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Be.CULTOUR
Beyond cultural tourism

Be.CULTOUR:

"Beyond CULtural TOURism: human-centred innovations for sustainable and circular cultural tourism"

HORIZON 2020
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Deliverable 1.5
Development of interactive user oriented Be.CULTOUR App (Digital Twin)

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Dissemination Level

☒	**PU:**	Public
☐	**CO:**	Confidential, only for members of the consortium (including the Commission Services)

Abstract

The Be.CULTOUR project aims to foster sustainable regional development through innovative data management for cultural tourism; it illustrates and investigates the integration of digital twin technology for the Parkstad/Heerlen area. This report encompasses a comprehensive exploration across ten sections, outlining the project's objectives, methodologies, findings, and recommendations.

Section 1 provides an overview of the project's scope, emphasizing its alignment with the United Nations Sustainable Development Goals (SDGs) and the New Urban Agenda. It underscores the significance of cultural tourism in urban economies and the imperative for balanced tourism planning.

In Section 2, the report explores the historical and cultural context of the Parkstad/Heerlen region, covering five distinct eras: the Roman Era, Middle Ages, Coal Mining Era, Interim Period, and Modern Era. Each era's footprint on the region is examined, highlighting key landmarks and historical developments.

Section 3 explores the concept of digital twins and their application in cultural tourism planning. It explores the foundational and engagement phases of the project, emphasizing the utilization of digital twins to simulate project scenarios and enhance visitor experiences.

Section 4 provides insights into the tourism sector in Zuid-Limburg, emphasizing its economic significance and the need for sustainable tourism planning among challenges such as mass tourism and cultural preservation.

Section 5 offers a detailed exploration of the five cultural-historical eras in South Limburg, shedding light on significant landmarks and developments during each period.

Section 6 introduces the Time Travel User Interface App, which enables users to access historical information and stories linked to specific locations within the digital twin environment.

In Section 7, the report explores data collection and geographical information for the Be.CULTOUR project, outlining the digital spatial data mapping process and the types of geographical objects included.

Section 8 provides an overview of the components used in the Digital Twin Viewer for Parkstad/Heerlen, highlighting the technologies and frameworks employed to create an engaging viewer experience.

Section 9 explores the functionalities of the Digital Twin Viewer, including map settings, library access, and insights into the digital twin construction process.

Final, Section 10 concludes the report with recommendations for employing digital planning tools in sustainable cultural tourism. It underscores the importance of stakeholder engagement, continuous updates, and collaborative research in shaping resilient and inclusive tourism destinations.

In conclusion, the report underscores the transformative potential of digital planning tools in promoting sustainable cultural tourism. By leveraging digital twins and advanced technologies, cities can navigate the complexities of tourism management while preserving cultural heritage and fostering community engagement.

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Figures Summary

Tables Summary

1. Description of the Project

Be.CULTOUR stands for "Beyond CULtural TOURism: heritage innovation networks as drivers of Europeanisation towards a human-centred and circular tourism economy". It expresses the goal to move beyond tourism through a longer-term *human-centred* development perspective, enhancing cultural heritage and landscape values.

Cultural tourism entails opportunities but also risks. Tourism as a whole can be a highly volatile economic sector. If not managed properly, cultural tourism can also easily turn into a "value extractive" industry, generating negative environmental, social and cultural impacts on local communities and ecosystems. This project will develop specific strategies to promote an understanding of cultural tourism, which moves away from a "stop-and-go" consumer-oriented approach towards one that puts humans and circular economy models at its centre, paying attention to nature, communities and cultural diversity. "Place", intended as the *genius loci*, the ancient spirit of the site expressing its "intrinsic value" and "people" as co-creators of its uniqueness, culture, art, tradition, folklore, productivity, spirituality, as well as its "time space routine", are the focus of Be.CULTOUR, which aims at realizing a longer-term development project for the pilot areas involved.

The overarching goal of Be.CULTOUR is to co-create and test sustainable human-centred innovations for circular cultural tourism through collaborative innovation networks/methodologies and improved investments strategies. Targeting deprived remote, peripheral or deindustrialized areas and cultural landscapes as well as over-exploited areas, local Heritage innovation networks will co-develop a long-term heritage-led development project in the areas involved enhancing inclusive economic growth, communities' wellbeing and resilience, nature regeneration as well as effective cooperation at cross-border, regional and local level.

Wide and diversified partnerships of stakeholders from 18 EU and non-EU regions of Northern-Central and Southern Europe, the Balkans, the Eastern neighbourhood and the Mediterranean will be the driving force of the project. A community of 300 innovators (which includes regional authorities and municipalities, clusters and associations, museums and tourist boards, entrepreneurs, chambers of commerce, citizens, researchers, practitioners as well as project partners) in 6 pilot regions will co-create innovative place-based solutions for human-centred development through *sustainable* and *circular* cultural tourism.

Collaborative "Heritage innovation networks" will be established in 6 European deprived remote, peripheral and deindustrialised areas and cultural landscapes identified as "pilot innovation ecosystems": committed to the project's objectives, they have defined clear cultural tourism-

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related challenges requiring innovation that will serve as the basis for the collaboration with the 16 additional "mirror innovation ecosystems". Mutual learning and up-scaling of business solutions will be the objectives of the collaboration between pilot and mirror ecosystems, building the sustainability of the project's results beyond its lifetime.

By adopting a human-centred quadruple/quintuple helix approach to co-design, Be.CULTOUR will result in 6 community-led Action Plans, 18 innovative human-centred solutions and 6 close-to-market prototypes of new cultural tourism integrated services and products: these will directly contribute to inclusive economic growth, communities' wellbeing and resilience, and nature regeneration in pilot and mirror regions, stimulating effective cooperation at a cross-border, regional and local level. The core partners of the Consortium will progressively build Be.CULTOUR sustainability by broadening the interregional collaboration while anchoring it to relevant EU initiatives in the academic, business and institutional realms.

