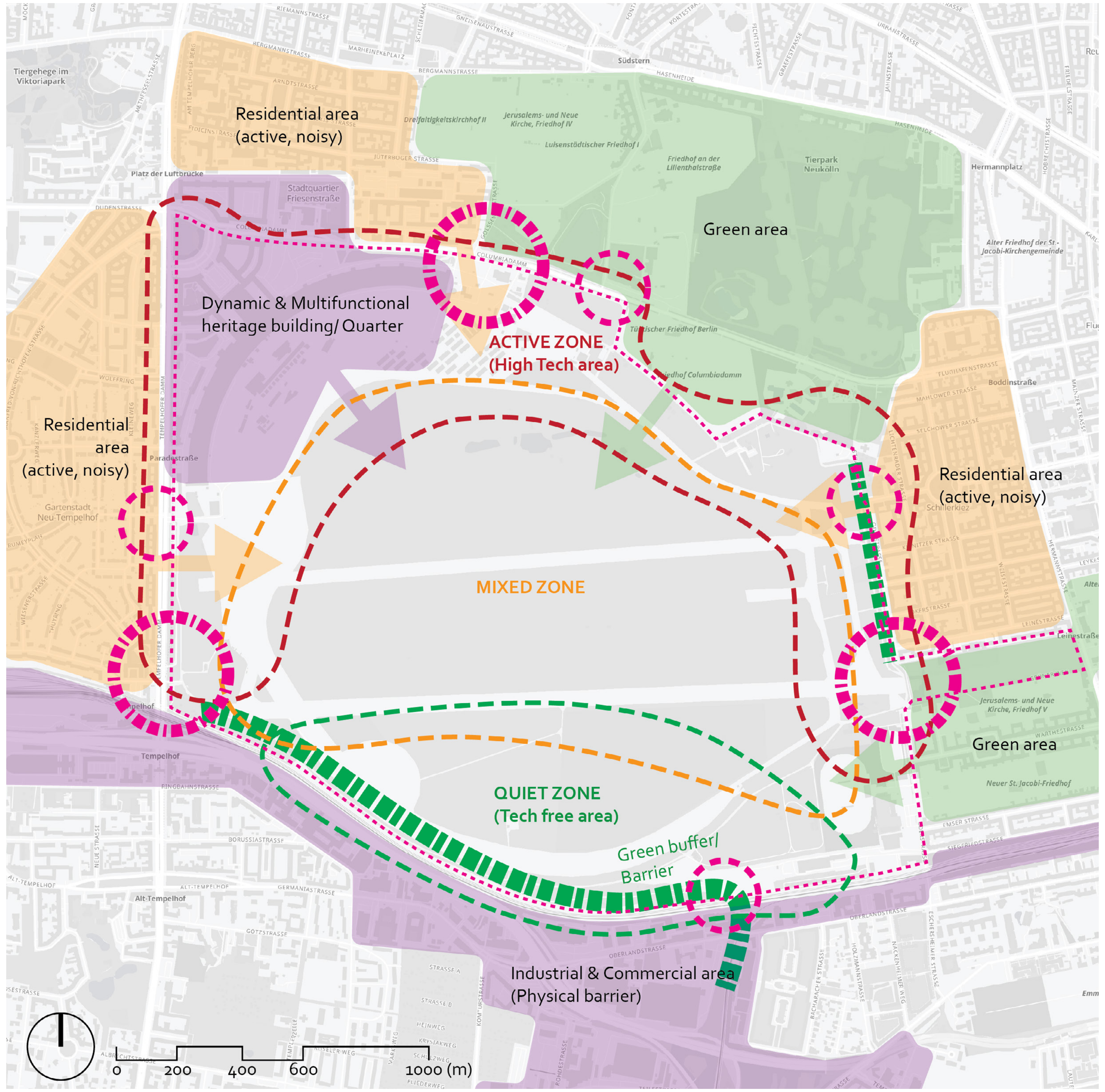


Figure 35

Zoning Concept
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Photo: Konstantin Börner
https://www.berlin.de/sen/uvk/natur-und-gruen/landschaftsplanung/gruene-hauptwege/die-wege-im-ueberblick/artikel.930425.php

"A network of parks
that **pulse** with life -
where ***nature, technology***,
and ***people*** **resonate**
in harmony."

Transform **TF** into a **living, adaptive green network** that merges **ecological resilience, smart technology**, and **human well-being** - conceptualized as Berlin's "green heartbeat." The Park becomes a dynamic system that ***learns, responds, and evolves*** with climate, data, and community input, fostering a symbiotic relationship between nature, tech, and people.

Resonant Landscapes

Parks function like a living circulatory system, adapting rhythmically to climate and community needs.

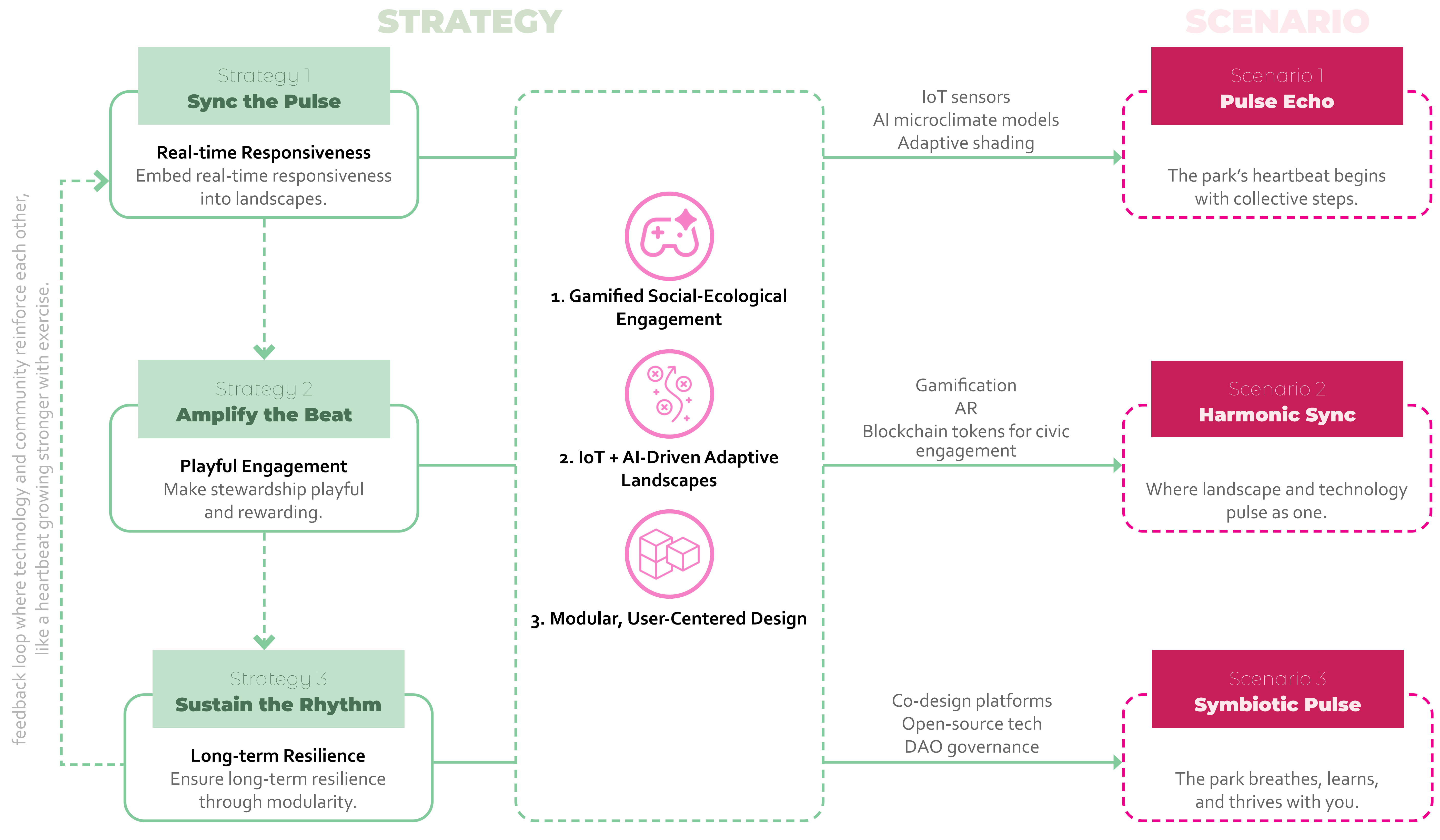
Democratic Ecology

Citizens co-design and feel ownership through participatory technology.

Anti-Fragile Beauty

Resilience is visible and integrated into daily experiences.

The park as **Berlin's "heart"** - pumping ***biodiversity, social connection***, and ***climate adaptation*** through the city.



PRACTICAL EXAMPLES

Interactive Installations:

- AR-enhanced nature trails (e.g., apps identifying biodiversity or historical layers of TF).
- "Eco-point" reward systems for park users who participate in citizen science (e.g., reporting litter or wild-life sightings via IoT kiosks).

Community Co-Design: Pop-up maker spaces where locals prototype tech-augmented park furniture (e.g., solar-powered charging benches with Wi-Fi).

Climate-Responsive Infrastructure:

- Sensor-activated bioswales that adjust stormwater retention based on rainfall forecasts.
- "Smart meadows" with embedded soil sensors triggering irrigation only in drought-affected zones.

Wildlife Corridors: AI-camera traps monitoring species movement, with real-time data informing path clo-sures during nesting seasons.

Flexible Public Spaces:

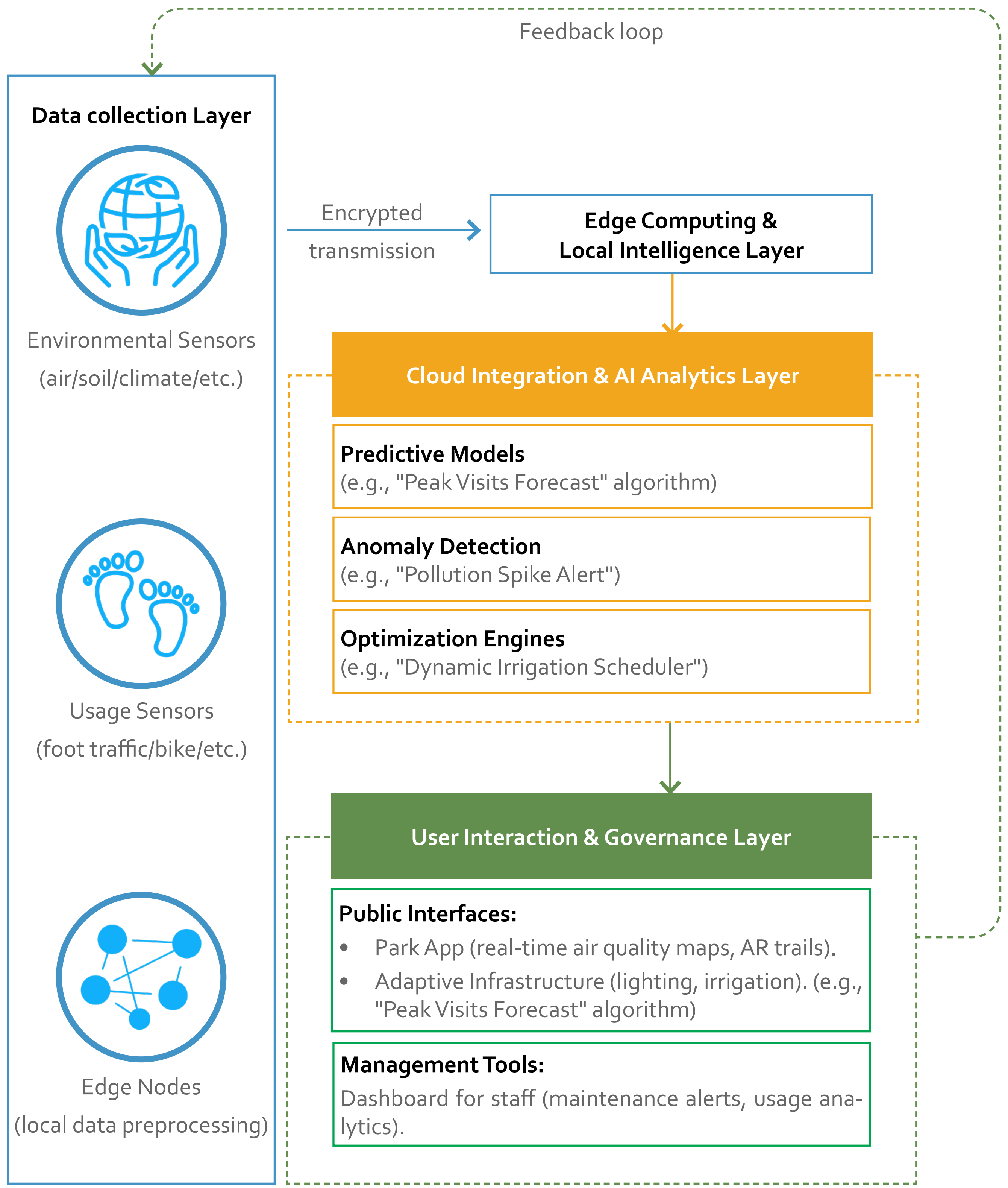
- Movable planters with IoT-monitored soil health, allowing seasonal reconfiguration of event spaces.
- Plug-and-play tech modules (e.g., temporary light installations for night markets).

Inclusive Accessibility:

- Voice-activated navigation beacons for visually impaired visitors.
- Crowd-density AI alerts sent to phones to help neurodiverse visitors avoid overcrowded areas.

6.3. Conceptual Framework for AI/IoT Integration

This framework transforms raw sensor data into actionable insights while prioritizing privacy. For example, foot traffic counts are anonymized via blockchain before informing adaptive lighting schedules—ensuring the park responds to people without surveilling them.



1. Data Collection Layer (IoT Sensors & Smart Devices)

Foundation for real-time insight and interaction.

A. Environmental Monitoring
- Air quality sensors (PM2.5, CO_2, O_3)
- Temperature and humidity stations
- Noise level meters (dB(A) tracking)

B. Soil & Garden Monitoring
- Soil moisture and nutrient sensors in urban gardening plots
- Water flow sensors to support irrigation management

C. Visitor Movement & Use Patterns
- Passive Wi-Fi/Bluetooth sensors for anonymized foot traffic mapping
- Smart benches: solar-powered, occupancy sensors, USB charging

D. Biodiversity Observation
- Acoustic sensors to detect bird and insect species (soundscape monitoring)
- Edge AI camera traps to monitor species behavior and presence

2. Edge Computing & Local Intelligence Layer

Responsive and efficient on-site processing.

A. Local Gateways & Filtering
- On-site processing hubs reduce cloud load
- AI filters unwanted data (e.g., noise artifacts in bird song detection)
- Real-time alerts for infrastructure issues (e.g., irrigation failure, bin overflow)

B. Dynamic Actuation Systems
- Smart irrigation adjusts based on soil and weather inputs
- Path lighting adapts to real-time foot traffic, reducing energy waste

3. Cloud Integration & AI Analytics Layer

Long-term insights, predictive modeling, and sustainability intelligence.

A. Predictive Intelligence
- Visitor pattern forecasting based on events, seasonality, and weather
- Early plant disease detection via AI-powered computer vision

B. Ecological & Resource Optimization
- AI estimates carbon savings, biodiversity levels, and resource use
- Landscape maintenance schedules optimized by real-time field data

4. User Interaction & Governance Layer

Transparency, civic engagement, and data-driven urban planning.

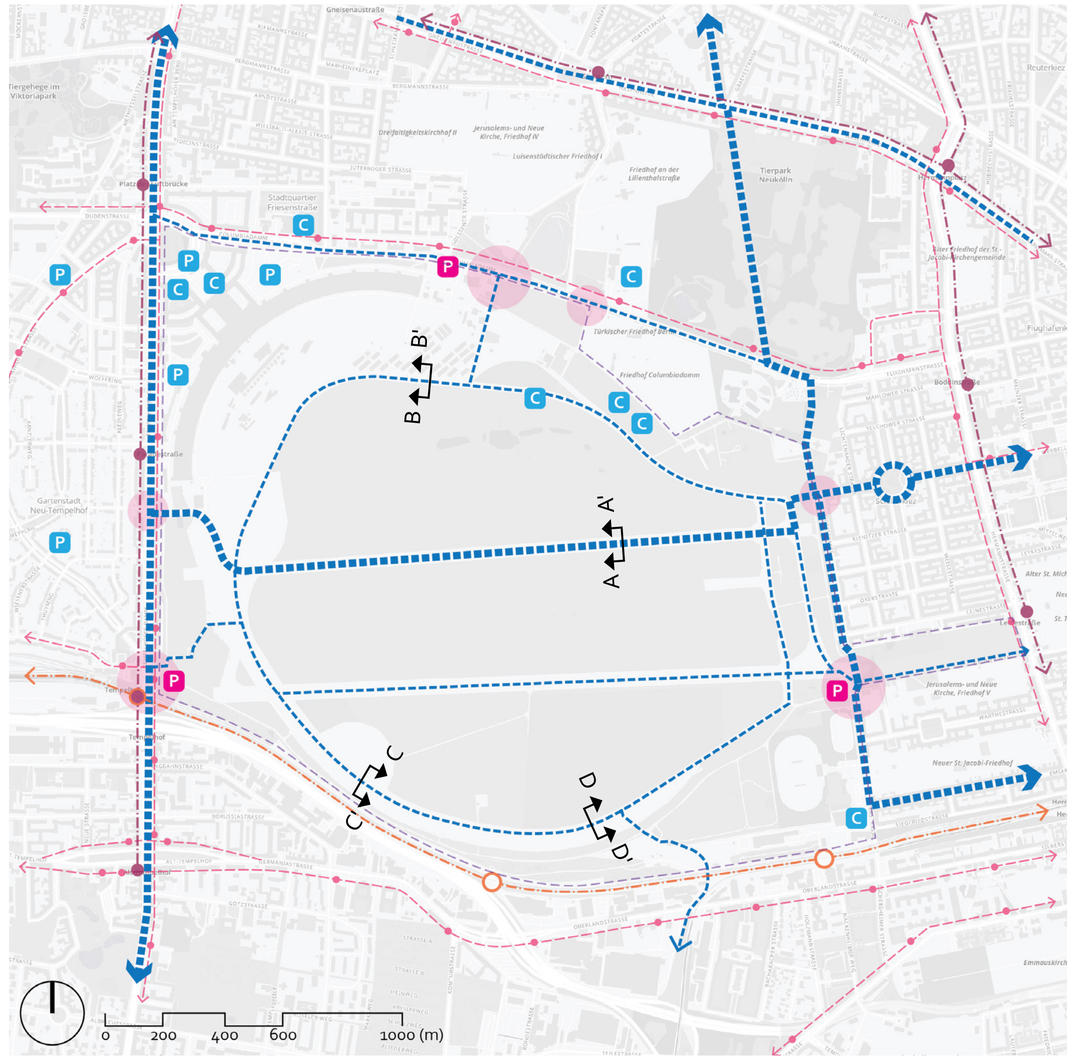
A. Visitor-Facing Tools
- Mobile and on-site dashboards showing air quality, noise, and activity hotspots
- Real-time event tips and wayfinding based on live visitor flow

B. Community & Crowdsourcing
- Apps for reporting damage, maintenance needs, or wildlife sightings
- Integration with local education programs and workshops

C. Urban Governance & Planning
- Open data sharing with Berlin urban planning bodies
- Long-term adaptation policies guided by collected environmental and usage trends

6.4. Research by Design Scenario

Scenario 1 - Pulse Echo - The park's heartbeat begins with collective steps



Connectivity and Accessibility (Figure 38)

- Maintain the existing access structure, but integrate smart parking zones for cars, e-bikes, and e-scooters.
- Combine parking with multi-use repair stations for small mobility devices.
- Upgrade the current runways and taxiways by cutting strips for wildflower planting (e.g., Berliner Mischung). These green strips reduce surface heat and increase permeability.
- Restructure walking routes by partially covering some existing pathways to improve comfort and flow.
- Link the local TR3 bike route with the Tempelhofer Damm route via the elevated runway.
- Propose a dedicated, separate bike lane to ensure safe and efficient cycling.

Legend

- Site area
- Highway
- Primary road
- Main road
- U-bahn
- S-bahn
- Main Bicycle way
- Secondary Bicycle way
- P Parking lot
- C Bicycle parking
- P Smart Parking

Figure 36 (Above)

Perspective along the Runway
Drawn by author

Figure 37 (Below)

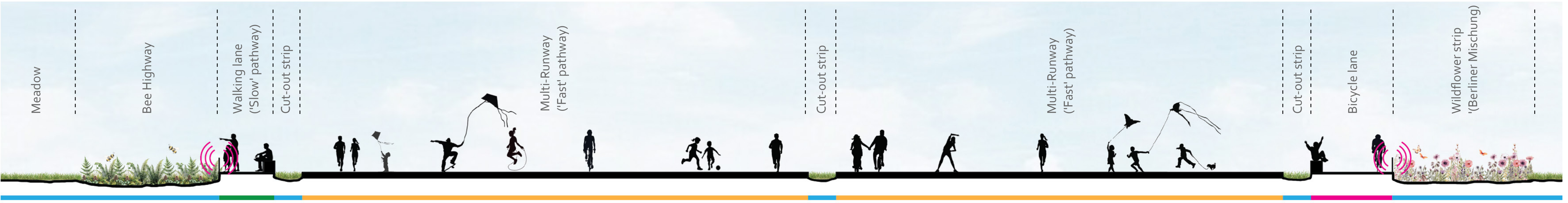
Multi-Runway Section _ A-A'
Drawn by author

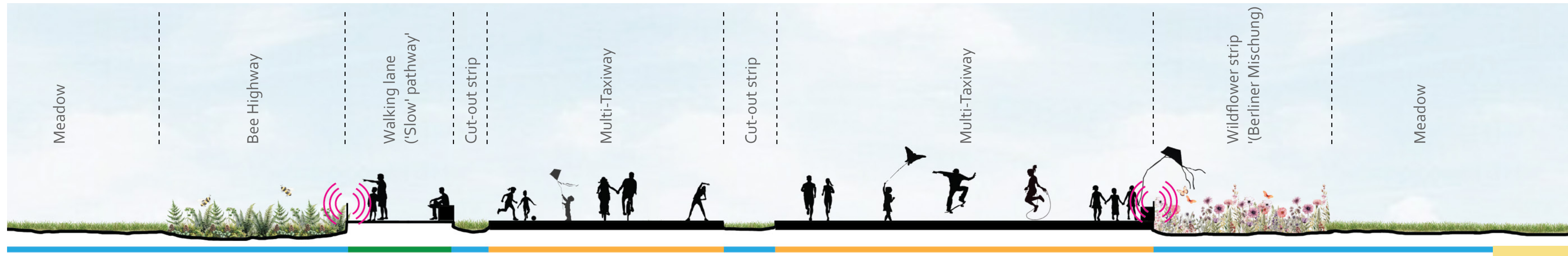
Figure 38 (Above)

Proposed Connectivity and Accessibility
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Figure 39 (Below)

Multi-Taxiway Section _ B-B'
Drawn by author





6.4. Research by Design Scenario

Scenario 1 - Pulse Echo - The park's heartbeat begins with collective steps

Connectivity and Accessibility (Figure 42)

- Designate dedicated walking lanes on the runways, clearly separated from bicycle lanes and multi-use activity zones.
- Preserve the existing taxiway loop as a secondary trail for walking, jogging, and relaxed cycling.
- Upgrade and enhance connector paths between different zones to improve internal access and circulation.

Legend

- Site area
- Highway
- Primary road
- Main road
- Main Access
- Secondary Access
- Priority Smart-Hub
- Secondary Smart-Hub
- Priority pathway ('Fast' pathway)
- Secondary pathway
- 'Slow' pathway

Figure 40 (Above)

Perspective along the Taxiway
Drawn by author

Figure 41 (Below)

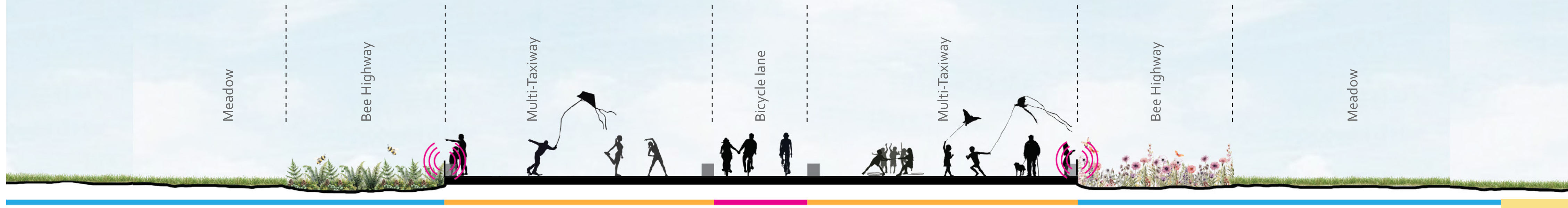
Multi-Taxiway Section _ Recycled Zone _ C-C'
Drawn by author

Figure 42 (Above)

Proposed Pathways Structure
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Figure 43 (Below)

Multi-Taxiway Section _ Quiet Zone _ D-D'
Drawn by author



6.4. Research by Design Scenario

Scenario 2 - Harmonic Sync - Where landscape and technology pulse as one

Green-Blue infrastructure (Figure 44)

- Preserve and enhance the open, expansive meadows as the defining character of TF.
- Create a "multi-jungle" zone on the old airfield to honor its historical significance through layered vegetation.
- Expand the community garden in the east and propose a new garden on the west side for better access and to serve as a green buffer.
- Strengthen the southern green buffer with dense trees and shrubs along the A100 highway to reduce noise and pollution.
- Propose a green bridge in the southeast corner to cross the highway and rail tracks, forming an ecological corridor linking southern Berlin's green spaces.
- Introduce tree canopy axes to provide shade, improve microclimate, and guide visitor movement visually through the landscape.

Legend

- Catch water basin
- Ruderal area
- Low meadow
- Medium meadow
- Community garden
- Mixed green area
- Dense green area

Figure 44

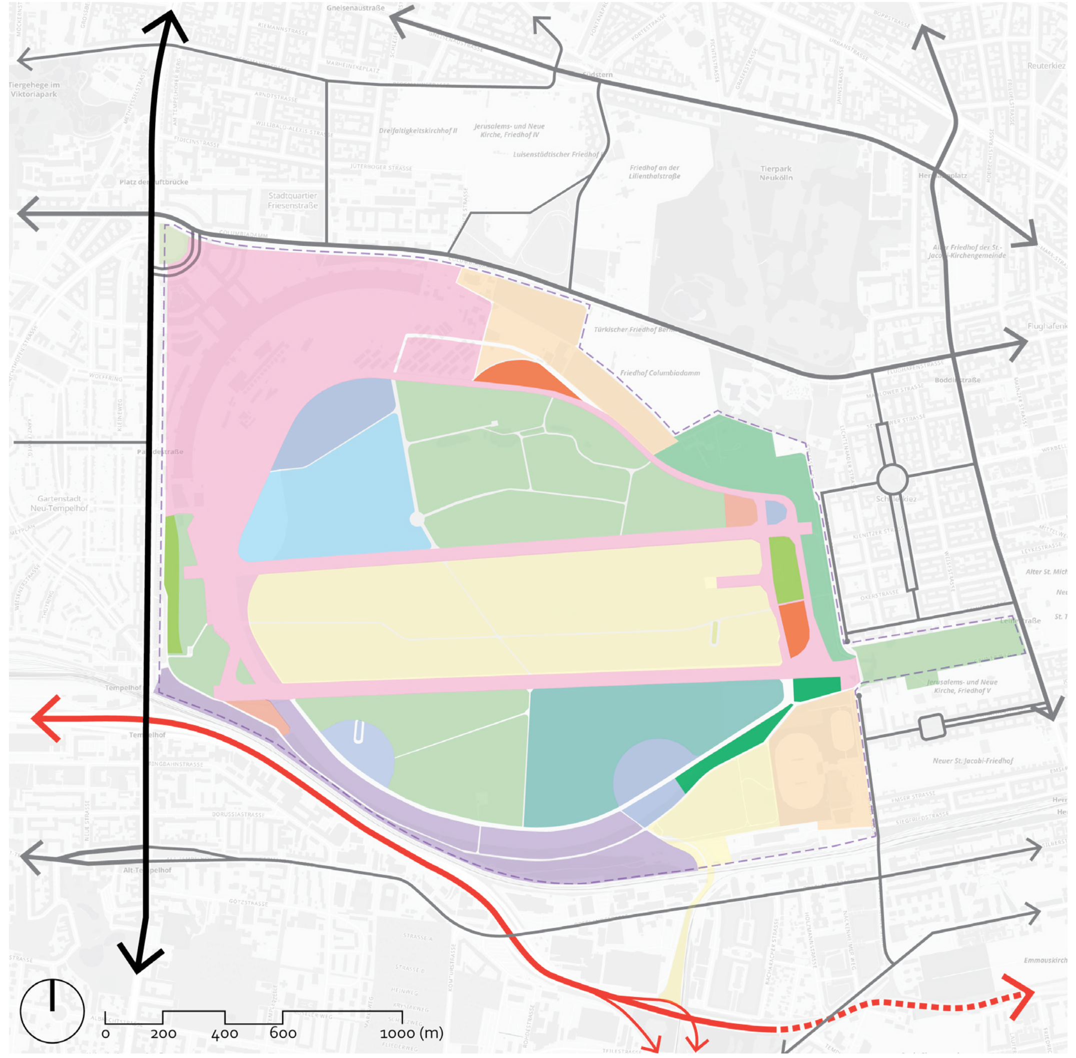
Proposed Green and Blue infrastructure
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Figure 45

Perspective Multi-Playground
Drawn by author

6.4. Research by Design Scenario

Scenario 3 - Symbiotic Pulse - The park breathes, learns and thrives with you.



Social - Cultural infrastructure (Figure 46)

- Protect and enhance the habitat zones for skylarks and sand lizards.
- Transform the runways, taxiways, and apron areas into a multifunctional activity loop for biking, running, skating, and wind surfing.
- Separate fast bike lanes from slow walking paths to improve safety and reduce conflicts.
- The space between lanes becomes flexible for informal or spontaneous use.
- Organize activities into three main zones: active, quiet, and mixed — all connected by the taxiway loop.
- Upgrade grill areas and integrate them with the community gardens as small, mosaic-like spaces that are inclusive and non-intrusive.
- Retain two dog parks in the northeast and southwest, near residential access points.
- Combine the existing ruderal ground with a sheep-grazing field and a playful multi-maze, including cut-outs for water flow and vegetation growth.
- Develop quiet zones with dense trees and shrubs for calm, reflective experiences.
- Repurpose the Tempo-Home and circus area into a multifunctional space for events and festivals.

Legend

Site area	
Sport area	Multicode Green area
Multicode Active area	Experient Playground area
Grill area	Calming area
Swamp area	Conservation area
Wind field	Dog-park area

Figure 46

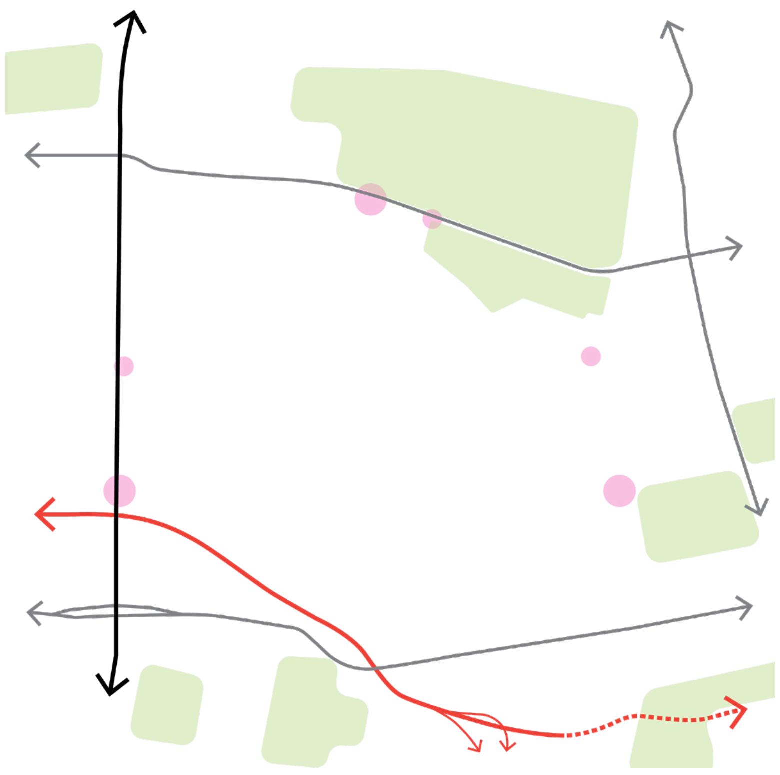
Proposed Activities Zoning
Drawn by author
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Figure 47

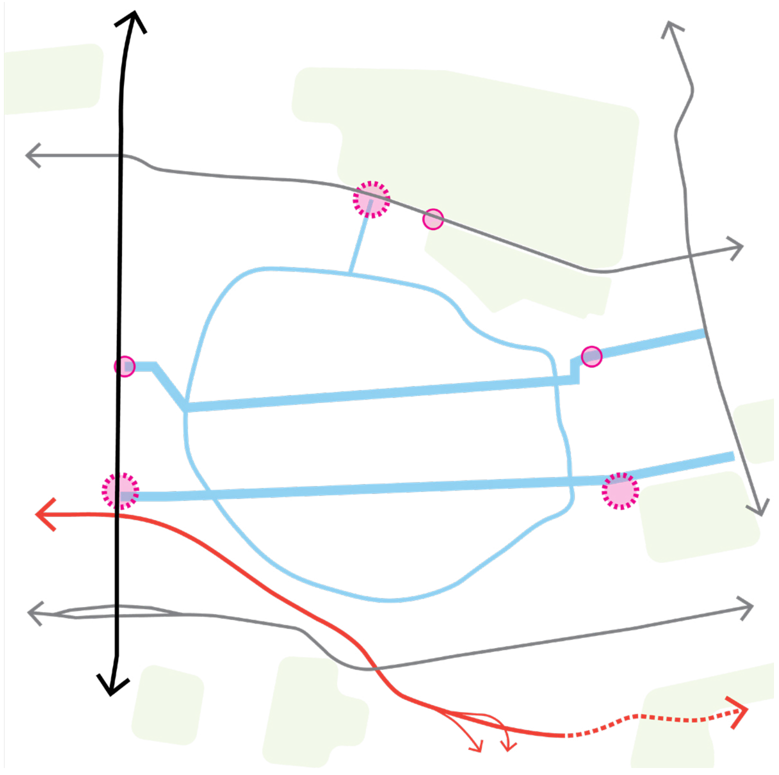
Perspective from THF Tower
Drawn by author