1.1 Be.CULTOUR specific objectives

The scopes of the Be.CULTOUR project will be achieved through a set of specific, measurable, achievable, realistic and time-constrained (SMART) specific objectives:

Objective 1 – To assess the impacts and market potential of sustainable and circular cultural tourism at national, regional and local level through multidimensional quantitative and qualitative indicators, innovative statistical methods and advanced smart data management systems;

Objective 2 – To build a Community of Practice of 6 pilot regional ecosystems and a Community of Interest with 16 "mirror ecosystems" in EU and non-EU countries actively engaged in knowledge-sharing and exploitation of Be.CULTOUR's approach, methodology, tools, and innovative solutions for sustainable and circular cultural tourism;

Objective 3 – To co-develop 6 Action Plans for sustainable and circular cultural tourism by establishing collaborative "Heritage innovation networks" in 6 pilot regions in Northern-Central and Southern Europe, the Balkans, the Eastern neighbourhood and the Mediterranean;

Objective 4 – To co-develop, prototype and test human-centred and place-specific product, process and service innovations for sustainable and circular cultural tourism in pilot heritage sites;

Objective 5 – To provide policy recommendations for more effective use of European Structural Investment Funds (ESIFs) and other EU funds to support cultural tourism innovation ecosystems in pilot and mirror regions, and develop a proposal of evolution of ESIFs through synergies with other public funds;

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Objective 6 – To contribute to deepen cultural Europeanisation through information and educational activities focused on the European history, identity and culture expressed in tangible and intangible cultural heritage and cultural landscapes, developing European Cultural Routes and European Heritage Labels in pilot heritage sites.

All partners have wide experience in developing and testing the Be.CULTOUR proposed approach, methodology and tools, ensuring the effective and time-constrained achievement of all the above-mentioned specific goals.

2. Framing

This report serves as the final phase in the development process of a Be.CULTOUR digital tool designed to be interactive for various users and stakeholders. This tool is intended to facilitate the collection and analysis of 'big data' through the utilization of advanced distance learning methods.

The primary objective is to create an interactive platform that allows agents and stakeholders to gather and analyze 'big data', thus providing valuable insights into both the opportunities and challenges present. Leveraging the expertise available at OUNL, the cultural tourism monitoring and interactive management tool will be developed with a human-centered design approach, as outlined in Deliverable 1.4. Moreover, it will be adaptable to pilot and 'mirror' regions, ensuring alignment with ongoing projects. Ultimately, this endeavor aims to produce an accessible, interactive, and user-friendly Be.CULTOUR digital twin. The city of Heerlen (NL) will serve as a model for this interactive peer-learning exercise, utilizing the distance learning capabilities available at OUNL.

In the development of new digital twin applications, it is crucial to consider relevant user stories to ensure the effectiveness and usability of the tool. Thus, the focus will be on identifying the processes that the digital twin should support and conducting comprehensive requirements analyses for various use cases. For the Be.CULTOUR project specifically, data collection will primarily occur at an aggregated level.

This report will provide detailed insights into the construction of a digital twin for Heerlen/Parkstad, acting as a gateway to its constituent elements. Through the digital twin, users will have the ability to visualize these components and address specific queries. For instance, inquiries related to time travel and information accessibility via the izi travel app will be seamlessly integrated into the digital twin (see Annex 2).

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3. Zuid-Limburg on the Move

3.1 Area description

Zuid-Limburg is one of the Netherlands' most attractive and visited vacation destinations, serving not only local residents and Dutch guests but also drawing visitors from abroad, especially from Germany and Belgium. In the post-coronavirus era, where individuals increasingly prioritize factors like green spaces and active recreation such as cycling and hiking, it becomes crucial for the region's amenities to align with tourists' preferences. Additionally, exploring the boundaries of residents' tolerance within this context is essential, adhering to the principles of Valuable Tourism as formulated by the Council for the Living Environment.

While Zuid-Limburg boasts a wealth of tourism-related information, there's still much to learn, particularly regarding visitors' motivations in the post-coronavirus era. This lack of understanding hampers the formulation of effective investment plans, especially concerning dispersion strategies from hotspots like the Heuvelland to less crowded areas such as Parkstad. The fragmented layout of attractions in Parkstad, coupled with occasional gaps in facilities like hospitality offerings, underscores the need for a comprehensive assessment of the region's key attraction factors and pain points.

Building upon foundational research conducted in collaboration with Visit Zuid-Limburg, Parkstad, and the OU, further exploration is essential to explore specific thematic areas. This includes a closer examination of mobility aspects, integration of history and ecosystem, and assessment of recreational facilities across different locales in Zuid-Limburg.

Culture is a broad economic sector that comprises inter alia art, history, architecture, entertainment, performing arts, creative professions, and so forth (see e.g., Nijkamp, 2012; Kourtit & Nijkamp, 2022). It goes without saying that tourism is all over the world attracted by rich local or regional cultural amenities. However, in the age of mass tourism, an uncontrolled influx of visitors may lead to countervailing crowding effects. Last year, 4.3 million tourists visited the area. Mass tourism can lead to environmental decay and a decline in the quality of life of the local community.

Motives of tourists in this region include nature, culture, history, shopping, and entertainment. Often tourists combine various motives (nature, history) and that explains the beneficial interaction between cultural assets and ecological resources. The combination of these assets and resources is therefore responsible for a positive relationship in becoming/creating tourist

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attractions. However, in the age of mass tourism, an uncontrolled influx of visitors may lead to countervailing crowding effects.

Our research aims to find a way to stimulate tourism in a sustainable way. This research framework seeks to address these multifaceted challenges and opportunities associated with tourism development in Zuid-Limburg. The tourist development of the Parkstad region has emerged from strong collaboration, both among entrepreneurs themselves and between entrepreneurs, governments, and other parties. This development is still ongoing. The COVID-19 crisis, which has resulted in declining visitor numbers and sometimes significant revenue losses for many, presents everyone with significant challenges. Especially now, people see good collaboration as an important strength that they want to boost, sharing ideas, questions, and offerings with each other and other parties active in the leisure economy (see Annex 1), including discussing themes of interest for collaboration, deciding which direction to take in the region, and taking concrete initial steps together with others. By adopting a holistic approach that integrates data-driven insights, stakeholder collaboration, and innovative digital technologies, the region can map a course toward a more sustainable and resilient leisure economy and tourism ecosystem.

3.2 Data-driven Approach

Since 2016, the municipality of Heerlen and Central Bureau Statistics (CBS) have embraced a data-driven approach to enable better-informed policy decisions across various domains. This highlights also the necessity to identify residents in need and enhanced understanding of mobility patterns among Heerlen residents and visitors. The collaboration with CBS has also brought professionalism to the organization, given CBS's expertise in responsible data usage, particularly in security and privacy. Moreover, it has facilitated networking with other municipalities, fostering joint policy planning.