6.5. Tempelhofer Feld Design Concept

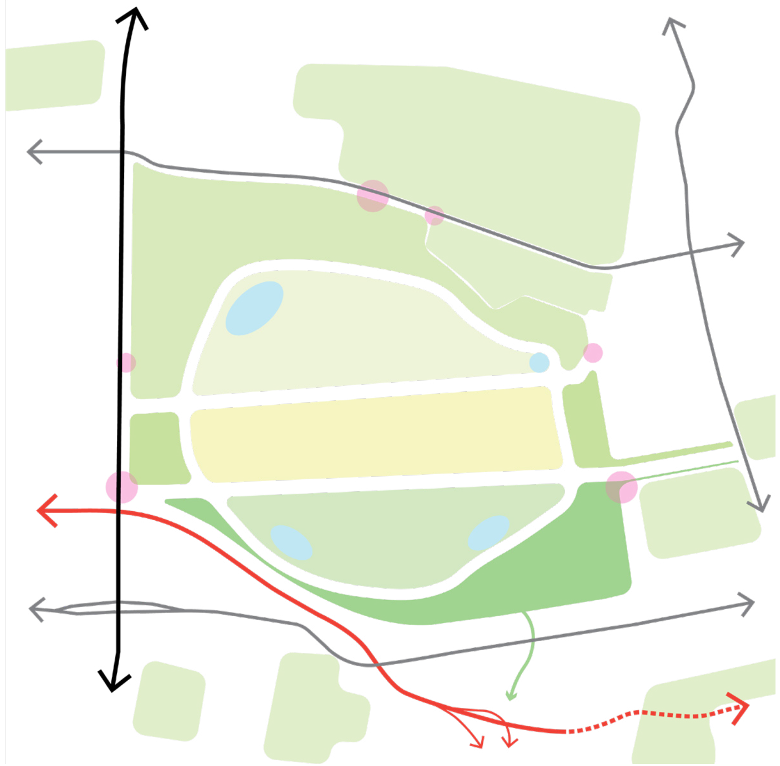
Design Approach



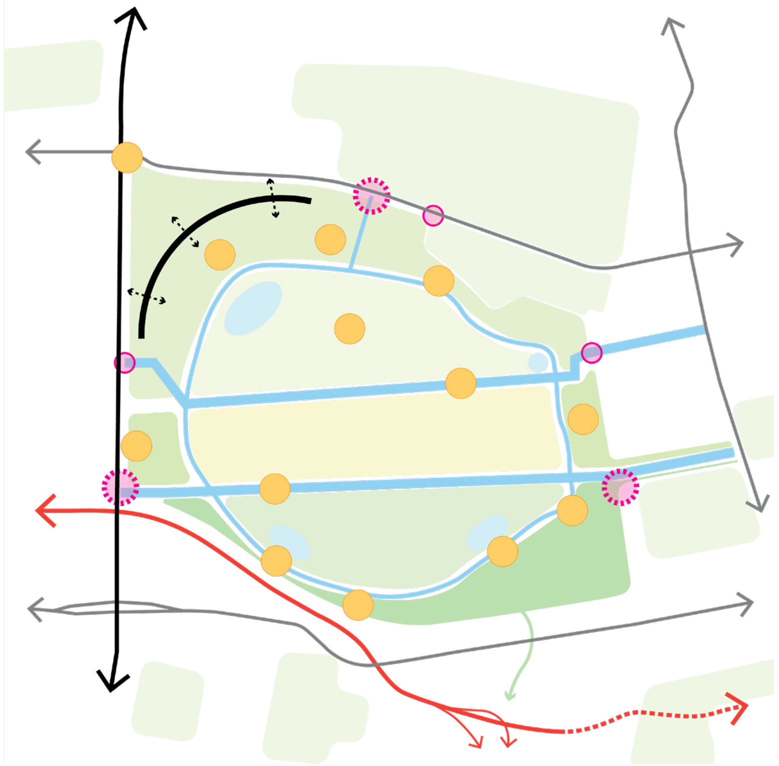
1. Map Key Nodes



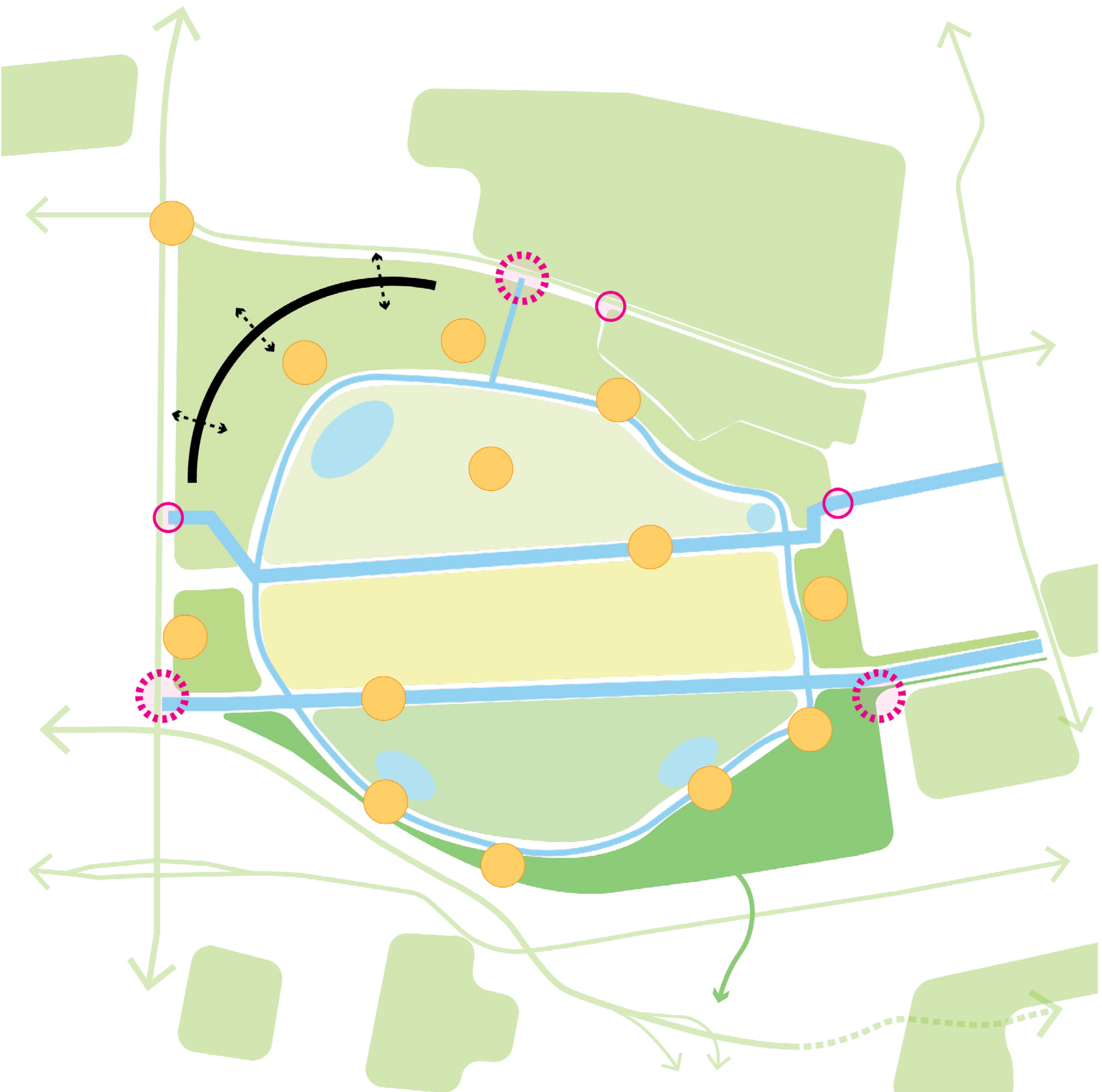
2. Weave Routes



3. Soften Edges



4. Activate with Soul



5. Sustain Momentum

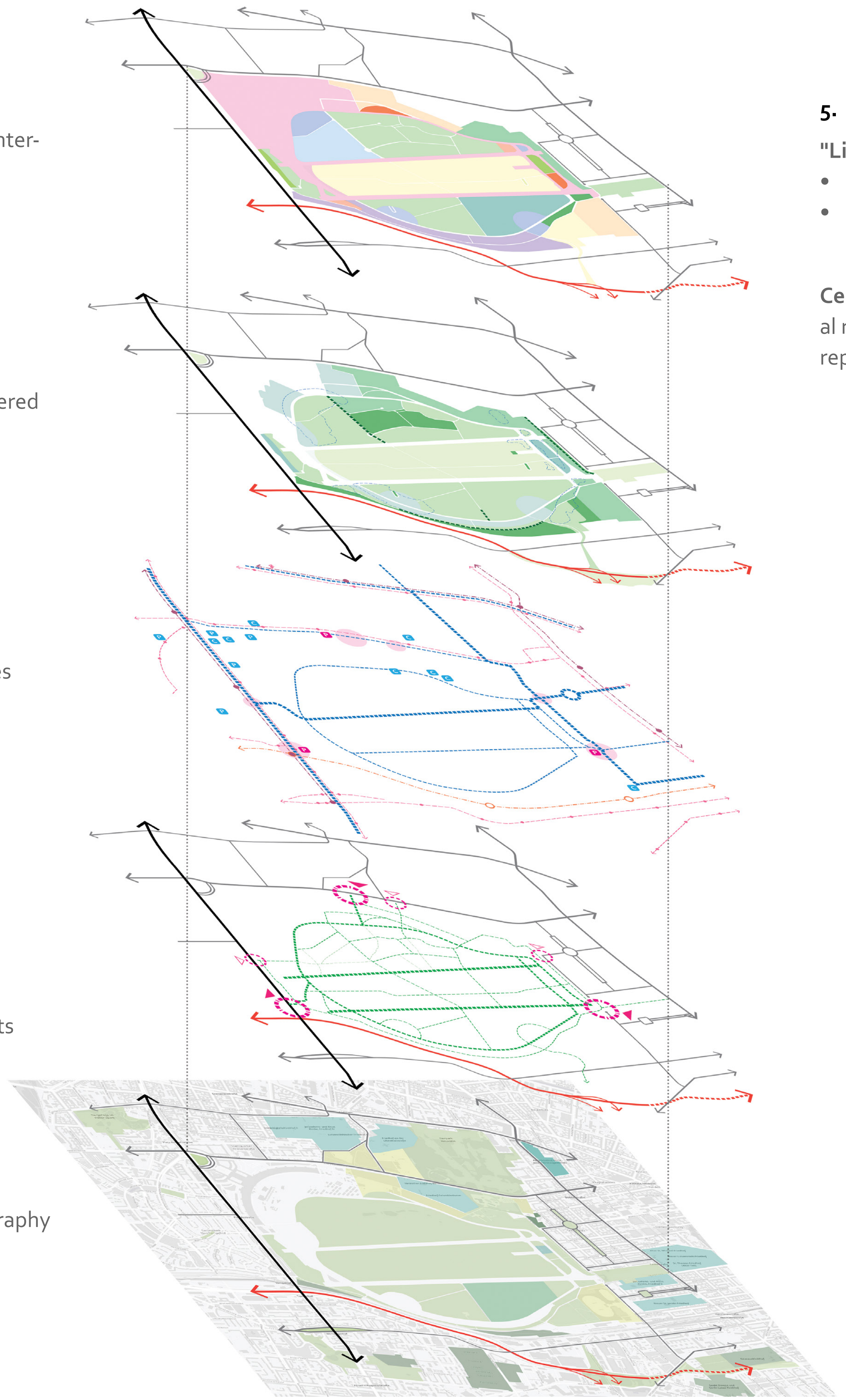
Figure 48

Diagrammatic illustration of the design steps for TF masterplan

Drawn by author

6.5. Tempelhofer Feld Design Concept

Build-up of TF's Masterplan - proposed steps for TF masterplan



4. Activate with Soul
Co-design installations and Interventions

3. Soften Edges
Transition zones by plant layered buffer and activity elements

2. Weave Routes
Connect nodes via desire lines
Improve the routes

1. Map Key Nodes
Identify must-pass-points
Add proposed gathering spots

Current situation
Green and Circulation Topography

5. Sustain Momentum

"Living Lab" approach:

- Monitor usage
- Adapt routes/activities quarterly

Celebration rituals: annual renewal festival (repair, repaint and reuse)

Figure 49

Layer Steps applied onto TF
Drawn by author

6.6. Tempelhofer Feld Masterplan

Designing Interactive Public Spaces

The proposed masterplan for TF adopts a **minimal-intervention approach**, preserving the site's iconic runways, path networks, and zoning structure while layering **adaptive technology and recycled materials** to introduce new functions. By embedding IoT sensors, solar-powered lighting, and modular recycled-design elements (e.g., repurposed airport materials for seating or art), the plan enhances usability without disrupting the park's open character. This strategy honors the site's heritage while transforming it into **a living lab for sustainable urbanism**, where low-impact tech and circular design principles activate underused spaces - such as turning runway edges into pollinator corridors or installing kinetic energy tiles on main paths. The result is **a seamless blend of old and new**, where existing infrastructure gains smart, ecological, and social value.

Figure 50

Designing Interactive public spaces into TF Masterplan
Drawn by author

1. Echo-Point (Main Access Hub)

Location: Primary entrances (e.g., Tempelhofer Damm, Columbiadamm, Oderstraße).
Functions:

– **Smart Dashboard:**
  - Real-time park data (air quality, noise levels, event schedules).
  - Interactive map with "pulse" visualization of visitor density.

– **Community Hub:**
  - QR-code-activated oral history archive/historical trail (stories of Tempelhof Airport).
  - Free Wi-Fi + charging ports.

– **Mobility Integration:** Shelter with seating, live transit updates (bus/U-Bahn), and shared e-bike docks.

– **Design Features:**
  - Recycled airport materials (e.g., repurposed runway signage).
  - Solar-powered LED canopy with adaptive lighting.

2. Community/Mobility Hubs (Secondary Access)

Location: Smaller entrances (e.g., Herrfurthplatz).
Functions:

– **DIY Repair Stations:**
  - Toolkits for bike/e-scooter repair (screwdrivers, air pumps).
  - AR tutorials (scan QR code --> overlay repair instructions).

– **Skill-Sharing Kiosks:**
  - Swap shelves for seeds/garden tools.
  - Community bulletin board (digital + analog).

– **Design Features:**
  - Modular wooden structures with green roofs.
  - Kinetic tiles powering tool-charging stations.

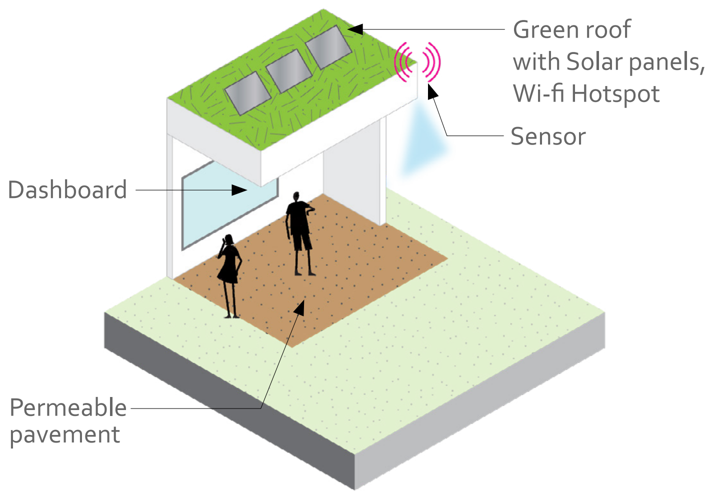
3. Charging Stations (Smart Parking Lots)

Location: Perimeter parking zones (e.g., Tempelhofer Damm, Columbiadamm).
Functions:

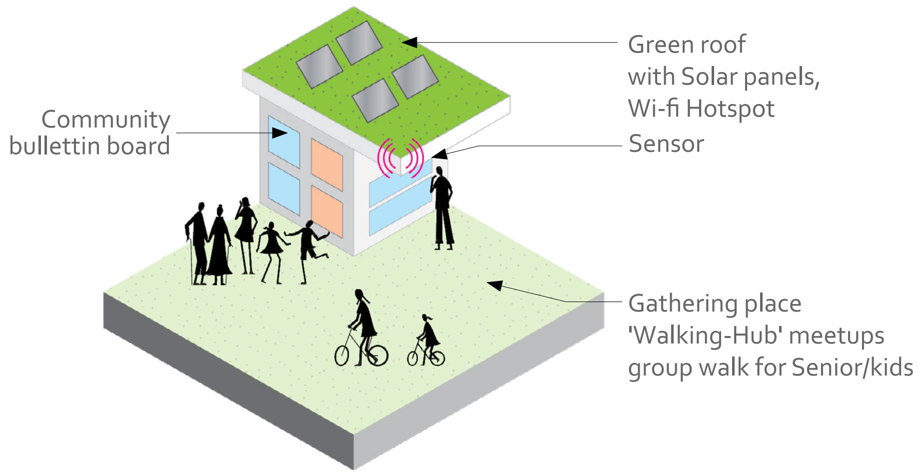
– **Smart Parking:**
  - LED indicators show available spots.
  - App-based reservations for events.

– **Multi-Vehicle Charging:**
  - Universal ports for e-cars, e-bikes, e-scooters.
  - Solar canopies with battery storage.

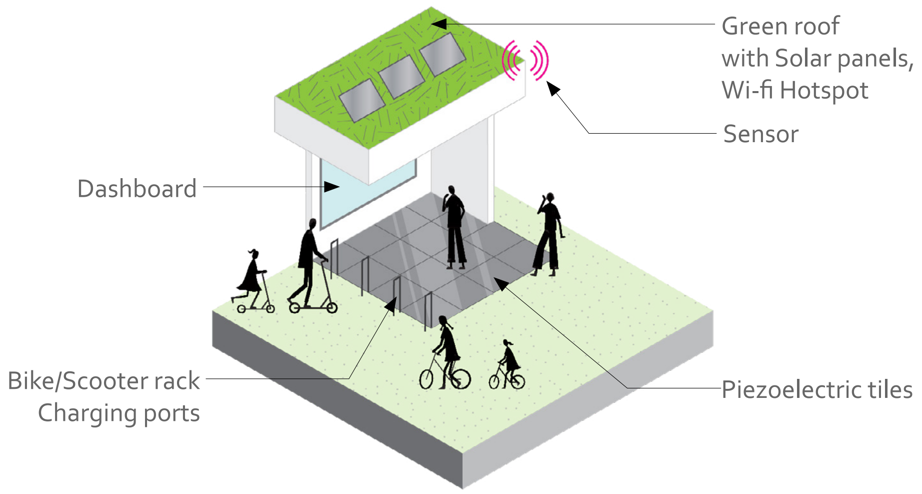
– **Design Features:**
  - Recycled rubber pavers (from old tires).
  - Wind/solar hybrid power for off-grid operation.



Principle design for Echo-Point
Drawn by author



Principle design for Community/Mobility Hubs
Drawn by author



Principle design for Charging Station
Drawn by author

6.6. Tempelhofer Feld Masterplan

Designing Interactive Public Spaces - Weave Interactive Routes: A multifunctional Network for TF

1. Runways: Multifunctional Linear Parks

– **Separate bike/walking lanes:**
  - ***Bike Lane (Smooth Asphalt):*** High-speed cycling corridor.
  - ***Walking Lane:*** Pedestrian-priority with tactile edges.
  - ***Barrier:*** Repurposed cut-out asphalt chunks as low benches/planters.

– **Central "Flex Zone":**
  - Pop-up markets, outdoor yoga, or art installations.
  - Embedded solar pavers to power runway-edge lighting.

– **Interactive Features:**
  - Pressure-sensitive tiles trigger light pulses when cyclists pass (syncing with Pulse Echo).
  - Insects sensor, count/trace insects along the Bee-Highway or Wildflower strip.

2. Taxiways: Biodiversity Loop

– Convert taxiways into **pedestrian loops** with:
  - **Berliner Mischung** (mixed native perennials) along edges.
  - **"Bee highways"**: Pollinator-friendly plants (e.g., lavender, echinacea) with NFC tags for species info.

– **Interactive Elements:**
  - Sound posts play buzzing/insect sounds when motion-detected.
  - Seasonal AR overlays (e.g., virtual bee swarms in summer).

3. Tree Canopy Bridge: Climate-Adaptive Shade Routes

Dual rows of trees along key paths, transitioning from dense to open:

– **Species Strategy:**
  - ***Dense Zones:*** Tilia cordata (linden) for shade + scent.
  - ***Transition to Meadows:*** Betula pendula (birch) with underplanted bulbs (Crocus, Allium).

– **Seasonal Drama:**

Spring: Blossom tunnels --> Summer: Meadow blooms --> Autumn: Golden foliage.

– **Tech Integration:** Soil moisture sensors trigger irrigation only in drought.

4. Therapeutic Pathways: Sensory Healing Routes

– **Scent Gardens:**
  - ***Calming:*** Lavandula (lavender), Mentha (mint).
  - ***Stimulating:*** Rosmarinus (rosemary), Juniperus (juniper).

– **Seating Nooks:**
  - Repurposed concrete slabs with moss cushions.
  - Wind-activated chimes for sound therapy.

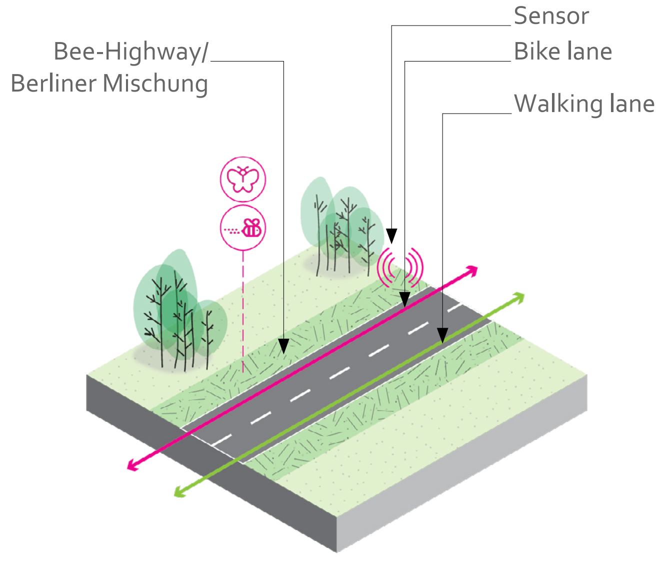
– **Wayfinding:** Gentle path curves + braille/tactile guides.

5. Smart Pathways

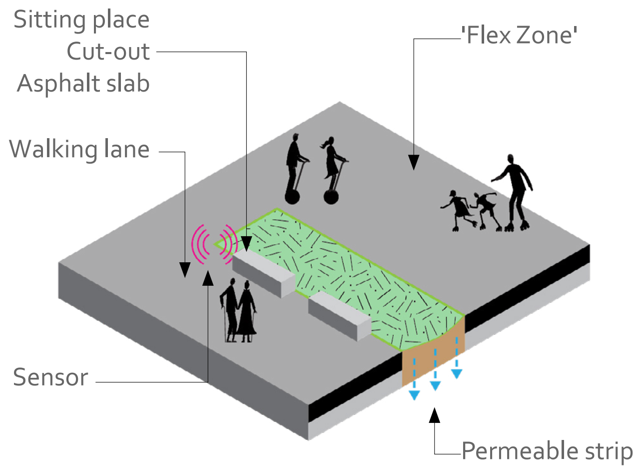
– **Noise/Crowd Sensors:** Cameras + decibel meters suggest quieter routes via app/AR arrows.

– **Dynamic Lighting:** Glowing pavers guide night walks; dim in low-traffic zones.

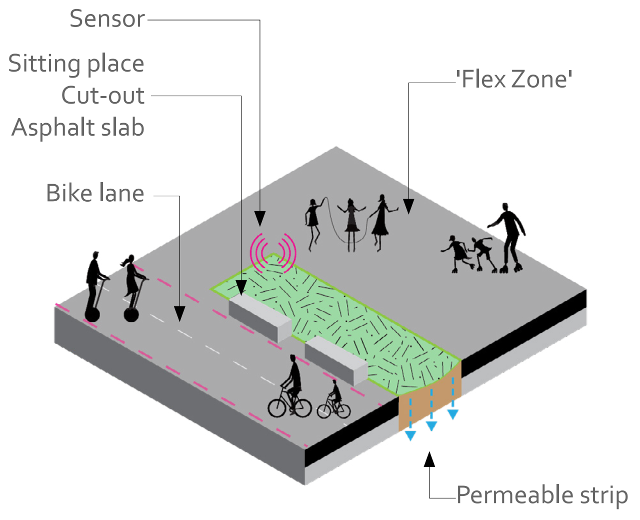
– **Rewards:** "Silent Explorer" badges for choosing low-impact routes.