The Datacenter Parkstad Limburg offers insights into municipalities' policy needs and aids in addressing societal issues through data analysis. Collaborative workspaces, such as the one at Brightlands Smart Services Campus in Heerlen, foster innovation at the intersection of data and public services.

3.3 Strategic Focus

Unlocking economic potential Heerlen and Parkstad possess significant economic growth potential, particularly through cross-border collaboration with the Aachen region. This

collaboration leverages the expertise and resources of both regions to maximize their economic potential, focusing on areas like innovation and digital technology. The establishment of the Datacenter Parkstad Limburg aligns with Parkstad's strategic priorities, including cross-border collaboration, energy transition, sustainable mobility, sustainable tourism development and economic development.

3.4 Exploring Critical Themes

• Mobility Aspects: Understanding mobility intricacies within Zuid-Limburg is crucial for comprehending visitor behaviors and preferences in relation to tourist amenities. By identifying opportunities to enhance transportation infrastructure while minimizing negative impacts, the region can improve visitor experiences sustainably.

• Integration of History and Ecosystem: Studying Zuid-Limburg's rich history alongside its diverse ecosystem provides valuable insights into the region's cultural and natural heritage. Preserving and promoting these assets sustainably requires a nuanced understanding of their interplay.

• Assessment of Recreational Facilities: Evaluating the quantity and quality of recreational amenities across Zuid-Limburg is integral to enhancing visitor experiences. Addressing gaps in service provision ensures the region caters to the diverse needs of tourists effectively.

3.5 Augmented Research Framework

To facilitate data visualization and analysis, an interactive digital tool, Digital Twin, has been integrated into the research framework. This tool, including advanced digital mapping techniques and immersive virtual experiences, aims to enhance stakeholder engagement and decision-making processes.

3.6 Accessibility

Efforts to improve mobility and accessibility are paramount for sustainable tourism development in Zuid-Limburg. Leveraging innovative digital solutions can promote alternative modes of transportation and reduce dependence on traditional vehicles. By prioritizing sustainability and inclusivity in mobility planning, Zuid-Limburg can position itself as a leading destination for eco-conscious travelers.

The ongoing research seeks to address the multifaceted challenges and opportunities associated with tourism development in Zuid-Limburg. By adopting a holistic approach that integrates data-

driven insights, stakeholder collaboration, and innovative digital technologies, the region can map a course towards a more sustainable and resilient tourism ecosystem.

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4. Cultural Heritage and Sustainable Tourism: A Dynamic Relationship

Over recent decades, the tourism sector has witnessed a rapid structural expansion, both locally and globally. It has evolved into one of the world's foremost industries, driven by factors such as increased leisure time, reduced transportation costs, globalization, logistical accessibility, and the proliferation of mass tourism benefiting from local scale advantages. Additionally, there has been a surge in global tourism participation from visitors originating from emerging economies (Yang and Wong 2021; The World Tourism Organization 2021, 2022; Kourtit et al., 2022). More recently, the advent of digital technology has emerged as a catalyst for global tourism growth. This is evident through the widespread adoption of e-booking systems, digital information dissemination covering virtually all corners of the globe, social media engagement, and electronic platform utilization (Lau 2020). Tourism has transitioned from being a relatively low-tech physical mobility activity for visitors to becoming a high-tech, information-driven, and data-based industrial sector (Daldanise 2016; Kourtit et al. 2022). It embodies the characteristics typical of an advanced Industry 4.0 sector.

However, modern tourism also presents numerous challenges. Environmental degradation stands out as one of the prominent consequences of tourism in destination areas, manifesting in forms such as noise pollution, waste accumulation, air, and water pollution. Additionally, negative externalities such as local overcrowding effects and the erosion of local identity and authenticity pose significant concerns (Gössling 2020a,b; Lu et al. 2022; Song et al. 2022). Cities like Venice and Barcelona serve as stark reminders that tourism is not without controversy and can have adverse impacts on the local economy. Is it possible to transform tourism into an economic activity that fosters environmentally friendly, climate-neutral, or circular outcomes for tourist destinations? Can digital technology offer tools to facilitate the journey towards sustainable outcomes at the local or regional level, supported by the local community, while also mitigating insider versus outsider conflicts? Addressing these multifaceted and complex challenges requires evidence-based creative solutions (Angrisano et al. 2016; Hampton 2005). The Be.CULTOUR project, part of the EU Horizon program, aims to develop a co-creation approach, engaging numerous partner institutions across Europe. The objective is to provide informed strategies and policy insights for cultural tourism within a circular economy context, leveraging modern research tools. In this context, robust digital data management capabilities are essential for effective sustainability- and circularity-oriented policy formulation.

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This report will showcase the potential of three-dimensional (3D) visualization methods in local cultural tourism planning. Emphasis will be placed on the utilization of 'digital twins' as spatial imaging tools to furnish policymakers and planners with pertinent, evidence-based information, enabling them to adopt an integrated perspective on sustainable cultural tourism planning.

4.1 Culture and Tourism: A Complex Relationship

Culture encompasses a broad economic sector that includes art, history, architecture, entertainment, performing arts, and creative professions, among others (Alberti and Giusti 2002; Coccossis and Nijkamp, 1995; Kourtit & Nijkamp, 2023). It comprises both material and spiritual components and serves as a reflection or manifestation of societal trends and mindful developments that bridge the past with the present. It is evident that tourism is drawn to rich local or regional cultural amenities worldwide, as evidenced by cities like Venice, Paris, Amsterdam, Boston, Cape Town, Mumbai, and Shanghai. This attraction extends to smaller cities such as Leeuwarden in the Netherlands, Bruges in Belgium, Delphi in Greece, or Bandung in Indonesia. Tourism represents a significant economic asset capable of generating substantial financial resources for the host area. However, in the era of mass tourism, an uncontrolled influx of visitors can lead to counterproductive crowding effects that jeopardize the cultural and ecological assets that form the foundation of tourism. The tourism paradox, illustrated in Figure 1, encapsulates this dilemma.