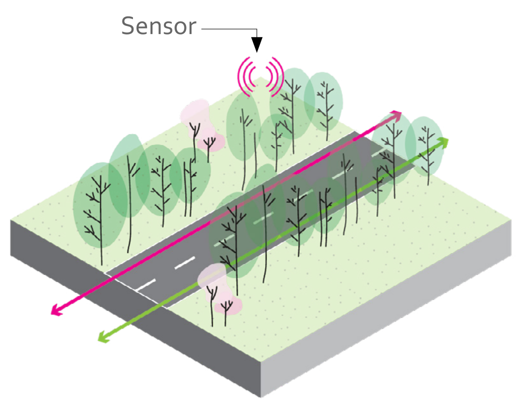
Seperate bike/walking lanes
Drawn by author



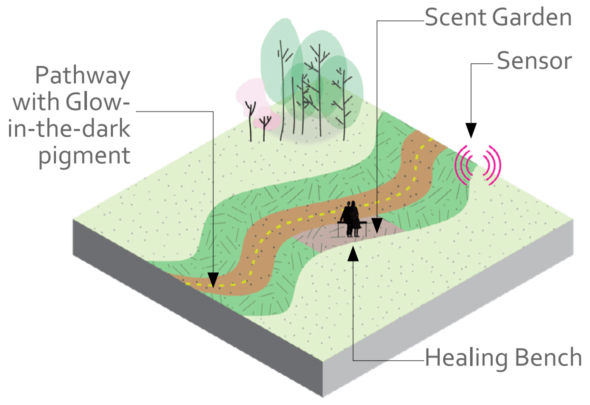
Multi-Runway/Taxiway principal_ Walking lane
Drawn by author



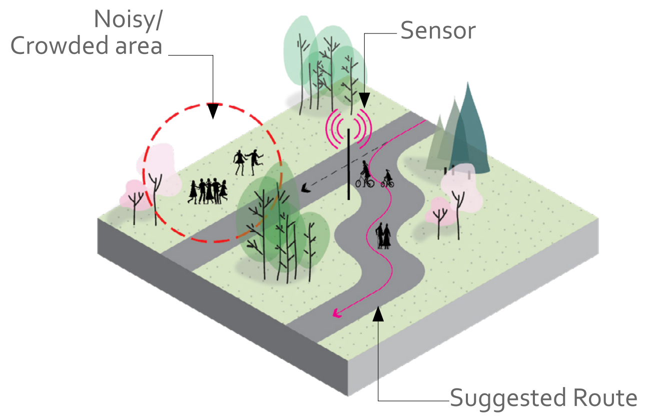
Multi-Runway/Taxiway principal_ Bike lane
Drawn by author



Tree Canopy
Drawn by author



Therapeutic Pathways
Drawn by author



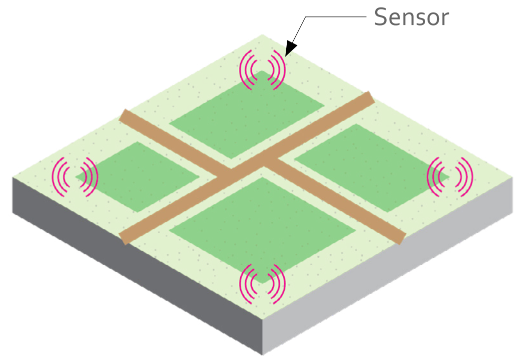
Smart Pathways
Drawn by author

6.6. Tempelhofer Feld Masterplan

Gamification for Well-being and Social Interaction

1. Adopt-a-Plot (Stewardship Gamification)

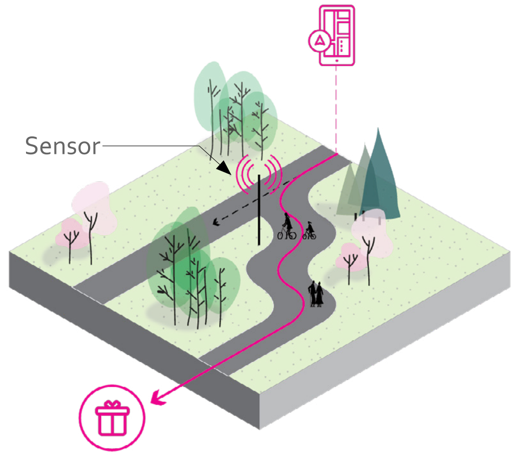
– **Task Board:** Digital/physical kiosks assign care tasks (e.g., "Water this pollinator patch 3x/week").
– **Rewards:**
  - Virtual badges (e.g., "Soil Hero") --> redeem for real seeds or workshop access.
  - Leaderboard shows top contributors (team vs. individual).



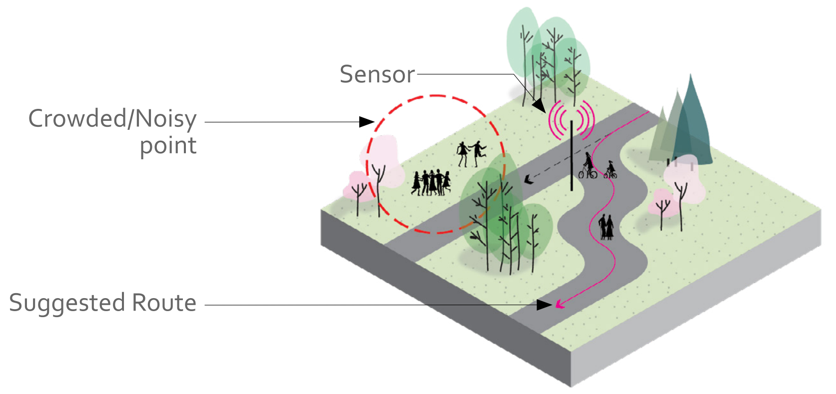
Wireless soil sensors and "Adopt-a-Plot" Program
Drawn by author

2. Wayfinding (Exploration Tokens)

– **"Detour Challenges":** App suggests new routes (e.g., "Take the Bee Highway today!").
– **Reward**: Scan QR at endpoint --> collect token (e.g., digital "TF Explorer" coin).
– **Social**: Trade tokens for communal rewards (e.g., unlock a new tree planting).



Wayfinding - 'Detour Challenges'
Drawn by author



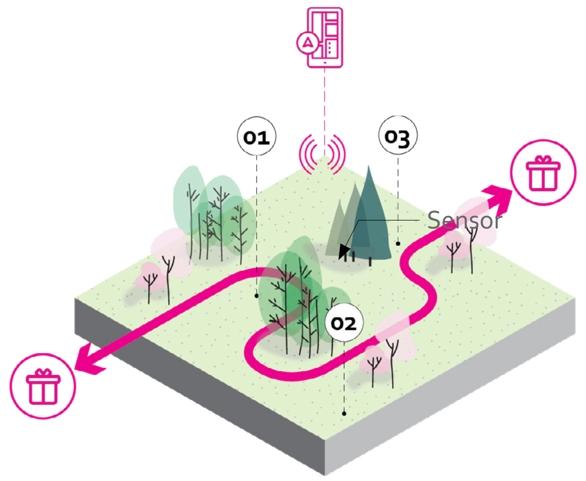
Wayfinding - Suggest the route not crowded/noisy
Drawn by author

3. Discover the Park (AR Wildlife Collection)

– **Virtual Species Hunt:** Spot AR birds/insects (triggered by GPS + real biodiversity data).
– **Rewards:**
  - Collect 10 species --> adopt a real bee hive.
  - Rare finds unlock park history trivia.

4. Historical Trail (Time-Travel Layer)

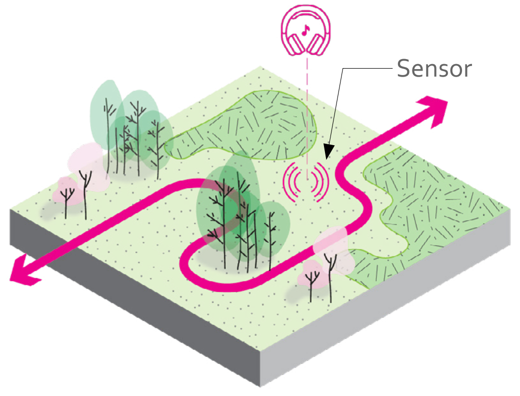
– **QR "Time Portals"**: Scan runway markers --> see 1945 airport AR reconstructions.
– **Achievement**: Complete the trail --> "Time Traveler" badge + invite to oral history night.



Discovery Trail
Drawn by author

5. Wildlife Trail (Biodiversity Quest)

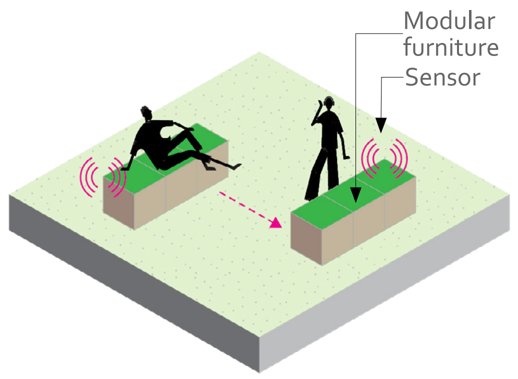
– **Bio-Blitz Challenges:** Log real species via app/camera traps.
– **Biodiversity Trail:** sound-alert 'You're passing a wildflower pollinator zone'.
– **Rewards:**
  - Data contributes to Berlin's biodiversity map.
  - Top spotters name a park habitat (e.g., "Emma's Hedgehog Grove").



Wildlife/BIodiversityTrail
Drawn by author

6. Co-Design Workshops (Social Fabric)

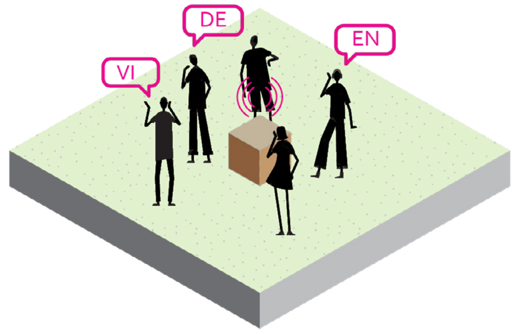
– **Modular Kits:** Build planters/furniture from recycled materials (e.g., old runway concrete).
– **Voting:** Best designs installed in park --> creator's name plaque.



Modular Co-Design Elements
Drawn by author

7. Multilingual Outreach
Tools:

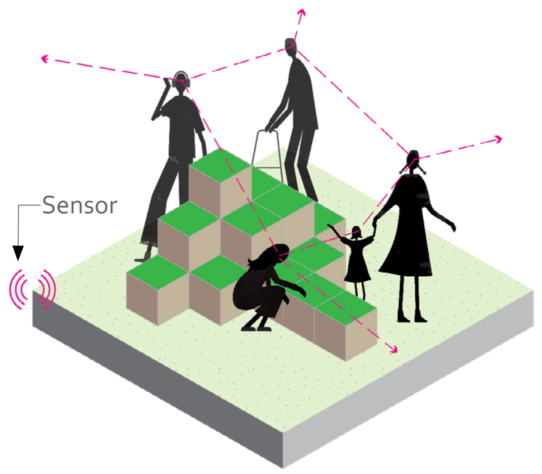
– App/audio guides in 10+ languages.
– Pictogram-based instructions for universal access.



Multilingual Outreach
Drawn by author

8. Ergonomic Raised Beds (Inclusive Gardening)

– Adjustable-height planters (wheelchair-friendly).
– Gamification: "Grow-a-Row" challenge, Tend a bed --> harvest goes to food banks.

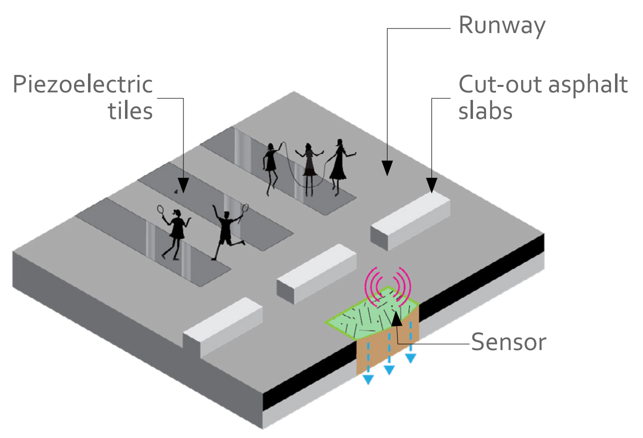


Modular ergonomic raised planting beds
Drawn by author

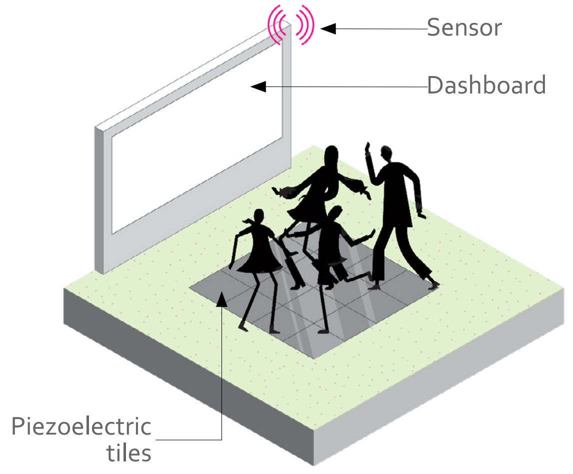
9. Kinetic Playground (Energy & Play)

Locations: Runway zebra crossings, Echo-Points/Charging Stations.

– **Jumping/Pedaling** on kinetic tiles --> power LED art or charge phones.
– **Group Challenge:** 1,000 jumps --> activate a light show, 10k steps --> a new bench/a new tree, etc.



Kinetic Playground with dashboard
Drawn by author



Kinetic Playground with dashboard
Drawn by author

6.6. Tempelhofer Feld Masterplan

Resilient Landscape Strategies for Climate Adaptation

This section presents data-driven, adaptive landscape interventions to combat climate threats—extreme heat, wind, and flooding—while enhancing ecological and operational resilience.

Water-Sensitive Design

A. Permeable Surfaces

Runways/Taxiways: Replace 30% of asphalt with:

- **Permeable pavers** (grasscrete or recycled rubber grid systems).
- **Cut-out planting strips** filled with drought-tolerant sedums or clover.

Paths: Gravel or resin-bound surfaces to allow infiltration.

B. Rainwater Harvesting

Echo-Points/Community Hubs:

- **Green roofs** --> channel water to underground tanks.
- **Rain chains + swales** direct runoff to multi-swales (see below).

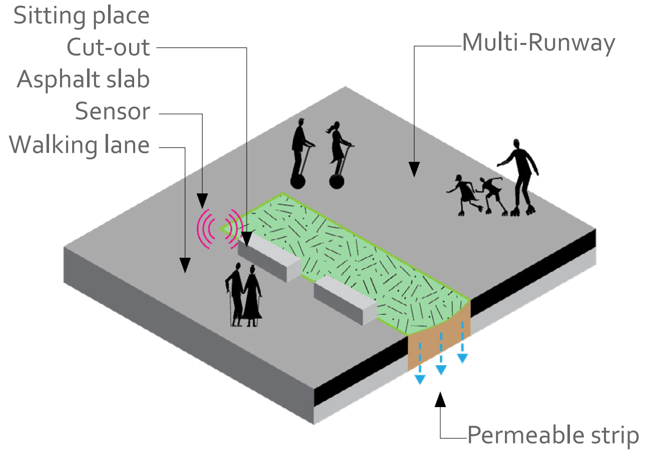
Charging Stations: Solar canopies with gutter systems --> irrigate nearby planting.

C. Multi-Swales & Bio-Swales

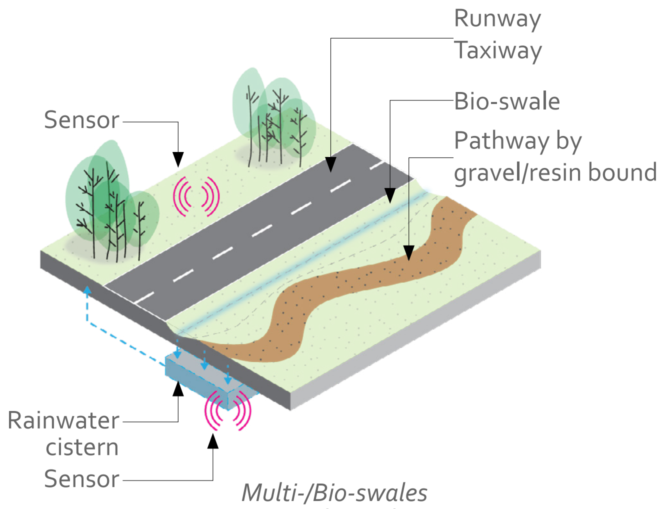
Location: Along runway edges, taxiway loops and some Multi-swamps.

Function:

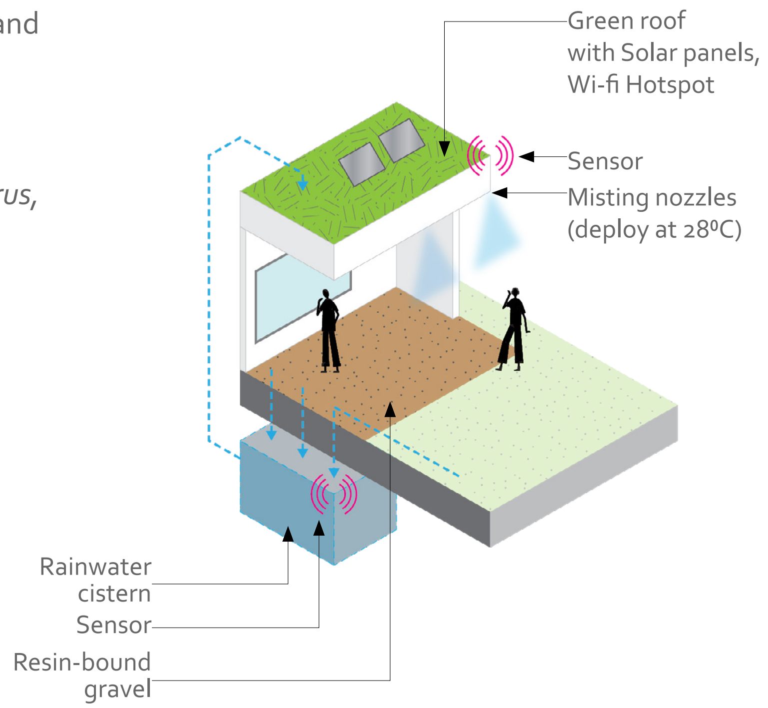
- Slow, filter, and store stormwater.
- Plant with wetland species (e.g., *Iris pseudacorus*, *Juncus effusus*).



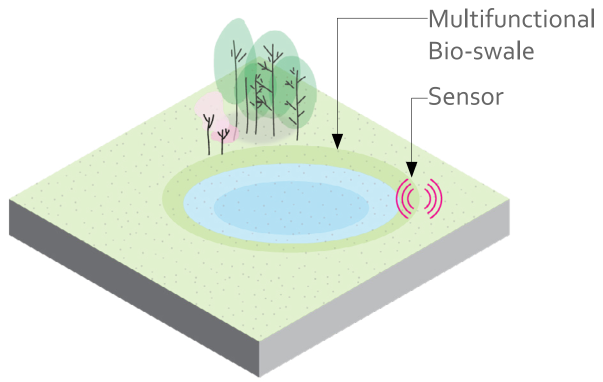
Multi-Runway/Taxiway with cut-out planting strip
Drawn by author



Multi-/Bio-swales
Drawn by author



Rainwater Harvesting and Smart Cooling System
Drawn by author



Multi-Swamp
Drawn by author

Heat Island Mitigation

A. "Jungle-Oasis" Microclimates

- **Pocket Jungles:** Dense groves of native trees (Tilia cordata, Acer campestre) + shrubs (Sambucus nigra).
- **Pocket Meadows:** Wildflower patches (Papaver rhoeas, Centaurea cyanus) for evaporative cooling.

B. Smart Cooling Systems

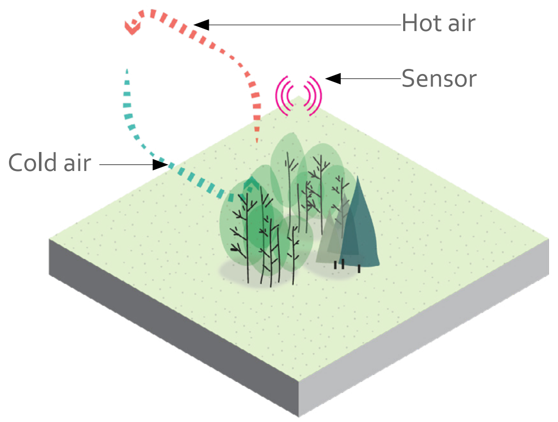
Temperature-Responsive Mist Sprays:

- **IoT Sensors** (Echo-Points, kiosks) trigger mist when >28°C.
- **Water Source:** Harvested rainwater or greywater.

C. Shade Maximization

Tree Canopy Expansion:

- **Runway Edges:** Double rows of fast-growing Betula pendula (birch).
- **Taxiways:** Espaliered fruit trees (Malus domestica) on trellises.

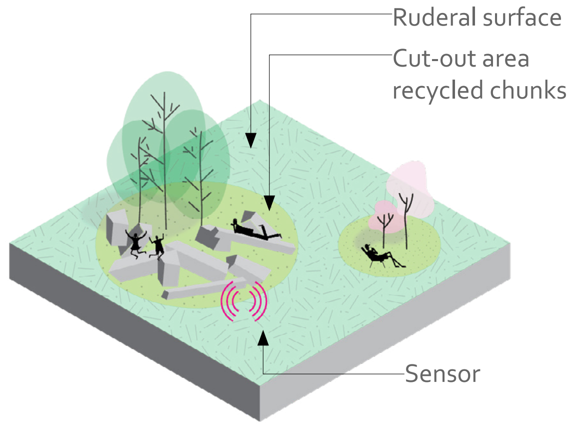


Multi-Jungle and Pocket Jungle
Drawn by author

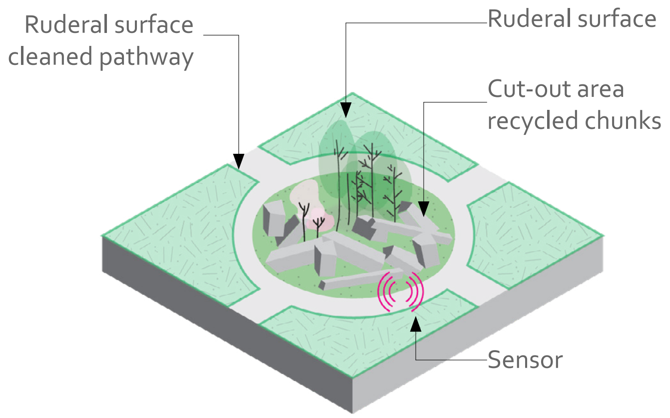
Material Circularity

Reused Asphalt/Concrete:

- Crushed for swale bases or sculptural seating.
- Cut-out runway chunks --> raised bed edges or art installations.