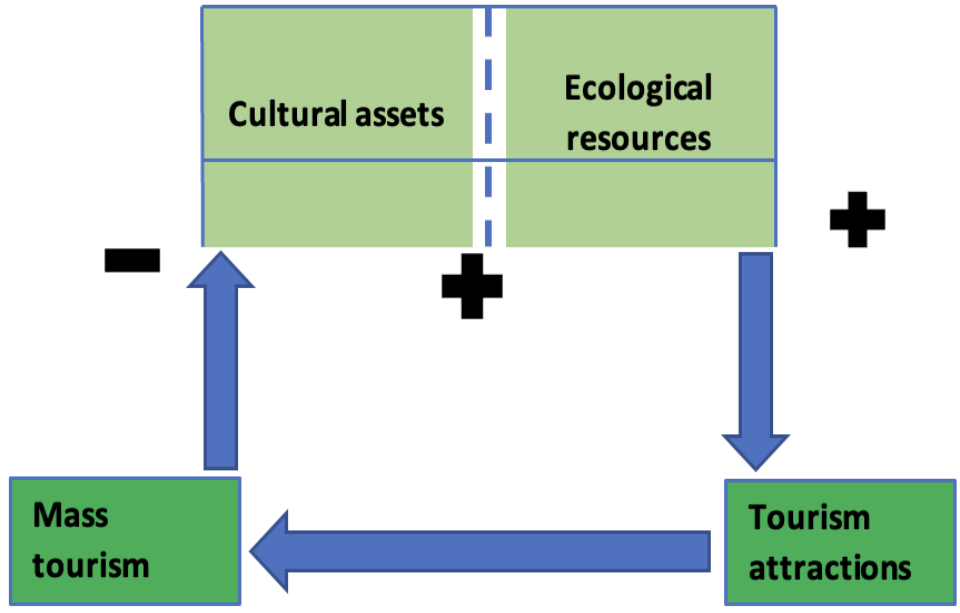

Figure 1 - The tourism paradox

Source: Kourtit et al. (2024), p.2

There exists a wealth of literature addressing the paradoxical developments in tourism (Fusco Girard and Nijkamp 2009; Greffe 2004; McManus and Carruthers 2014). Studies explore various aspects including crowding effects, environmental degradation, and the decline in the quality of life of residents in destination places (Gössling et al. 2020a,b; Hall et al. 2020; Yang and Wong 2021; Song et al. 2022). It is crucial to note that cultural-historical heritage is not merely a static asset from the past but a dynamic phenomenon influenced by different periods or cultural-historical epochs. This will be elucidated using the case of Zuid-Limburg in the Netherlands, a region endowed with rich cultural-historical and vulnerable ecological resources near the German and Belgian border. While considered a peripheral region for Dutch nationals, it boasts accessibility for Germans (proximity to Aachen) and Belgians (proximity to Liege and Brussels). It is also among the most attractive natural areas for Dutch tourists, boasting a plethora of cultural-historical and ecological resources dating back to the Roman period (Kourtit & Nijkamp, 2023).

In 2020, the new tourism vision was ratified by the 16 municipalities comprising South Limburg. This vision serves as the overarching framework for Parkstad's tourism strategy as well. An important aspect of the 'Destination South Limburg 2030' vision involves aligning tourism development more closely with the authentic essence of the region. The Parkstad 2020-2024 Leisure Economy Development Plan outlines four main objectives, including sustaining the current successful strategy, enhancing residential appeal, improving tourist and recreational connections, and amplifying Parkstad's identity through its core narrative. The essence of Parkstad is embodied in five distinct "eras," which represent significant timelines in the region's history and are visually depicted. The historical, political, and cultural timeline of Zuid-Limburg can be delineated into five distinct cultural-historical epochs (Visit Zuid Limburg 2022):

- The Roman period; 750 BC – 500 AC ('Carrefour of the Romans')
- The Medieval period; 500 AC till the 17th century ('Knights and Bandits')
- The coal mine era; modern time till the 1970s ('Golden Mining')
- The intermediate era; the breakdown period at the end of the last century ('Dramatic Transition')
- The modern era; beginning of the 21st century ('New Revival')

Icons of the Roman junction

Icons of the middle ages to the 18th century

Icons from the coal mining era

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Icons from the social collapse & transition years

Icons from the 'new élan' today

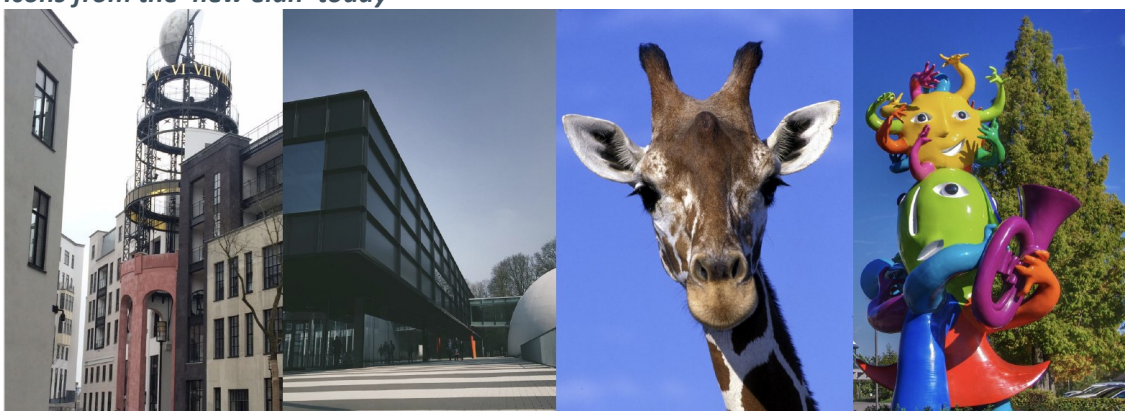

Figure 2 - Five distinct cultural-historical epochs (Visit Zuid Limburg 2022), pp 10-14

Source: The Story of Parkstad, and its implementation within the Customer Journey Model, a presentation by Anya Niewierra, General Director Visit Zuid Limburg, on 8 September 2022 (pp. 27).

Each epoch contributes to the region's narrative and has left behind significant characteristic imprints or 'icons' (see Figure 2). For each epoch, a map can be generated depicting the location of cultural-historical landmarks in the area. Overlaying these five maps yields a comprehensive map of the entire region encompassing cultural-historical assets in an integrated manner (see Figure 3).

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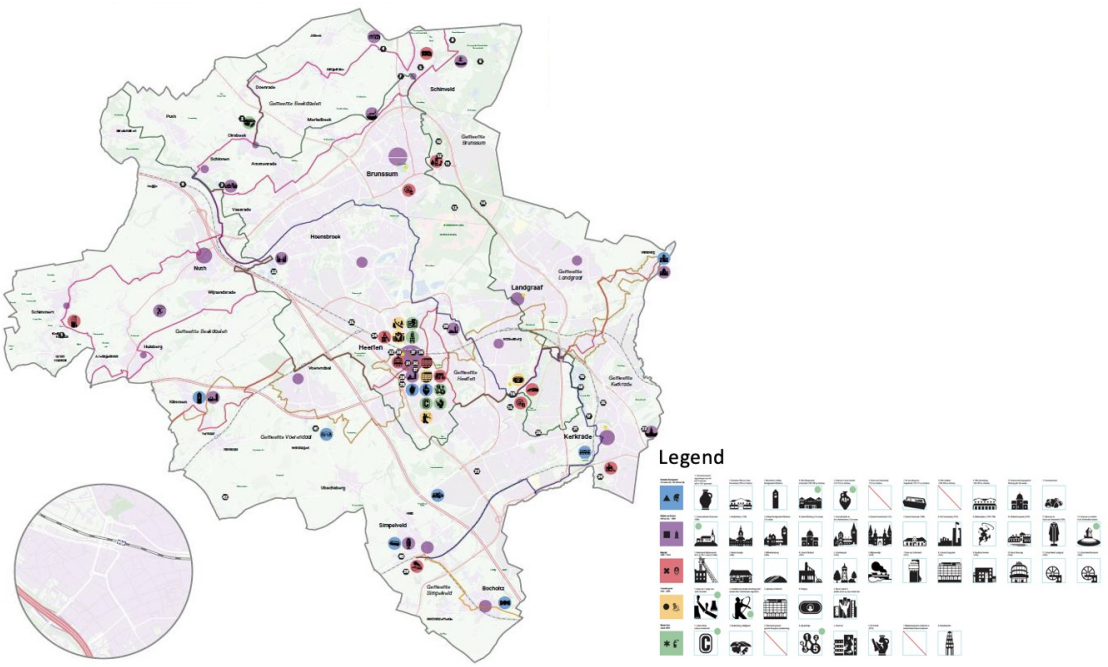

Figure 3 - An integrated representation of the cultural-historical assets across the entire region in the form of a comprehensive map

Source: The Story of Parkstad, and its implementation within the Customer Journey Model, a presentation by Anya Niewierra, General Director Visit Zuid Limburg, on 8 September 2022 (pp. 27).

In visual form, the cultural-historical evolution of Zuid-Limburg can be systematically depicted from a synthetic multi-faceted temporal perspective (see Figure 4).

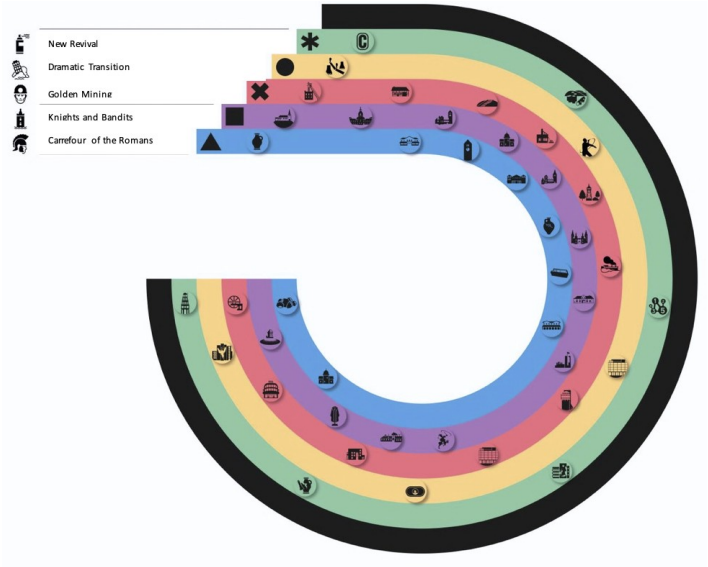

Figure 4 - Sketch of the cultural-historical epochs in Zuid-Limburg

Source: The Story of Parkstad, and its implementation within the Customer Journey Model, a presentation by Anya Niewierra, General Director Visit Zuid Limburg, on 8 September 2022 (pp.27).

It is evident that visitors to Zuid-Limburg are driven by various motives including nature, culture, history, shopping, and entertainment. Particularly during the summer season, overcrowded areas are apparent, diminishing the tourist appeal of the region and causing dissatisfaction among local residents. Tourism policy thus necessitates a delicate balance between conflicting interests. Achieving such a balance requires detailed, user-friendly information on tourist attractions, tourist pressure, and negative externalities. To this end, the use of digital support tools is indispensable, as discussed in Section 6.

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5. Relevance & Application of Digital Twins

5.1 Introduction

Over the last few decades, academia, engineering companies, and asset managers have embraced various digital technologies to tackle end-of-service life challenges for infrastructural objects. For instance, detailed Finite Element Models (FEM) have been employed to compute stress levels in various components, advanced fatigue growth models have been updated using inspection data, and innovative sensor solutions have been deployed to monitor actual loads, stresses, and various condition levels (Zhang et al., 2024; Khajavi et al., 2019). Traditionally, these methods relied heavily on physical knowledge, but recent years have witnessed a significant surge in data availability, data-driven methods, computational power, and visualization technology, with this trend expected to continue. This raises the question of how these digital technologies can be effectively applied to address the end-of-service life challenges faced by asset managers.

GIS technology experiences a significant advancement through the integration of diverse data sources. Conventional datasets are enriched by the inclusion of demographic, behavioral, sectoral, and structural data. However, leveraging these datasets, which are dispersed across various administrative levels globally, poses a formidable challenge in such applications. Hence, data integration emerges as a critical component for advancing, particularly, public warning systems. The solution lies within the realm of digital twins.

A digital twin is defined as 'a digital replica of a living or non-living physical entity'1. By establishing a connection between the physical and virtual domain, data seamlessly flows, facilitating the coexistence of the virtual entity alongside its physical counterpart. These models are capable of encapsulating detailed information across diverse domains and scales.

Digital twins have already demonstrated considerable value in urban planning and integrating data pertaining to individuals and spaces, thereby facilitating decision-making processes23. In the case of Heerlen/Parkstad, a digital twin offers an integrated viewpoint, consolidated within a unified infrastructure to streamline data enrichment and modeling activities.