Material Circularity _ Multi-Calm area
Drawn by author



Material Circularity _ Multi-Maze
Drawn by author

Smart Monitoring & Adaptation

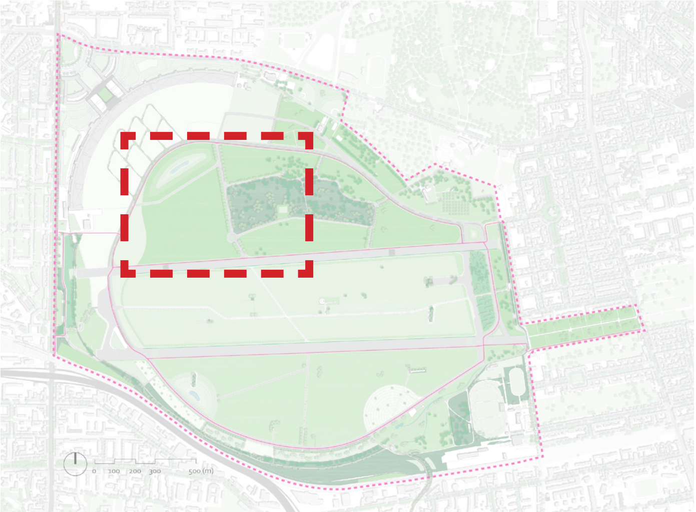
IoT Network:

- Soil moisture sensors --> optimize irrigation.
- Heat maps --> prioritize shade/mist zones.

Community Alerts: App notifications: "High heat today! Seek Jungle-Oasis #3."

6.7. Design Elaboration

Site 1 - Hangar Quarter



Legend

1. Main access
2. Secondary access
3. Green-Apron
4. Multi-Hangar
5. Multi-Active-Zone
6. Multi-Grill
7. Multi-Swamp
8. Multi-Wind
9. Multi-Jungle
10. Multi-Field
11. Multi-Taxiway
12. Multi-Sport

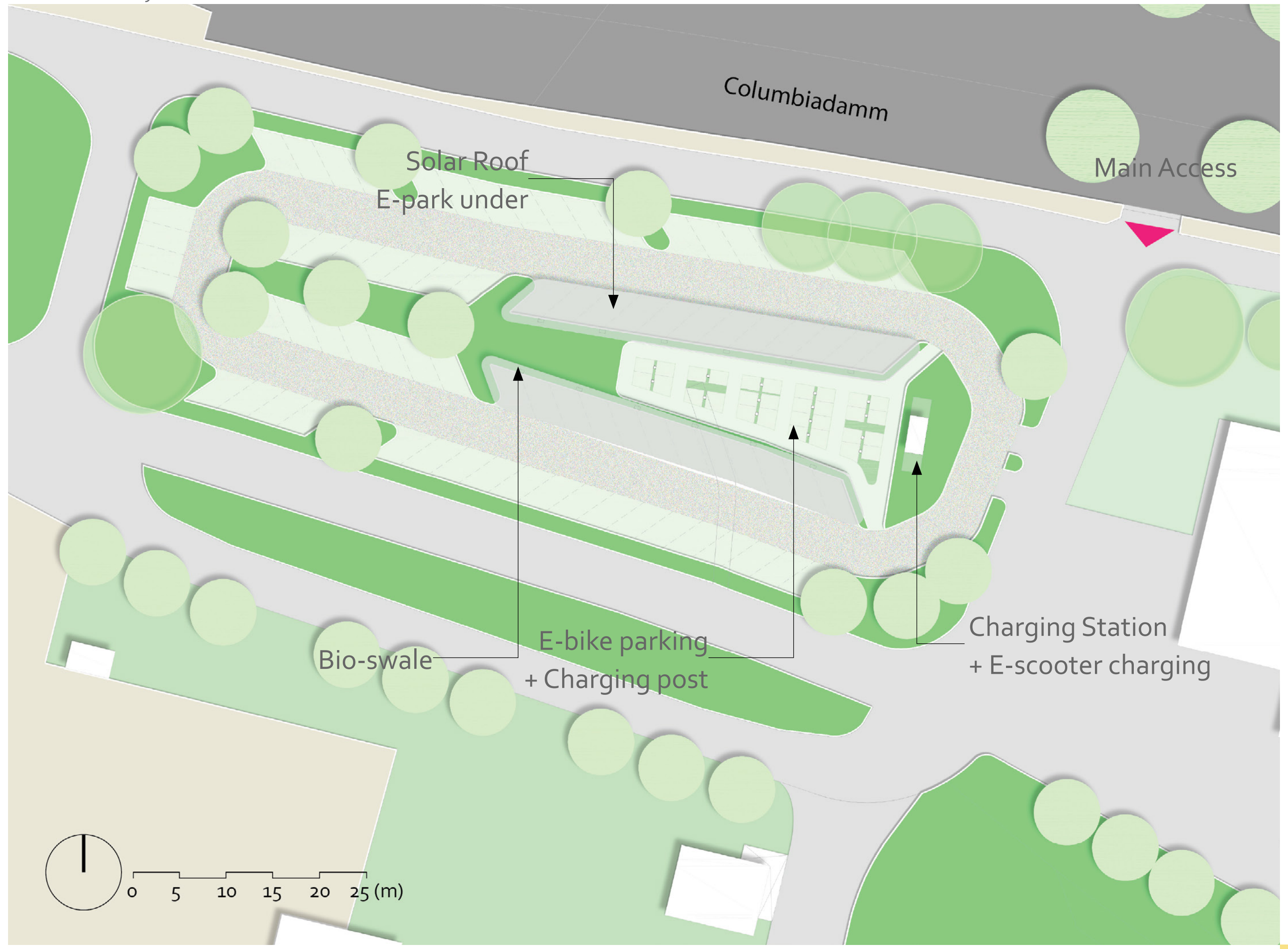
Bike Lane
Wildflower Strip
Existing Tree
Planning Tree

Figure 51 (Left)

Elaboration Site 1 - Hangar Quarter
Drawn by author

Figure 52 (Below)

Elaboration Detailed Smart Parking lot Comumbiadamm
Drawn by author



6.7. Design Elaboration

Site 2 - Quiet Quarter

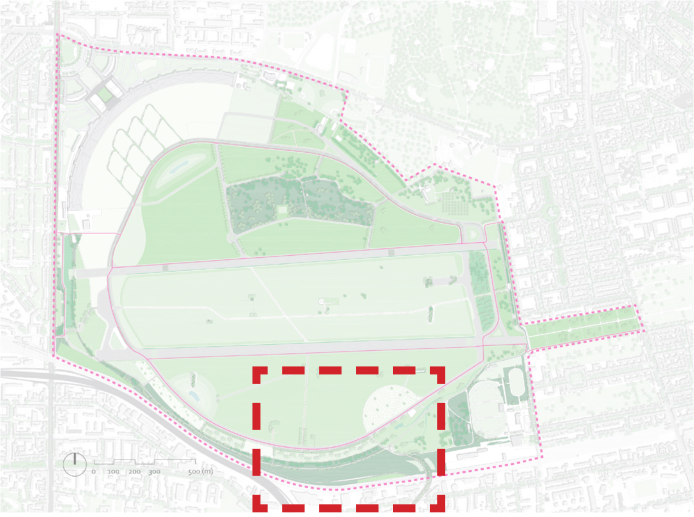


Figure 53 (Right)

Elaboration Site 2 - Quiet Quarter
Drawn by author

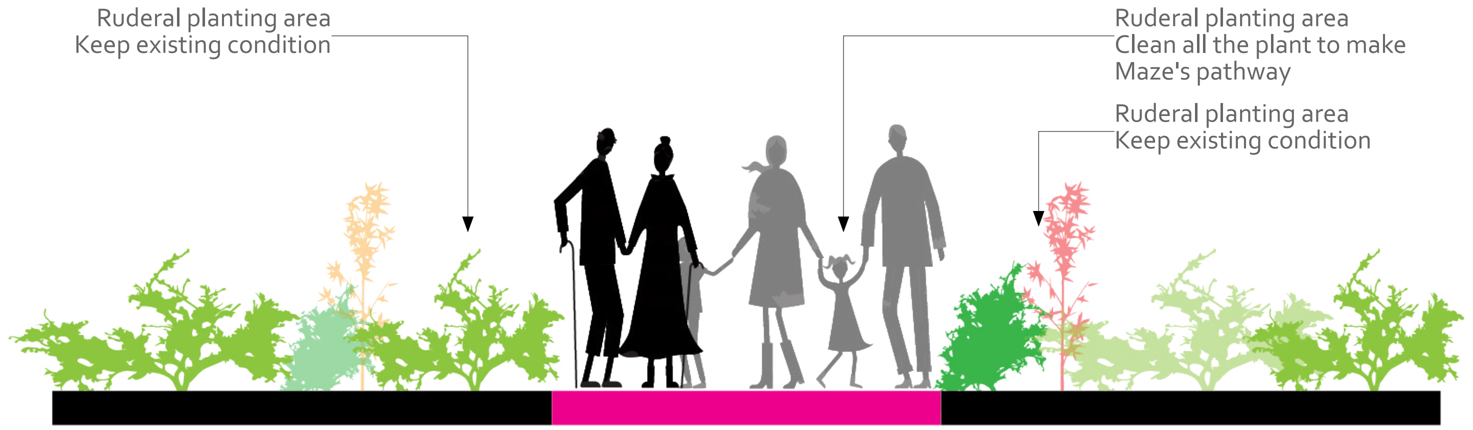
Legend

1. Multi-Taxiway
2. Parkour Area
3. Sheep-Zone
4. Pocket-Jungle
5. Therapeutic Garden
6. Observation Tower
7. Lizard-Zone
8. Multi-Calm
9. Recycled-Runway
10. Wildlife Adventure Playground
11. Green-Bridge

- Bike-lane
- Therapeutic Garden
- Bee-Highway
- Wildflower Strip
- Existing Tree
- Planning Tree

Figure 54 (Below)

Principle section pathway of Maze
Drawn by author



07

Composing Landscape Designing Green Future

7.1. Smart infrastructure proposals
7.2. Data-driven landscape design elements
7.3. Pilot project phases and timeline
7.4. Resource management and sustainability strategies

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1

"All gardening is ***landscape painting."***

– William Kent

7.1. Smart Infrastructure Proposals

1. Climate-Adaptive Infrastructure

A. Dynamic Shade Systems

- ***Solar-Powered Retractable Canopies:*** Deploy over tarmac zones, which have crowded group, when temps exceed 28°C (IoT weather triggers).
- ***Living Pergolas:*** Fast-growing vines (e.g., hops) on steel frames, monitored via moisture sensors.

B. Smart Water Management

- ***AI-Optimized Rain Gardens:*** Adjust storage capacity in real-time during storms.
- ***Leak-Detection Pipelines:*** Acoustic sensors to identify irrigation system failures.

2. Mobility & Connectivity

A. Integrated Transit Hubs

- ***E-Bike Charging Stations:*** Powered by park solar trees, linked to Berlin's Jelbi mobility app.
- ***Smart Parking:*** License plate recognition guides cars to open spots, reducing congestion.

B. Accessible Pathways

- ***Tactile Navigation:*** Vibrating wristbands sync with park app for visually impaired visitors.
- ***Self-Illuminating Trails:*** Glow-in-the-dark gravel (strontium aluminate) for nighttime safety.

3. Energy & Resource Systems

A. Renewable Microgrids

- ***Solar Benches:*** With USB charging and Wi-Fi (e.g., Strawberry Energy models).
- ***Piezoelectric Walkways:*** Harvest energy from foot traffic. (bus doorstep area, playground, parkour area)

B. Circular Waste Solutions

- ***Smart Bins:*** AI sorts recyclables, alerts cleaners when full (Pilot: Seoul, 40% cost reduction).
- ***Compost Hubs:*** Community kitchens supply organic waste for park soil enrichment. (from BBQ area, community garden)

4. Biodiversity & Ecology Tech

A. Wildlife Support

- ***AI Nesting Boxes:*** Temperature-controlled for endangered birds (e.g., skylarks).
- ***Pollinator Highways:*** Native plant corridors with embedded RFID tags to track species movement.

B. Soil Health Monitoring

- Nanotech Sensors: Measure pH, heavy metals, and microbial activity in real time.
- Mycoremediation Zones: Fungi inoculated to break down tarmac pollutants.
- Tool: Bioacoustics Monitors (e.g., Rainforest Connection) to track bird/frog populations.

5. Social & Cultural Infrastructure

A. Community Engagement Tools

- ***AR Storytelling:*** Scan historic sites (e.g., airlift memorials) to unlock immersive narratives. (historical trail from Berlin center to TF)
- ***Participatory Budgeting Kiosks:*** Propose/vote on park upgrades via blockchain.

B. Event & Space Management

- ***Modular Pop-Up Stages:*** Foldable structures with built-in sound dampening.
- ***Crowd-Sensing Pavilions:*** Adjust ventilation/lighting based on occupancy.

6. Safety & Maintenance Innovations

A. Predictive Infrastructure

- ***Crack-Detecting Drones:*** Scan pavement for pre-emptive repairs.
- ***Self-Healing Concrete:*** Bacteria-infused material repairs its own fractures.

B. Emergency Systems

- ***Flood Alert Beacons:*** Flashlights + sirens activated by water sensors.
- ***Falling Detection:*** Lidar identifies accidents, alerts medics.

7.2. Data-driven Landscape Design Elements

1. Dynamic Planting Systems

- ***Smart Irrigation:*** Soil moisture sensors + weather forecasts to optimize watering schedules (Example: Barcelona's Parc del Centre Poblenou saves 40% water).
- ***Biodiversity AI:*** Camera traps identify species to guide native plant selection (Tool: Google's Wildlife Insights).
- ***Climate-Adaptive Palettes:*** GIS-mapped microclimates inform drought/flood-resistant species placement.

2. Human-Flow Responsive Layouts

- ***Wi-Fi Heatmaps:*** Reveal desire lines to formalize paths (e.g., NYC's The High Line redesign).
- ***Crowd Prediction AI:*** Adjusts event space configurations based on ticket sales/weather (Used in London's Olympic Park).
- ***AR Wayfinding:*** Overlays optimal routes via smartphone (Pilot: Singapore Botanic Gardens).

3. Real-Time Environmental Modulators

- ***IoT-Canopy Lighting:*** Adjusts brightness based on foot traffic and lunar cycles (Implemented in Amsterdam's Smart Parks).
- ***Pollution-Buffering Hedges:*** Air quality sensors trigger misting systems in high-PM2.5 zones (Seoul's Digital Media City).
- ***Noise-Mapping Benches:*** Redirect users to quieter zones via app alerts (Tested in Berlin's Tiergarten).

4. Material Performance Systems

- ***Self-Reporting Pavements:*** Embedded sensors detect cracks/fatigue, prioritizing repairs (Tech: self-healing concrete).
- ***Phase-Change Surfaces:*** Absorb/release heat based on temperature thresholds (Material: BASF's Cool Pavement).

5. Participatory Feedback Loops

- ***Sentiment Analysis:*** NLP scans social media posts to gauge space satisfaction (Tool: IBM Watson).
- ***QR Code Surveys:*** On-site prompts for instant feedback on new installations.
- ***Biometric Gardens:*** Wearable data tracks stress reduction in green zones (Research: University of Melbourne).

6. Predictive Resilience Models

- ***Flplain Simulation AI:*** Anticipates flood patterns to position bioswales (Software: Autodesk's CFD).
- ***Wildfire Risk Mapping:*** LiDAR identifies fuel loads for defensible spacing (Used in California's SMART Landscapes).
- ***Carbon Sequestration Dashboards:*** Live CO_2 uptake metrics displayed on kiosks (Example: Milan's Biblioteca degli Alberi).

Key Benefits

- ***Precision:*** 30–60% resource savings vs. conventional design (World Economic Forum).
- ***Adaptability:*** Spaces evolve with climate/use patterns.
- ***Equity:*** Data reveals underserved user groups for targeted improvements.

Implementation Checklist:

- Deploy IoT sensors for baseline data (air/soil/water).
- Train AI models on local ecological/social datasets.
- Co-design interfaces with community stakeholders.

7.3. Pilot Project Phase & Timeline

2025 — **2027** — **2030** — **2040**

Phase 1 (Years 0–2) "Test & Learn"

Goal: Validate minimal viable interventions with community input.

Key Actions:

Pilot IoT Network: Deploy 50 sensors across 3 zones:

– **Runway Edge:** Foot traffic + noise sensors (adaptive lighting).

– **Grassland:** Soil moisture + biodiversity cameras (AI species ID).

– **Allotment Gardens**: Water usage + microclimate trackers.

Echo-Points & Charging station: Install Echo-Point and Charging station with:

– USB/wireless charging.

– Air quality displays (PM2.5, CO_2).

Community Co-Design

– **Workshops**:

- AR nature trails (scan QR codes --> bird calls/history).
- "Hack the Park" prototyping (e.g., citizen-built insect hotels).

– **Output**: Curated AR content library.

Phase 2 (Years 2–5) "Scale Up"

Goal: Expand proven systems, embed ecological resilience.

Key Actions:

Sensor Grid Expansion: Cover 80% of TF with:

– **AI Irrigation**: Soil probes + weather data --> optimize water use.

– **Noise-Routing**: Dynamic path suggestions via app.

Biodiversity Corridors

– Convert taxiways into "**Bee highways**" (native plants + IoT pollinator cams).

– **Berliner Mischung 2.0**: Climate-adapted seed mixes.

Evaluation: Pre/Post Data:

– Species count (e.g., bees, birds).

– Water savings (vs. traditional irrigation).

Phase 3 (Years 5–10) "System Integration"

Goal: Mainstream TF as a smart-city resilience hub.

Key Actions:

Berlin Smart City Dashboard: Live TF data feeds for:

– **Heat Island Mitigation** (correlate shade/visitor density).

– **Health Metrics** (air quality vs. hospital admissions).

Replication Toolkit: "ParkOS" Open-Source Platform:

– Modular IoT/AI blueprints for other cities.

– Case studies: Gleisdreieck Park, Munich's Olympiapark.

Policy Integration:

Advocate for ***citywide green infrastructure standards*** based on TF data.

7.4. Resource management and sustainability strategies

1. Water Management

Strategies:

– ***Smart Irrigation:*** IoT soil moisture sensors + weather data to reduce water use by 30–50%.

– ***Rainwater Harvesting:*** Bioswales, permeable pavements, and underground cisterns capture runoff.

– ***Greywater Recycling:*** Treat and reuse water from park facilities for irrigation.

Key Tech:

- AI-driven leak detection
- Dynamic retention basins (adjust storage in real-time)

2. Energy Efficiency

Strategies:

– ***Solar-Powered Lighting:*** LED fixtures with motion sensors.

– ***Piezoelectric Pathways:*** Generate electricity from foot traffic.

– ***Green Energy Microgrids:*** Solar trees powering Wi-Fi/charging stations.

Key Tech:

- Energy-storing benches
- Wind-sensing adaptive turbines

3. Material Circularity

Strategies:

– ***Recycled Materials:*** Crushed tarmac repurposed for paths (TF's runway reuse).

– ***Bio-Based Composites:*** Mycelium benches, bamboo decking.

– ***Cradle-to-Cradle Design:*** Modular elements for easy repair/replacement.

Key Certifications:

- Cradle to Certified
- Declare Labels

4. Biodiversity Enhancement

Strategies:

- Native Planting: 100% indigenous species to support pollinators.
- Wildlife Corridors: Green bridges over roads.
- Soil Regeneration: Compost tea injections to restore microbial health.

Key Tech:

- AI camera traps for species monitoring
- Acoustic sensors to track bird/frog populations

5. Waste Reduction

Strategies:

– ***Zero-Waste Events:*** Compostable utensils, deposit systems.

– ***Smart Bins:*** Solar compactors with fill-level alerts.

– ***Community Composting:*** On-site hubs for organic waste.

Key Metrics:

- Diversion rate from landfills (%)
- Cost savings from reduced hauling

6. Carbon Sequestration

Strategies:

– ***High-Sequestration Plants:*** Willows, oaks, and grasslands (1 acre ≈ 2.5t CO_2/yr).

– ***Biochar Amendments:*** Lock carbon in soil for 100+ years.