Furthermore, there is a burgeoning interest in Personal Digital Twins (PDTs). PDTs serve as digital representations of individuals, constructed from their digital footprints. This technology is already

[1] Joint Research Centre, Digitranscope The governance of digitally-transformed society. 2021.
[2] R. Al-Sehrawy, B. Kumar, and R. Watson, "A digital twin uses classification system for urban planning & city infrastructure management," J. Inf. Technol. Constr., vol. 26, pp. 832–862, 2021, doi:10.36680/J.ITCON.2021.045.
[3] X. Niu and S. Qin, "Integrating crowd-/service-sourcing into digital twin for advanced manufacturing service innovation," Adv. Eng. Informatics, vol. 50, 2021, doi: 10.1016/j.aei.2021.101422.

in widespread use across various industries. PDTs encompass a broad spectrum of information, encompassing activities, behaviors, and more, thereby providing substantial support for numerous studies, particularly those focusing on aggregated data analysis.

Early warning systems are essential tools required to enhance efforts in preventing emerging hazards. These systems depend on a Digital Twin framework, acknowledged as a cornerstone for comprehending, modeling, and simulating complex phenomena. Digital twinning emerges as a solution to bridge the gap between the physical and digital worlds by creating virtual replicas of real-world assets. This virtual environment enables data-driven operations and facilitates more efficient decision-making and asset management in an increasingly digitized society. While the concept of digital twinning finds application across various sectors and industries, its definition varies substantially, often emphasizing intelligent systems enabled by continuous interaction, communication, and synchronization between the digital twin, its physical counterpart, and the surrounding environment, frequently incorporating predictive elements (Barricelli et al., 2019; Grieves, 2023).

5.2 Digital Twin Maturity model

The Digital Twin Maturity Model outlines a progressive evolution in digital twin applications, reflecting increasing levels of sophistication and integration across organizational and operational domains (see Figure 5).

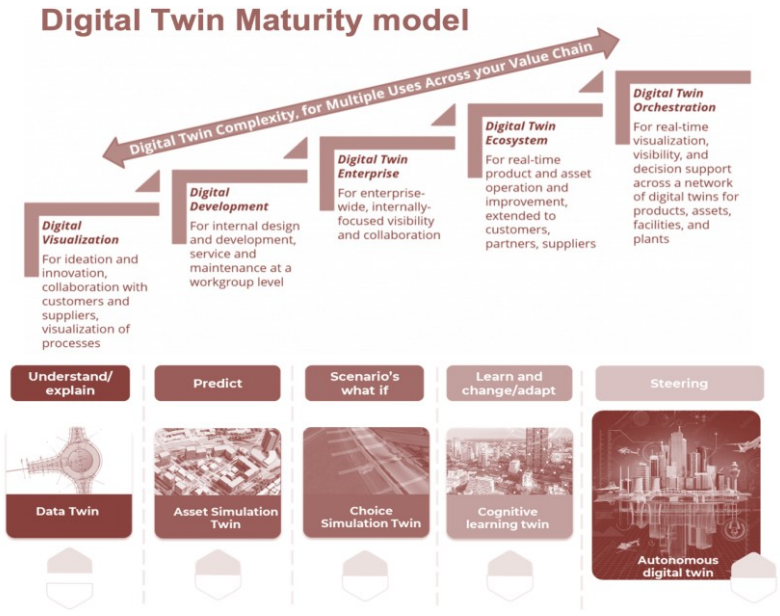

Figure 5 - Digital Twin Maturity model

Source: Rook, 2019

1. Visualization and Exploration: At the initial stage, digital twins serve primarily as visualization tools, allowing stakeholders to explore and understand the digital representation of a given area or environment.
2. Internal Process Optimization: Moving forward, the focus shifts towards optimizing internal work processes within specific organizations. Digital twins become more tailored to the unique needs and workflows of the organization, facilitating enhanced operational efficiency and effectiveness.
3. Shared Goals and Projects: The maturity model advances as digital twins evolve into platforms for collaborative goal-setting and project management. Organizations utilize digital twins to share objectives and initiatives, fostering alignment and coordination across teams and departments.
4. Operational Integration and External Connectivity: As digital twins mature further, they transition into operational tools for real-time production and asset management. Importantly, they also become open to external stakeholders, enabling connectivity with external systems, partners, and stakeholders.
5. Networked Digital Twins for Holistic Decision-Making: In the final stage of maturity, digital twins transcend individual organizations and processes, forming interconnected networks of digital twins. These networks facilitate real-time visualization, exploration, and decision-making across a broad spectrum of processes and stakeholders, fostering holistic and integrated approaches to problem-solving and innovation.

As organizations progress through the Digital Twin Maturity Model, they transition from basic visualization tools to interconnected networks of digital twins, fostering holistic decision-making and innovation across diverse processes and stakeholders.

5.3 Digital Twin Application Potential

In the built environment, digital twins are gaining prominence, particularly for inspection and predictive maintenance purposes, leveraging sensor data and model results (Khajavi et al., 2019). Building Information Models (BIM) play a crucial role, providing detailed architectural information essential for creating accurate digital twins (Lu et al., 2022; Deng, 2021). However, advancements in data and technology present opportunities for developing more sophisticated digital twin infrastructures, including comprehensive Digital Twins for the Physical Living Environment (DTFL), integrating geospatial data and dynamic processes on a regional scale.

Standardization of architecture is envisioned as a key strategy to unlock the full potential of digital twins. A standardized Digital Twin System Architecture (see Figure 6) is proposed to enable the creation of asset-specific digital twins in a flexible, repeatable, and efficient manner. Standardization enhances efficiency by optimizing system architecture, interfaces, and building blocks while maintaining the flexibility to accommodate various asset types and problems. Decoupling system layers and standardizing interfaces also mitigate vendor lock-in, fostering interoperability and information retention throughout the asset life cycle.