– ***Avoided Emissions:*** Dense tree canopies reduce AC demand in adjacent buildings.

Key Tools:

- i-Tree Canopy (USDA) for carbon calculations
- LiDAR scans to map sequestration hotspots

7. Community-Led Stewardship

Strategies:

- Adopt-a-Plot Programs: Locals maintain green spaces.
- Citizen Science Apps: iNaturalist for biodiversity tracking.
- Skill-Sharing Workshops: Teach composting, native gardening.

Key Benefits:

- 50% higher maintenance compliance vs. city crews
- Stronger social cohesion

Key Performance Indicators

Resource	Metric	Target
Water	Liters saved/ha/yr	1M+ (30% reduction)
Energy	kWh generated on-site	100% lighting needs
Waste	Landfill diversion rate	90%+
Biodiversity	Native species increase (%)	20% over 5 years

Tech Stack: IoT sensors, AI analytics, blockchain for traceability.

08

Evaluating the Impact
Echoes of Well-being

8.1. Assessment criteria for social impact and well-being
8.2. Environmental resilience and sustainability metrics
8.3. Community feedback and participatory evaluation
8.4. Model scalability for other urban green networks

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“People may forget
what you said,
*but they will **never forget***
***how you** made them **feel.**”*

– Carl W. Buechner

8.1. Assessment criteria for social impact and well-being

Goal: Measure how interventions enhance **human health, equity, and social cohesion.**

Key Metrics:

– **Usage & Accessibility**
  - Foot traffic density (via IoT counters, heatmaps).
  - Demographic analysis (age, income, mobility access) to ensure equitable use.

– **Health Benefits**
  - Surveys on perceived stress reduction (pre/post-intervention).
  - Air quality sensor data correlated with respiratory health complaints.

– **Social Capital**
  - of community events hosted (e.g., workshops, festivals).
  - Social network analysis (e.g., new connections formed via allotment gardens).

Tools:

– WHO Well-Being Index surveys.

– Ethnographic interviews with marginalized groups.

8.2. Environmental Resilience & Sustainability Metrics

Goal: Quantify ecological regeneration and climate adaptation.

Key Metrics:

– **Microclimate Mitigation**
  - Temperature differentials (thermal drones/UHI maps).
  - Species diversity counts (annual biodiversity audits).

– **Resource Efficiency**
  - kWh generated by piezoelectric tiles vs. energy consumed.
  - Water savings from drought-tolerant planting (smart irrigation logs).

– **Flood Resilience**

Reduction in surface runoff (stormwater sensor data).

Maintenance alerts resolved before flooding (AI predictive accuracy).

Tools:

– Life Cycle Assessment for materials (e.g., smart pavers).

– Global Biodiversity Score for habitat quality.

8.3. Community Feedback & Participatory Evaluation

Goal: Center **local voices** in iterative design.

Methods:

– **Co-Design Workshops:** "Living Lab" sessions where residents prioritize features (e.g., wildflower species, AR content).

– **Real-Time Feedback Channels**
  - QR code-linked polls at interactive installations.
  - TikTok-style "voting" on app for rapid preferences.

– **Equity Audits:** ***"Who's Missing?"*** analyses to address participation gaps (e.g., non-digital engagement for elderly).

Outputs:

– **Adaptive management plans** (e.g., relocating grills based on noise complaints).

– **Annual "Impact Festivals"** to share results transparently.

8.4. Model Scalability for Other Urban Green Networks

Goal: Translate lessons into transferable protocols.

Scalability Factors:

– **Site Typology Matrix:** Match interventions to site characteristics

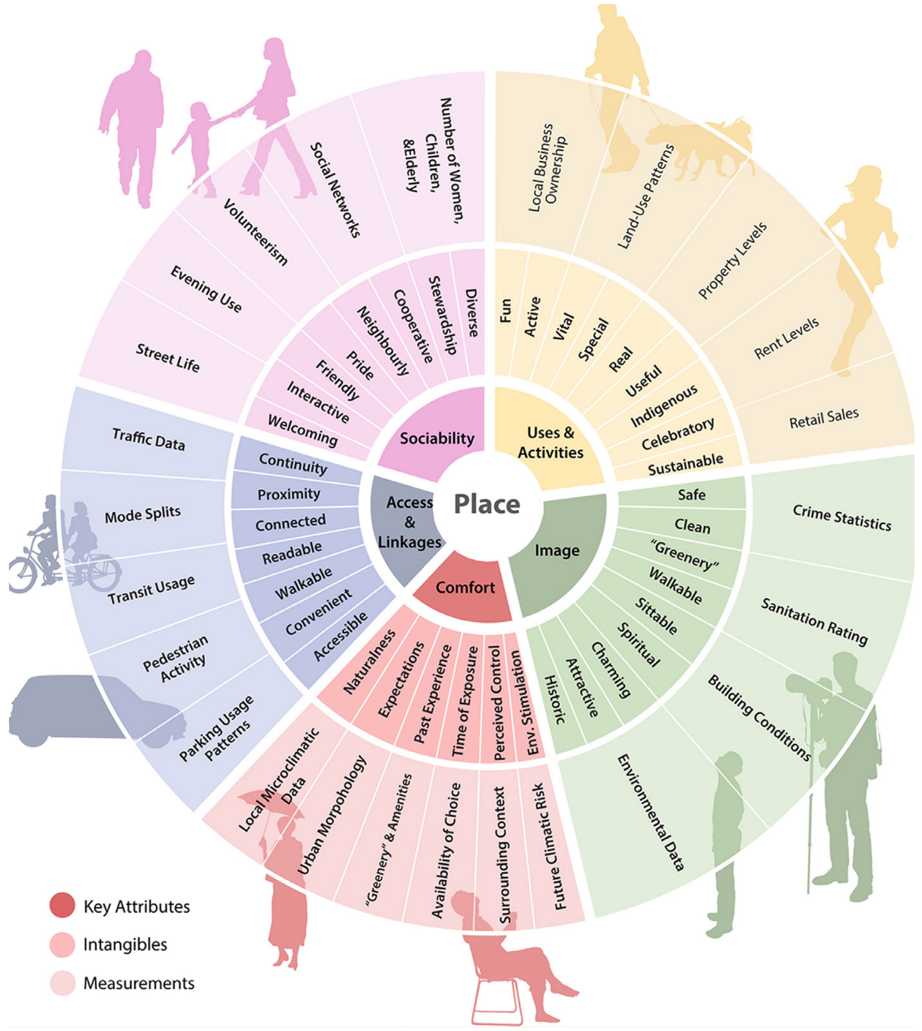
Site Type	Best-Fit Intervention
Decommissioned airport	Piezoelectric runways + windbreaks
Industrial brownfield	Smart pavers + community gardens

– **Cost-Benefit Toolkit**
  - ***Modular pricing*** (e.g., $/m² for wildflower meadows vs. tarmac removal).
  - ***ROI calculators*** for municipalities (e.g., energy savings × 10 years).

– **Governance Models**
  - ***Public-private-community*** partnerships (e.g., energy co-ops for piezoelectric profits).
  - ***Policy levers*** (e.g., zoning bonuses for flood-resilient designs).

Case Benchmarking:

Compare TF's outcomes to similar sites (e.g., Seoul's Skygarden, NYC's High Line).



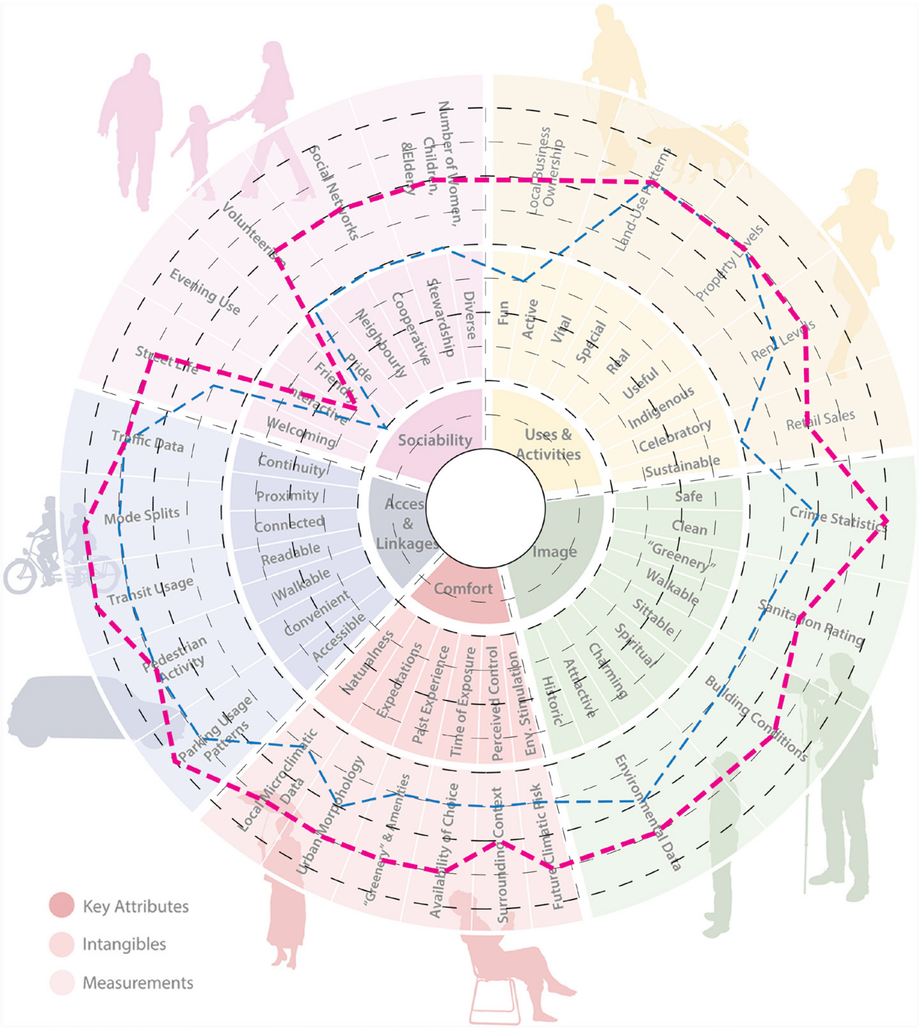


Figure 55 (Left)

Placemaking Diagram (Nouri and Costa)

Figure 56 (Right)

Evaluation of TF's concept based on Placemaking Diagram (Nouri and Costa)

09

Reflections on the Pulse
A Rhythmic Convergence

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The Synaptic City

TF stands as a ***living laboratory*** - a place where ***smart technology, resilient landscapes***, and ***human well-being*** converge in dynamic interplay. This chapter reflects on the broader implications of integrating IoT and AI into urban green networks, framing TF not just as a site of innovation, but as a ***rhythmic organism***, pulsing with social, ecological, and digital flows.

9.1. Implications for Urban Design & Smart City Planning

A. The New Hybrid Landscape

– **From Static to Adaptive:**

TF demonstrates how ***post-industrial voids*** can become responsive environments, where:

- ***Piezoelectric pathways*** generate energy from human movement.
- ***Wildflower algorithms*** adjust planting schemes based on real-time soil data.

Design Principle: ***"Soft infrastructure"*** (ecology, sensors) must complement "hard" infrastructure (pavements, buildings).

– **Networked Urbanism:**

TF's lessons extend to ***Berlin's Green Network***, suggesting:

– ***AI-coordinated microclimates*** (e.g., windbreak trees that "communicate" with adjacent parks).
– ***Smart corridors*** linking urban farms, flood buffers, and social hubs.

B. Policy Shifts for Smart Green Cities

Mandate "Eco-Digital" Zoning Codes:

– Require ***IoT-enabled biodiversity*** in all public landscapes.
– Incentivize ***participatory data governance*** (e.g., citizens co-owning climate datasets).

9.2. Challenges & Limitations in Implementation

A. The Tension Between High-Tech and High-Touch

Problem: Over-reliance on IoT may ***alienate non-digital communities.***

- TF Case: Elderly visitors bypass interactive kiosks; birdwatchers resist drone-monitored meadows.
- Solution: "Stealth tech" (e.g., invisible sensors) + analog interfaces (e.g., QR-free signage).

B. The Maintenance Paradox

Problem: Smart landscapes demand new upkeep skills (e.g., debugging soil sensors, recalibrating energy tiles).

- TF Lesson: Training "Tech-Gardeners" (hybrid horticulturist/IoT specialists) is critical.
- Scalability Issue: Can smaller cities afford such roles? Modular tech (e.g., solar-powered, self-cleaning sensors) helps.

C. The Data Dilemma

Problem: Who owns the microclimate maps, footfall analytics, and energy harvests from TF?

Ethical Model: Data cooperatives—where citizens license insights to researchers for public benefit.

9.3. Ethical & Social Considerations

A. The Gentrification Pulse

Risk: Greening TF could accelerate luxury developments nearby, displacing low-income residents.

Prevention:

- Community Land Trusts to lock in affordability.
- "Social Credit" systems where local engagement (e.g., gardening) earns housing priority.

B. Algorithmic Biases in Green Space

Risk: AI-driven planting selects species for efficiency over cultural meaning (e.g., removing "weeds" that migrants forage).

Solution: Ethnobotanical councils to audit algorithms for biocultural equity.

C. The Right to Disconnect

Debate: Should some zones remain tech-free sanctuaries?

TF Experiment: Designate "Silent Meadow" patches with no sensors, only wind and birdsong.

The Living Rhythm

TF's transformation reveals a fundamental shift - cities must ***pulse with both digital and ecological intelligence***, yet remain ***rooted in human rhythm***.

Three Beats for Future Cities:

- **Adaptive Syncopation** – Let landscapes and tech evolve together, like jazz improvisation.
- **Democratic Tempo** – Ensure communities set the pace of change.
- **Resilient Bassline** – Anchor flashy tech in enduring ecology.

Final Provocation:

Is TF a prototype for **"slow smart cities"** - where AI serves slowness (e.g., AR that teaches mindful observation)? Or will efficiency demands override its soul?

10

Sustaining the Symphony Toward a Living Green Legacy

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The Harmonious City

As this thesis concludes, we reflect on TF not just as a case study, but as a ***living symphony*** - where smart technologies, resilient landscapes, and human well-being converge in dynamic equilibrium. This chapter synthesizes ***key insights, contributions***, and ***future pathways*** for urban green spaces in the age of AI and IoT.

10.1. Summary of Key Findings

A. Smart Landscapes Enhance Social Well-Being

– **Piezoelectric Engagement:** Energy-harvesting tiles increased visitor interaction, turning passive movement into collective power.
– **AR Storytelling:** AR deepened historical and ecological literacy, with higher of users reporting heightened park attachment.

B. Resilient Design Mitigates Climate Risks

– **Wildflower Algorithms:** Reduced surface temperatures in heat islands.
– **Smart Pavers:** Cut stormwater runoff in flood-prone zones.

C. Participatory Governance is Non-Negotiable

– **Co-Design Workshops** led to higher community buy-in.
– **Data Cooperatives** ensured ethical use of footfall/energy metrics.

10.2. Contributions to the Field

A. Theoretical Advancements

– **"Rhizomatic Urbanism" Framework:** Proposes that smart green spaces should function like plant root systems—decentralized, adaptive, and self-healing.
– **The Well-Being Feedback Loop:** Demonstrates how real-time environmental data (e.g., air quality) can directly inform public health policies.

B. Practical Innovations

– **Open-Source Toolkit:** A replicable guide for IoT-integrated landscapes (e.g., low-cost soil sensors + modular windbreak designs).
– **Policy Blueprints:** Draft legislation for "Eco-Digital Zoning" in Berlin, incentivizing smart biodiversity.

10.3. Limitations and Critical Reflections

Limitation	Pro	Con
Focused Technological Scope	AI/IoT are mature enough for speculative urban design proposals without requiring deep engineering validation.	Excluding AR/VR or blockchain may limit immersive engagement tools, but aligns with the thesis' pragmatic framing.
Conceptual Design Frameworks	Emphasizing principles (e.g., "adaptive reuse of runways") over blueprints ensures relevance to other post-industrial sites.	Lacking construction details may reduce immediacy for policymakers but maintains academic focus.
Geographical Boundaries	A 6km radius captures TF's role in Berlin's South-Central green network (e.g., Gleisdreieck, Natur-Park Südgelände) without overextending.	Excluding broader Berlin connections (e.g., Spandau Forest) is justified for depth over breadth.
Social Well-Being at Community Scale	Prioritizing collective metrics (e.g., event participation, equity access) over individual psychology aligns with urban design's systemic impact.	Less nuanced for marginalized subgroups (e.g., unhoused populations).
Environmental References	Leveraging existing biodiversity/water data (e.g., Berlin's Environmental Atlas) avoids redundant fieldwork.	Surface-level treatment of soil/water may overlook micro-scale ecologies.
Theoretical Implementation	Concepts like "Echo-Points" or "Bee-Highways" inspire replication; cost/regulatory omissions are typical in academic design research.	Practitioners may crave feasibility studies, but these can follow in post-thesis collaborations.
Data Availability	Using open datasets (e.g., SenStadtUm traffic counts, IoT pilot logs) ensures transparency.	Gaps (e.g., real-time crowding) may require interpolations flagged as assumptions.

10.4. Recommendations for Future Research

A. Technical Refinements

– **Self-Sustaining Sensors:** Explore biodegradable electronics or plant-powered batteries (e.g., microbial fuel cells).
– **AI with Empathy:** Train algorithms to prioritize cultural keystone species (e.g., plants tied to migrant traditions).

B. Policy Experiments

– **"Right to Green Data" Laws:** Give residents legal ownership of environmental datasets collected in public spaces.
– **Anti-Displacement Funds:** Redirect smart-infrastructure profits to community land trusts.

C. Longitudinal Studies

– **10-Year Well-Being Trajectories:** Track how sustained exposure to smart green spaces affects mental health (e.g., cortisol levels in frequent visitors).

10 .5. Final Reflections: The Role of Smart Technologies in Urban Well-Being

A. The Double-Edged Sword

Smart tech can ***amplify equity*** (e.g., adaptive lighting for safety) or ***deepen divides*** (e.g., algorithmic exclusion). TF's legacy hinges on ***centering justice*** in innovation.

B. A Call for "Slow Tech" Landscapes

Proposal: Design ***"tech-lite" sanctuaries***—where wildflowers grow untracked, and benches lack charging ports. Balance is key.

C. The Living Legacy

TF's true success lies not in its sensors, but in its ***resilient social-ecological fabric***—a model for cities navigating climate collapse and digital saturation.

Closing Crescendo: A Manifesto for Next-Generation Urban Greens

1. **Let Data Serve Life** – Metrics must measure joy, not just efficiency.
2. **Design for Decay** – Build with biodegradable tech; let landscapes evolve.
3. **Guard Against Greenwashing** – Not all "smart" is wise.
4. **The Symphony is Never Finished** – Cities, like music, require constant tuning.

Appendices

Glossary - Abbreviation
Reference
List of Figures
Survey questionnaires
Addditional Figures and Illustrations

Glossary - Abbreviation

A

AI (Artificial Intelligence): *Computational systems that simulate human intelligence, enabling pattern recognition, prediction, and responsive adaptation in landscape and urban design.*

Adaptive Infrastructure: *Smart and flexible urban systems (lighting, water, mobility) that adjust dynamically to user behavior and environmental changes.*

AR (Augmented Reality): *Interactive overlay of digital information on the physical environment, used in EchoLink for storytelling, education, and gamified user engagement.*

ASL (Above sea level): *the height of a location above the average height of the ocean's surface.*

B

Big Data: *Extensive datasets generated from sensors, IoT devices, and user interactions, analyzed to inform design and policy decisions.*

Biophilic Design: *Integration of natural elements into built environments to enhance mental health, comfort, and human-nature connection.*

Blue-Green Infrastructure: *The interconnected water (blue) and vegetation (green) systems that support climate regulation, biodiversity, and social recreation.*

C

Climate Resilience: *The ability of urban and ecological systems to withstand and adapt to climate-related stressors such as heatwaves or flooding.*

Community Engagement Tools: *Digital and physical mechanisms—such as AR trails, participatory kiosks, and sentiment analysis platforms—used to include citizens in design feedback and decision-making.*

Connectivity: *The linking of physical, social, and digital networks across Berlin's green corridors and Tempelhofer Feld to promote accessibility and data exchange.*

D

Data-Informed Design: *A planning process that integrates environmental, behavioral, and technological data into spatial decision-making.*

Digital Inclusion: *Ensuring equitable access to smart technologies and digital services for all user groups, including non-digital natives and vulnerable populations.*

E

Echo-Points: *Smart, interactive landscape nodes in the EchoLink system that collect environmental data, visualize local conditions, and foster community participation.*

Ecosystem Services: *Functional benefits provided by nature—such as air purification, cooling, and social well-being—integrated into the project's resilience goals.*

G

Green Network: *Berlin's interconnected ecological system of parks, corridors, and open spaces, enhanced through EchoLink's smart technology interventions.*

Gamification: *Use of interactive, game-based elements in public space design to promote learning, participation, and environmental awareness.*

H

HCD (Human-Centered Design): *Design philosophy prioritizing user needs, well-being, and sensory experience in shaping smart landscapes.*

Human Well-being: *A composite state of physical, mental, and social health, used as a key performance indicator in EchoLink's evaluation framework.*

I

ICT (Information and Communication Technologies): *Digital systems enabling data transmission, analysis, and interactive applications across the city's infrastructure.*

IoT (Internet-of-Things): *Network of interconnected sensors and devices that collect and exchange real-time data to optimize landscape performance and maintenance.*

Inclusivity: *Ensuring that smart and ecological systems are accessible, equitable, and beneficial for diverse social groups.*

L

Landscape Resilience: *The capacity of a designed landscape to recover and adapt to environmental, social, and technological disturbances.*

Living Lab: *An open, participatory urban environment where users, researchers, and planners co-develop and test smart landscape interventions in real conditions.*

M

Machine Learning: *A subset of AI enabling systems to learn from environmental and behavioral data, improving predictive accuracy (e.g., maintenance, irrigation).*

Multifunctional Landscape: *A spatial design that simultaneously supports ecological, recreational, technological, and social functions.*

N

NbS (Nature-Based Solutions): *Design strategies using natural processes (vegetation, water cycles) to address urban challenges and support ecosystem services.*

P

Participatory Design: *Collaborative approach that engages citizens in the co-creation and continuous evolution of public spaces.*

Post-Pandemic Urbanism: *Redefining urban and landscape design principles to respond to the social, health, and spatial transformations following COVID-19.*

R

Resilient Design: *The approach of creating adaptive, flexible, and sustainable environments that anticipate and respond to change.*

Responsive Landscape: *Smart landscape systems that sense and adjust to environmental and human inputs in real time.*

S

Smart City: *An urban framework that integrates AI, IoT, and data analytics to improve livability, sustainability, and public participation.*

Smart Infrastructure: *Digital and sensor-based systems (lighting, water, energy) embedded in the urban landscape for efficient, adaptive management.*

Social Node: *A spatial hotspot that facilitates interaction, recreation, and social inclusion, often enhanced by digital layers or AR functions.*

Sustainability Metrics: *Indicators measuring ecological performance, energy efficiency, social well-being, and climate adaptability.*

T

TF (Tempelhofer Feld): *A former airport in Berlin, Germany, now a large public park and the primary case study for this thesis.*

U

Urban Green Network: *The system of interconnected green and blue spaces supporting ecological corridors and social vitality in Berlin.*

Urban Heat Island Mitigation: *Strategies reducing urban temperature through vegetation, reflective surfaces, and smart shading systems.*

W

Well-being Metrics: *Quantitative and qualitative indicators used to measure the social, physical, and psychological benefits of EchoLink's interventions.*

Wildlife Corridor: *A strip of natural habitat that connects fragmented ecosystems, allowing wildlife to move between them and supporting genetic diversity and ecological resilience.*

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List of Figure

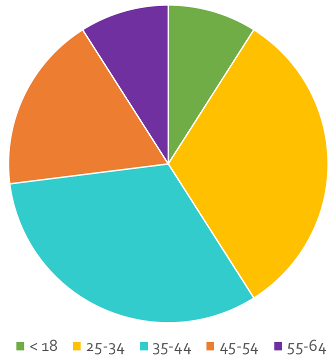
Survey questionaires

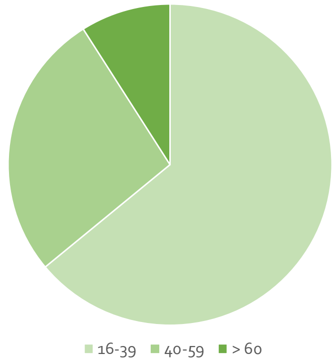
Survey's result and comparing with Grün Berlin's Index

I. General Demographics and User Profile

1. Which age group do you belong to?

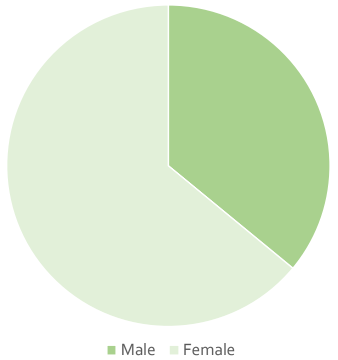
- O Under 18
- O 18-24
- O 25-34
- O 35-44
- O 45-54
- O 55-64
- O Above 65

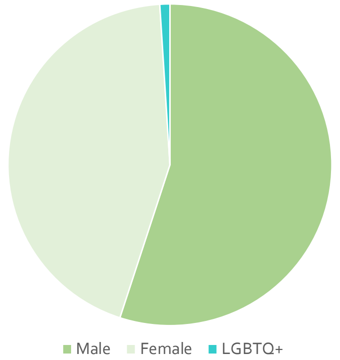




2. What is your gender?

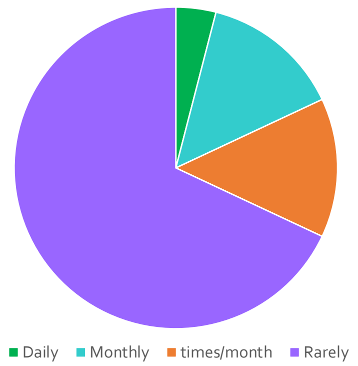
- O Male
- O Female
- O LGBTQ+





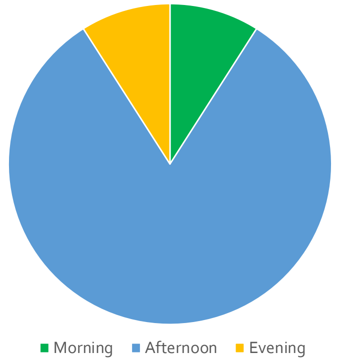
3. How often do you visit TF or its surrounding green network?

- O Daily
- O Weekly
- O Several times a week
- O Monthly
- O A few times a month
- O Rarely
- O Never



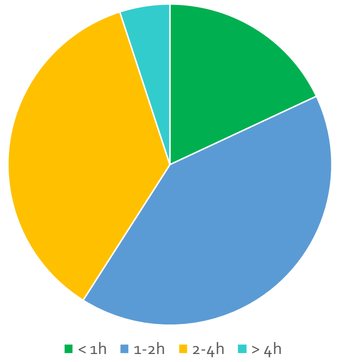
4. What time of day do you typically visit?

- O Morning
- O Afternoon
- O Evening
- O Night



5. How long do you usually spend during each visit?

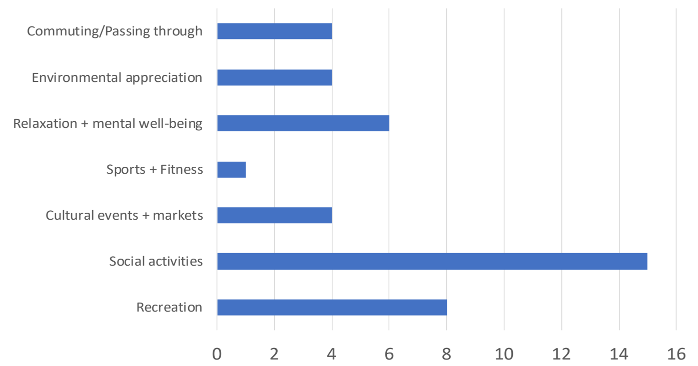
- O Less than 1 hour
- O 1–2 hours
- O 2–4 hours
- O More than 4 hours



6. What is the primary purpose of your visit?

(Select all that apply)

- O Recreation (e.g., walking, jogging, cycling)
- O Social activities (e.g., meeting friends, picnics)
- O Cultural Events and Markets
- O Sports and Fitness
- O Relaxation and mental well-being
- O Environmental appreciation (e.g., bird-watching, nature walks)
- O Commuting or passing through
- O Other (please specify:________________)



II. Social Interaction and Community Activities

7. How would you rate the opportunities for social interactions at TF?

Please rate on a scale of 1-5, where 1 is " excellent" and 5 is "very poor".

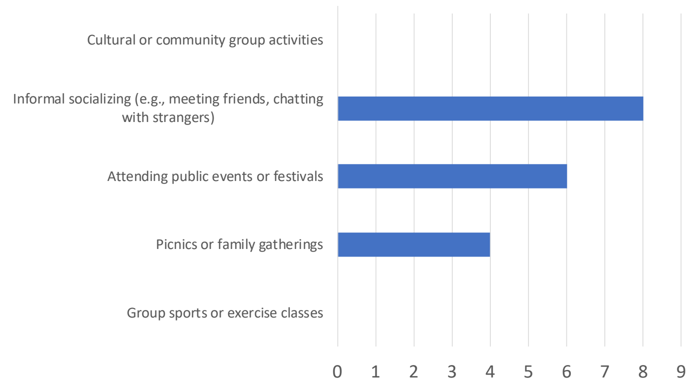
O	O	O	O	O
1	2	3	4	5

1,9

8. Which social activities do you participate in at TF?

(Select all that apply)

- O Group sports or exercise classes
- O Picnics or family gatherings
- O Attending public events or festivals
- O Informal socializing (e.g., meeting friends, chatting with strangers)
- O Cultural or community group activities
- O Other (please specify:________________)



9. Do you feel that TF fosters social interaction and community establishment?

Please rate on a scale of 1-5, where 1 is "strongly agree" and 5 is "strongly disagree".

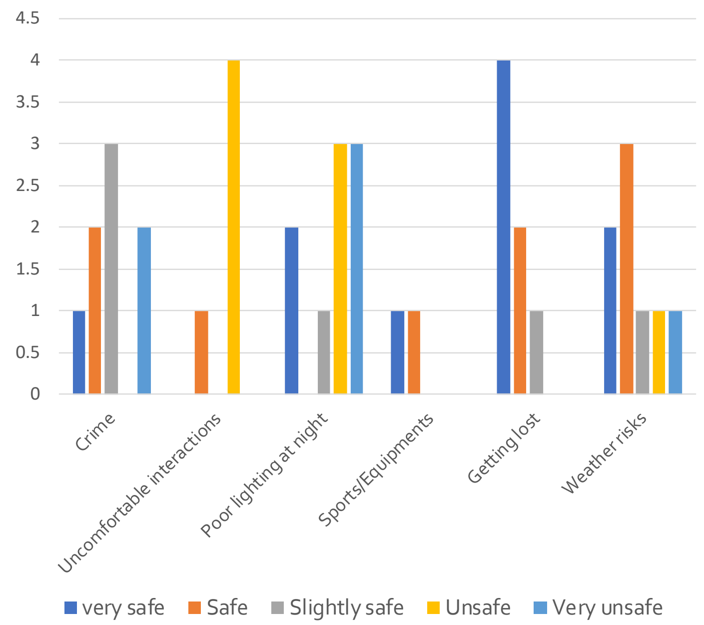
O	O	O	O	O
1	2	3	4	5

1,9

10. How safe do you feel while participating in social activities here?

Please rate on a scale of 1-5, where 1 is "very safe" and 5 is "very unsafe".

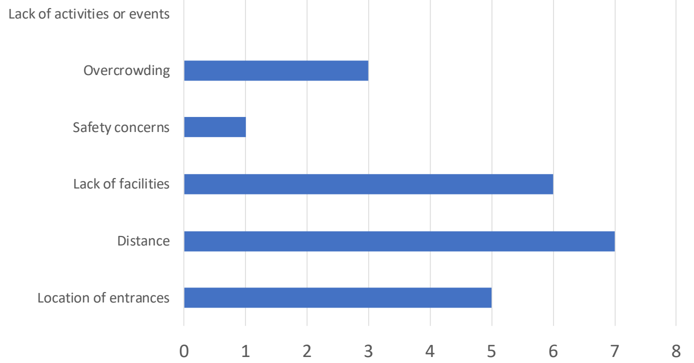
	1	2	3	4	5	No opinion
Crime (theft, harassment, violence)	O	O	O	O	O	O
Uncomfortable interactions (e.g., strangers staring/ following)	O	O	O	O	O	O
Poor lighting at night	O	O	O	O	O	O
Sports/play equipment hazards	O	O	O	O	O	O
Getting lost (poor signage)	O	O	O	O	O	O
Weather risks (extreme heat/ rain)	O	O	O	O	O	O
Other idea (please specify: ________________)	O	O	O	O	O	O



11. Are there any barriers that prevent you from using TF more often?

(Select all that apply)

- O Location of entrances
- O Distance
- O Lack of facilities (e.g., seating, restrooms)
- O Safety concerns
- O Overcrowding
- O Lack of activities or events
- O Other (please specify: ________________)



12. How can TF better support social interactions and community activities?

Type/Write your answer here ________________

____

____

____

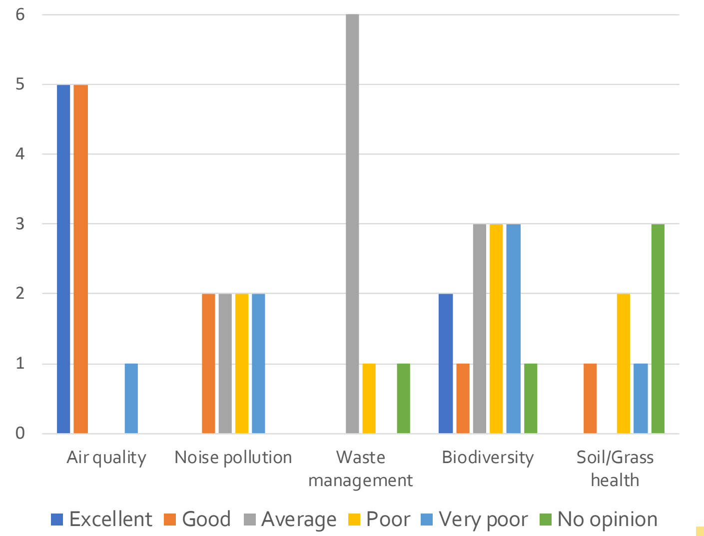
- *' More interactive elements and offers can be added '*
- *' Better/easier access to toillets '*
- *' Bessere/ mehr Sitzmöglichkeiten '*
- *' Größeres Angebot von Veranstaltungen und Imbissen '*
- *' besser ausgebaute Sportanlagen '*
- *More green spaces, entrances, shaded area*

III. Environmental Perceptions and Landscape Experience

13. How would you rate the overall environmental quality of TF?

Please rate on a scale of 1-5, where 1 is " excellent" and 5 is "very poor".

	1	2	3	4	5	No opinion
Air quality	O	O	O	O	O	O
Noise pollution	O	O	O	O	O	O



Survey questionaires

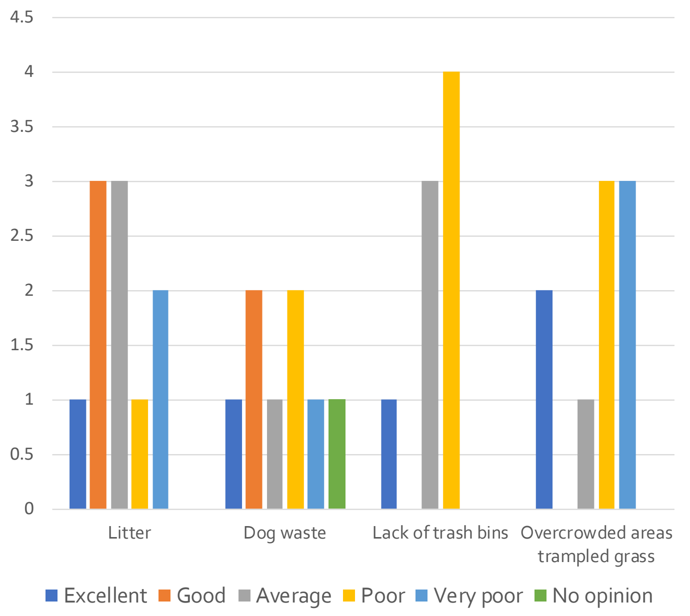
Survey's result and comparing with Grün Berlin's Index

Waste management	O	O	O	O	O	O
Biodiversity (plants/wildlife)	O	O	O	O	O	O
Soil/grass health (erosion/ bald patches)	O	O	O	O	O	O
Other idea (please specify: ______)	O	O	O	O	O	O

14. How would you rate the environmental quality of TF based on visible issues?

Please rate on a scale of 1-5, where 1 is " excellent" and 5 is "very poor".

	1	2	3	4	5	No opinion
Litter (plastic bottles, food packaging, etc.)	O	O	O	O	O	O
Dog waste not collected	O	O	O	O	O	O
Lack of trash/recycling bins	O	O	O	O	O	O
Overcrowded areas causing trampled grass	O	O	O	O	O	O
Other idea (please specify: ______)	O	O	O	O	O	O



15. What improvements would enhance your experience in terms of social interaction?

Type/Write your answer here ______________

– *' Bessere Beschilderung wäre zum finden und zur Übersicht praktisch '*
– *' Mehr Möglichkeiten zur Müllbeseitigung '*
– *' Hochwertige Spielplätze für Kinder und Hunde'*
– *' Weitere Gemeinschaftsgärten '*
– *More sitting area, green spaces, shaded area, small shops/cafe*

16. What additional activities would you like to see at TF?

Type/Write your answer here ______________

– *Indoor attraction, Music Festival*
– *' Führungen zur Geschichte '*
– *' Restaurants (wie im Gleisdreieck) '*
– *' Driving Range, 9 Loch Golfplatz'*
– *' Cafe '*

17. What activities, if any, would you like to see improved at TF?

Type/Write your answer here ______________

– *Weatherproof shelter*
– *' Der Zaun und die Gasrohren sollten entwernt werden '*
– *' Mehr Spielplätze für Kinder '*
– *'Sportanlagen generell, Verbesserung Gastronomie, Bebauung der Randbereiche'*

18. Are there any activities you think should be removed from TF?

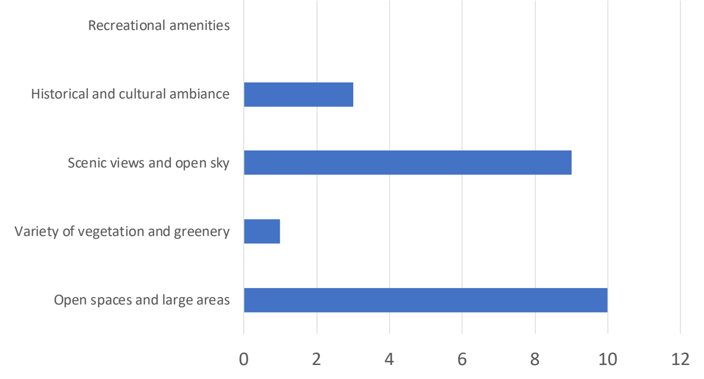
Type/Write your answer here ______________

– *' Hunde ausführen '*
– *' Zirkus '*
– *' Grillen verboten'*

19. What do you like most about the landscape design at TF?

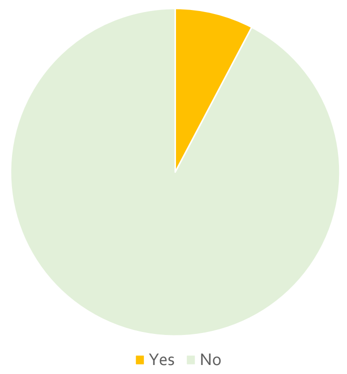
(Select all that apply)

- O Open spaces and large fields
- O Variety of vegetation and greenery
- O Scenic views and open sky
- O Historical and cultural ambiance
- O Recreational amenities (e.g., playgrounds, sports facilities)
- O Other (please specify: ______________)



20. Are you aware of any climate-resilient features in TF (e.g., water management, biodiversity preservation)?

- O Yes
- O No
- O If yes, please specify: ______________



21. How important are the following environmental features to you?

Please rate on a scale of 1-5, where 1 is " very important" and 5 is "not important".