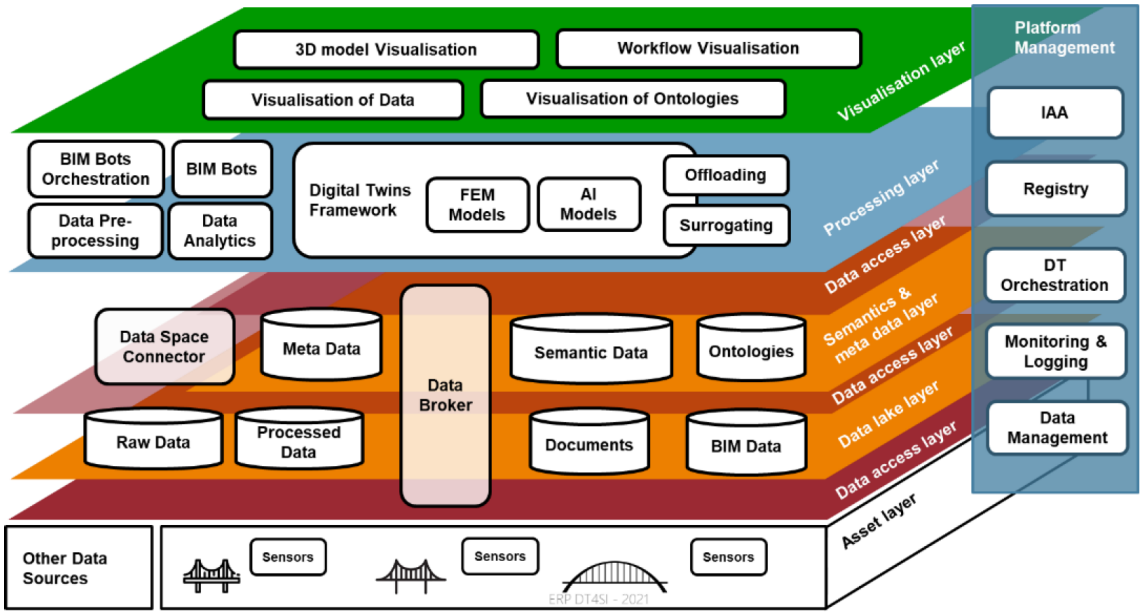

Figure 6 - Standardized Digital Twin System Architecture

Source: de Raat et al. (2023), p. 1005

Integration of data from the Internet of Things (IoT) into digital twins presents opportunities for real-time monitoring and simulation, enhancing decision-making in cultural tourism and heritage management. By incorporating IoT sensor data into digital twins, stakeholders gain immediate access to critical information about the condition and usage of cultural assets. This integration enables informed decisions about resource allocation, visitor engagement strategies, and maintenance prioritization to enhance the overall visitor experience.

Moreover, the development of open-source data infrastructure and standards is crucial for fostering collaboration and innovation in the field of digital twins for cultural tourism and heritage preservation. Open-source platforms provide a common framework for data sharing and integration, facilitating interdisciplinary collaboration and knowledge exchange among

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stakeholders. This collaborative approach enables the co-creation of digital twins tailored to the unique needs and challenges of cultural heritage sites.

5.4 European Perspective

The digital twin technology operates on a foundation of data, making data quality and standardization crucial. As the EU advances its data strategy, the concept of a common data space emerges as an important component. This strategy encompasses various sectors, aiming to create interconnected digital environments where data can seamlessly flow between producers and consumers (see Figure 7).

Among the envisioned common European data spaces are those dedicated to industrial manufacturing, green initiatives under the European Green Deal, mobility, health, finance, energy, agriculture, and public administration. Each data space serves as a platform for facilitating the exchange of valuable data assets, driving innovation and enhancing digital twin capabilities across sectors.

Indeed, data is increasingly recognized as a valuable commodity, and the establishment of digital spaces aims to streamline its movement within and across industries. By fostering a conducive environment for data sharing and collaboration, these initiatives are poised to significantly enhance digital twin functionalities.

An early exemplar of such a data space is INSPIRE, which encompasses diverse datasets related to tourism, including sea regions, building and facilities, commercial uses, and Natura 2000 sites. By harmonizing and integrating these datasets, INSPIRE lays the groundwork for comprehensive data-driven insights in the tourism sector and beyond.

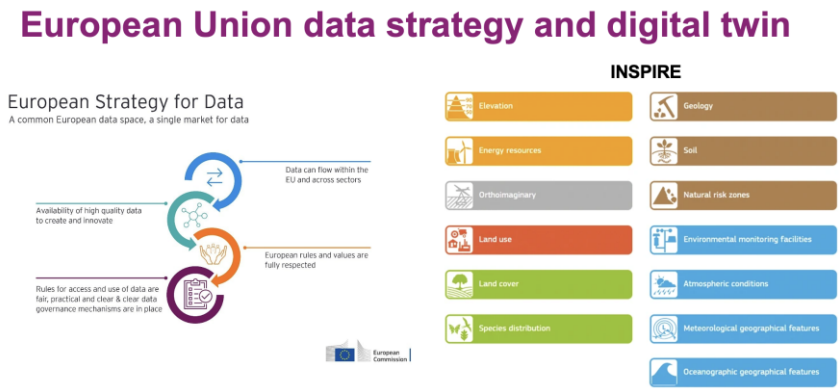

Figure 7 - European Union data strategy and digital twin

Source: EU 2020, http://dataeconomy.eu/eu-data-strategy-2020/#page-content[4]

[4] https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy

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5.5 Building Blocks of the Digital Twin

The digital twin of the physical environment comprises several generic components, akin to a cookbook with recipes and necessary ingredients. These components can be applied across multiple specific digital twins and thus reused, as depicted in Figure 8.