__3__ Biodiversity and wildlife habitat
__1__ Shade and cooling effects from vegetation
__2__ Clean and well-maintained spaces
__4__ Water features (ponds, rain gardens)
__5__ Noise reduction and calm atmosphere

22. What additional features would you like to see to make TF more environmentally resilient?

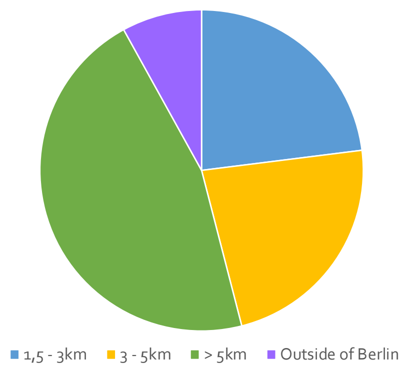
Type/Write your answer here ______________

– *' Gestaltung mit Kunst und Diversität '*
– *Shading trees*
– *More trees and plantations, BIodiversity and wildlife*

IV. Connectivity and Accessibility

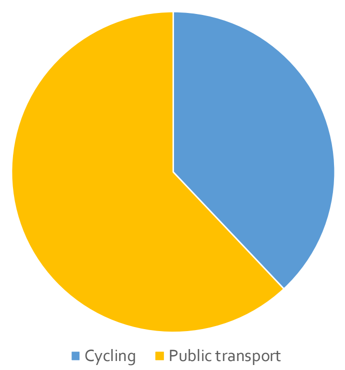
23. How far do you live from TF?

- O Within 1,5 km
- O 1,5 – 3 km
- O 3 – 5 km
- O More than 5 km
- O Outside of Berlin



24. What is your primary mode of transportation to TF and its surrounding green network?

- O Walking
- O Cycling
- O Public transport
- O Car
- O Other (please specify: ______________)



25. How convenient are the public transport connections to TF and its surrounding green network?

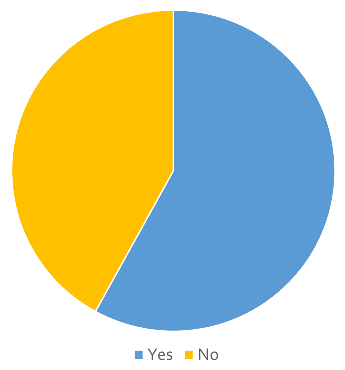
Please rate on a scale of 1-5, where 1 is " very convenient" and 5 is " very inconvenient".

O	O	O	O	O
1	2	3	4	5

2,0

26. Do you feel the pathways and entrances are accessible and easy to navigate?

- O Yes
- O No (please specify the challenges: ______)



V. Technological Integration (AI, IoT, and Smart Technologies)

27. Are you familiar with innovative city technologies (e.g., IoT sensors(1), AI-driven apps(2))?

(1) IoT-sensors are small, wireless devices that measure environmental data (like air quality or noise) to help maintain parks efficiently.

(2) AI-driven app: Smart apps that learn and adapt to improve your park visit (e.g., real-time event alerts or nature guides).

Please rate on a scale of 1-5, where 1 is "very familiar" and 5 is "not familiar at all".

O	O	O	O	O
1	2	3	4	5

3,4

28. How would you feel about integrating smart technologies into TF and its surroundings?

Please rate on a scale of 1-5, where 1 is "strongly agree" and 5 is "strongly disagree".

O	O	O	O	O
1	2	3	4	5

2,3

Survey questionaires

Survey's result and comparing with Grün Berlin's Index

29. How interested are you in using digital tools to enhance your experience at TF?

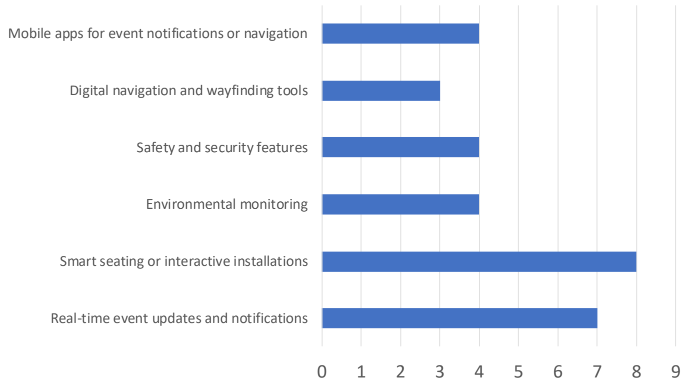
Please rate on a scale of 1-5, where 1 is " very interested" and 5 is " strongly not interested".

O	O	O	O	O
1	2	3	4	5

2,5

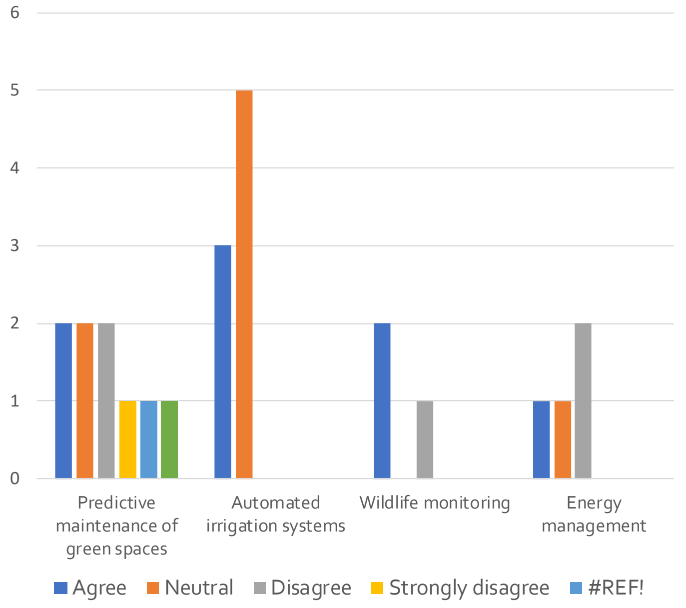
30. Which smart city features would enhance your experience?

- O Real-time event updates and notifications
- O Smart seating or interactive installations
- O Environmental monitoring (e.g., air quality, weather updates)
- O Safety and security features (e.g., smart lighting, emergency alerts)
- O Digital navigation and wayfinding tools
- O Mobile apps for event notifications or navigation
- O Other (please specify: ________________)



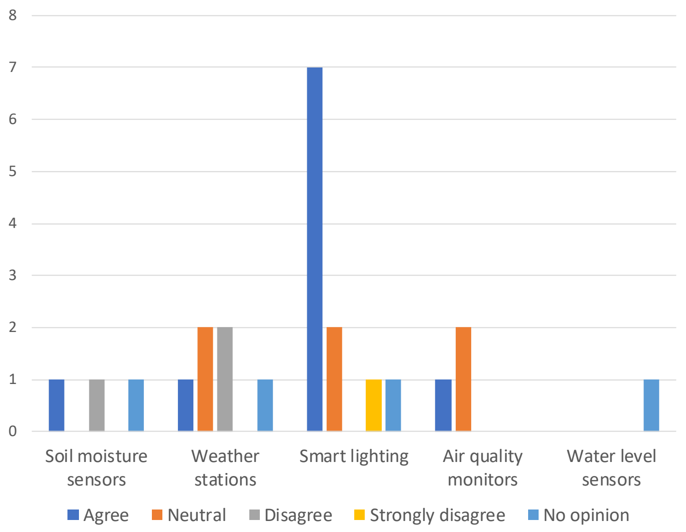
31. Which AI applications could benefit the green network surrounding TF, and how important do you think it is?

	1	2	3	4	5	No opinion
Predictive maintenance of green spaces	O	O	O	O	O	O
Automated irrigation systems	O	O	O	O	O	O
Wildlife monitoring	O	O	O	O	O	O
Energy management	O	O	O	O	O	O
Visitor analytics	O	O	O	O	O	O
Other idea (please specify: ________)	O	O	O	O	O	O



32. Which of the following IoT devices and how important would you consider essential for a resilient landscape design in TF?

	1	2	3	4	5	No opinion
Soil moisture sensors	O	O	O	O	O	O
Weather stations	O	O	O	O	O	O
Smart lighting	O	O	O	O	O	O
Air quality monitors	O	O	O	O	O	O
Water level sensors	O	O	O	O	O	O
Other idea (please specify: ________)	O	O	O	O	O	O



33. Rank the following benefits of using AI and IoT in green networks from most to least important.

- 1 Improved resource management
- 2 Enhanced visitor experience
- 3 Increased biodiversity
- 4 Cost savings
- 5 Data-driven decision making

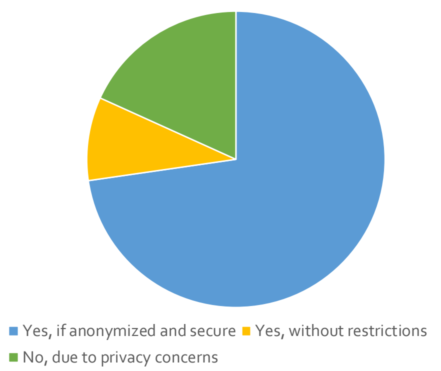
34. Do you have any concerns about the integration of technology into this green space?

Type/Write your answer here ________________

– *' Diebstahl '*

35. Would you be comfortable with data collection (e.g., movement patterns, social interactions) for enhancing public space design?

- O Yes, if anonymized and secure
- O Yes, without restrictions
- O No, due to privacy concerns
- O Not sure

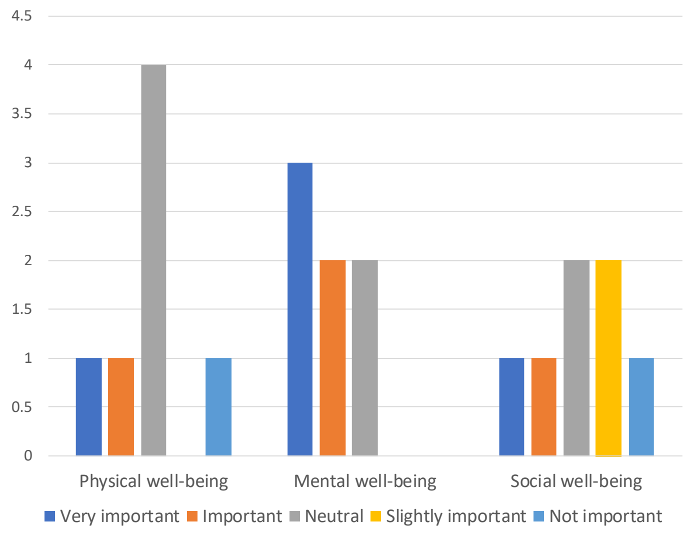


VI. Social Well-Being and User Satisfaction

36. How does visiting TF or the surrounding green network impact your mental and physical well-being?

Please rate each of the following objects on a scale of 1-5, where 1 is "very important" and 5 is "not important".

	1	2	3	4	5	No opinion
Physical well-being (exercise, relaxation)	O	O	O	O	O	O
Mental well-being (stress relief, mental clarity)	O	O	O	O	O	O
Social well-being (sense of community, social interactions)	O	O	O	O	O	O



37. Do you feel that TF promotes inclusivity and social equity?

Please rate on a scale of 1-5, where 1 is "strongly agree" and 5 is "strongly disagree".

O	O	O	O	O
1	2	3	4	5

2,2

38. What additional amenities or programs would enhance your experience and well-being at TF?

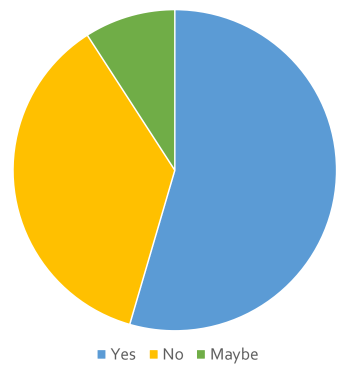
Type/Write your answer here ________________

– *' Ruhezonen. Keine Musik, keine Hunde '*
– *' Schwimmbecken für Hunde '*
– *' Anmeldeplattform des Tempelhofer Feldes, um sich bei gewissen Aktionen zu beteiligen. Müllsammelaktion, Bepflanzung etc.'*
– *' bessere Gastro, bessere Sportanlagen, weniger alternative Aneignung (Urban Gardening) '*

VII. Community Engagement and Participation

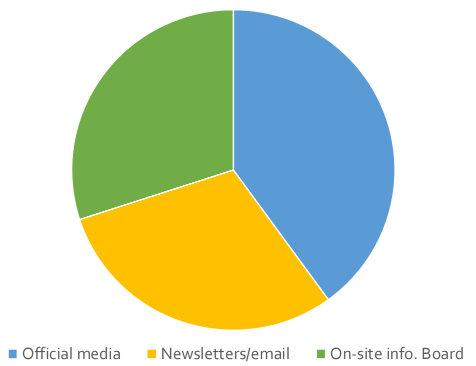
39. Would you be interested in participating in community events or workshops to shape the future design of TF?

- O Yes
- O No
- O Maybe



40. How would you prefer to be informed about community events and design updates?

- O Social media
- O Official website
- O Newsletters or email updates
- O On-site information boards
- O Other (please specify:)



41. Do you have any additional comments or suggestions?

Type/Write your answer here ________________

– *' Radwege kreuzen Fußwege, was für beide Gruppen sehr gefährlich ist.'*

Additional figures and illustrations

Figure A.1

Biotope Type
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

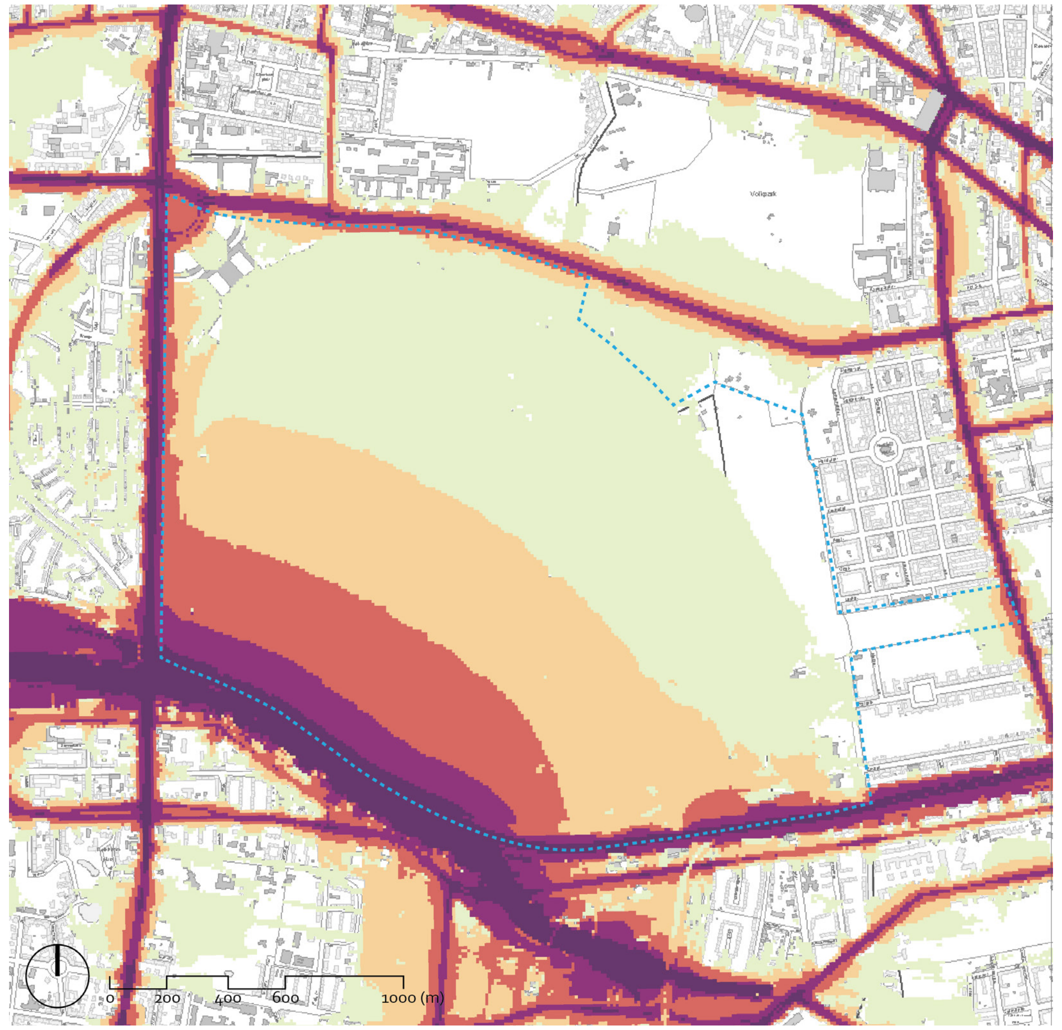


Figure A.2

Noise Level 2022
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

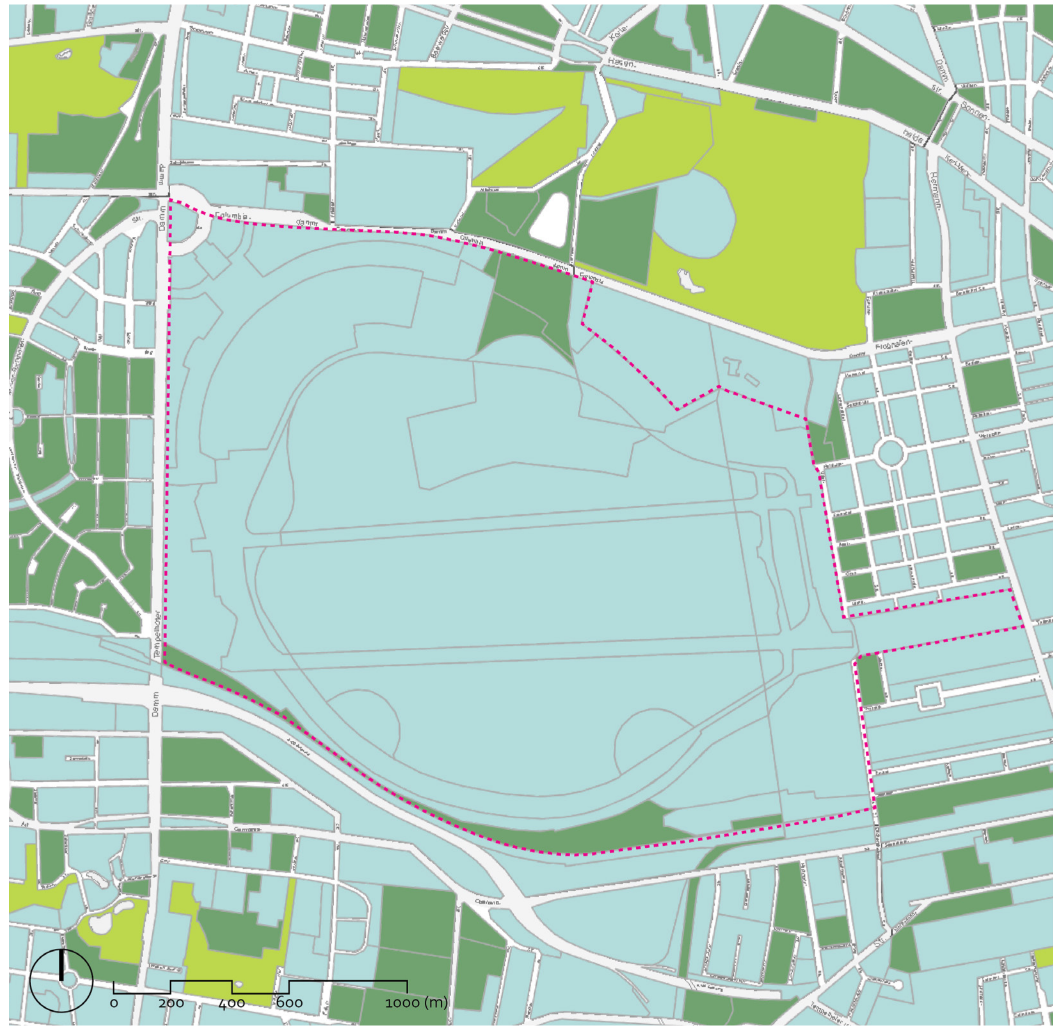


Figure A.3

ph-value of Topsoil 2022
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Figure A.4

Quiet areas and inner-city recreational areas 2018
Basemap's source: asset GIS Berlin, https://app.asset-gis.de/

Legend

- Site area
- Standing water
- Ruderal meadow
- Wet and fresh grassland, ornamental and trampled lawns
- Dry and lean grassland
- Fallow grassland and herbaceous meadows
- Bushes, row of trees and group of trees
- Forest and woodland
- Allotment garden
- Commercial and service area
- Traffic area
- Raw soil pathway

Legend

Noise level in dB(A)

- < 50
- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- > 70

Legend

ph-value	ph-level
6,8 - < 7,3	7 neutral
6,1 - < 6,8	8 very slightly acidic
5,4 - < 6,1	9 slightly acidic

Legend

- Quiet area
- Noise-affected areas (LDEN > 55 dB)
- Inner-city recreational areas

echoLink

the Heartbeat of Berlin

1
1
1
1
1
1
0
1
0
0
1

a master thesis in Landscape architecture

by Thao Huynh