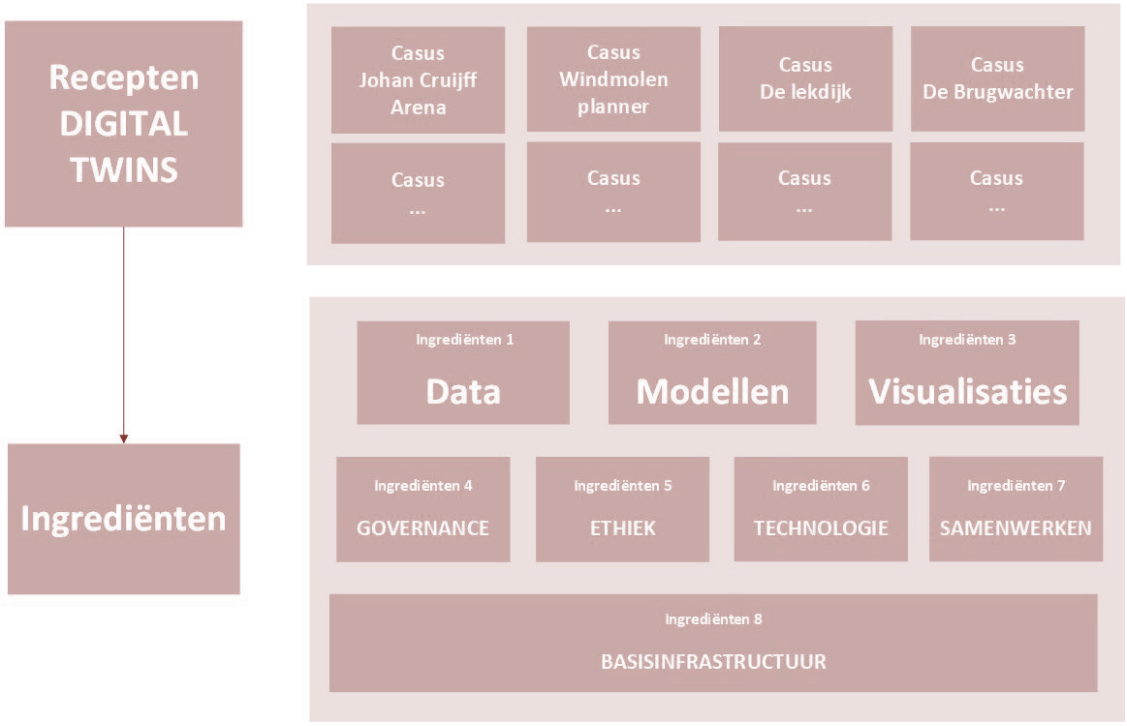

Figure 8 - The digital twin of the physical environment consists of several generic components

Source: Bruijn & Padding (2021), p. 13[5]

5.5.1 Data

Data serves as the raw material for the digital twin, with geospatial databases forming its core. These databases, including Cadastre, Addresses, Buildings, Topography, Large-Scale Topography, and Subsurface, each provide detailed and socially relevant reflections of the Netherlands. Together, they form the national geodata foundation to which various parties can relate their additional (sector-specific) data.

[5] https://www.geonovum.nl/uploads/documents/20210401%20investeringsvoorstel%20DRFL%20versie%200.86.pdf

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5.5.2 Computational Models

In addition to data, computational models are utilized to simulate the consequences of interventions in the environment and develop alternatives. These models often leverage dynamic data collected, sometimes with sensors, and processed with AI algorithms.

5.5.3 Visualization

While basic data of the physical environment is available in two dimensions, increasingly, it's also accessible in three dimensions. For the digital twin, visualizing in 3D is crucial to enhance understanding and clarify the (im)possibilities, both above and below ground. Virtual Reality, Augmented Reality, and other technologies are employed to create as realistic a depiction of reality as possible, depicting both static elements (buildings, roads, agriculture, water, etc.) and dynamic data like traffic, groundwater, energy, noise, particulate matter, etc. Here, in addition to space (3D), time is also depicted.

5.5.4. Platform Technology

Several technical platforms commercially available enable clients to form a digital twin around a physical challenge. These platforms allow the integration of various ingredients into a digital twin for a specific situation.

5.5.5 Ethics

The digital twin can be viewed within the broader context of societal datafication. The digital and physical worlds increasingly intersect, with emphasis placed on ethical and public values, enshrined in legislation regarding data and AI usage (privacy, transparency, reuse, participation, and openness).

5.5.6. Responsible Use

Organizing and utilizing the digital twin in a responsible manner is paramount. We have a collective responsibility to ensure that technology and data serve people's needs. This is achieved through various ethical design principles, such as legality, purposefulness, openness, transparency, human-centeredness, data sovereignty, and faithful reflection of the physical environment. Continued engagement with these principles ensures that technological advancements remain aligned with societal values.

5.5.7. Infrastructure

Our country boasts a world-class National Geo Information Infrastructure. Geo-base registrations, established with relatively modest means, serve as essential utilities for Dutch society. They are indispensable for various societal and economic activities, ensuring that our infrastructure functions smoothly.

5.5.8 Collaboration

The digital twin, formed to address a physical challenge, is the product of co-creation among all stakeholders. Collaboration ensures that the maximum potential of this tool is realized and that all interests are balanced.

5.5.9 Security

For the widespread applicability of digital twins, it's crucial to trace the origin and integrity of data. This transparency and integrity are vital for stakeholders affected by processes involving digital twins, as well as for government users in public safety and defense, ensuring they're working with unaltered data. Additionally, it safeguards against reputational damage for owners of digital twins caused by malicious actors manipulating components.

In conclusion, digital twins offer immense potential for advancing cultural tourism and preserving cultural heritage in the 21st century. By integrating IoT data, modeling data gaps, and facilitating behavioral simulations, digital twins empower stakeholders to make informed decisions that enhance the visitor experience and ensure the long-term sustainability of cultural assets. Through open-source data infrastructure and collaboration, the full potential of digital twins can be realized, unlocking new opportunities for circular cultural tourism and heritage preservation.

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6. Advantages of Geoscience and Geodesign Techniques

6.1 Merits of Geoscience Approaches

In recent decades, the increase of interest in the advancement and application of geoscience and geodesign methodologies has been noteworthy. This increase is driven by various factors, with a key aspect being the emergence of the 'quantitative revolution in geography' during the 1970s, which marked a significant shift in geographical analysis. Alongside this, there has been a growing demand for effective visualization of complex spatial data systems, characterized by multidimensional features and multiscale geographical information. In response to these evolving needs, Geographic Information Systems (GIS) have emerged as prominent tools, offering a myriad of applications in spatial planning on a global scale. The transformative trends observed within geoscience have been largely propelled by the quantitative and modeling focus embedded within spatial sciences. The integration of spatial data systems with advanced spatial visualization techniques has spurred the widespread adoption of geoscience in modern spatial analytics and urban or regional planning across various policy domains. Building upon these transformative trends, geodesign has emerged as the subsequent evolution of geoscience, facilitating the seamless integration of spatial data representations with spatial design challenges. This integration extends from municipal planning tasks to addressing urbanization complexities, including housing stocks, infrastructural facilities, and environmental provisions. Consequently, these innovative toolsets have laid the foundation for a new planning tradition within the realms of urban and regional policy and management. Gradually, this paradigm shift has also permeated into the sphere of tourism planning (Brown & Weber 2012; Liritzis et al. 2015; Valjarević et al. 2017; Albuquerque et al. 2018; Melenchuk 2021). The tourism sector embodies a complex blend of supply conditions and visitor demand or responses. On the supply side, various core tourist facilities, including cultural amenities (e.g., museums, historical quarters), tourist assets (e.g., hotels), urban ambiance (e.g., historical-cultural atmosphere), and environmental quality (e.g., green areas and nature), play crucial roles. On the other hand, in terms of demand, key metrics such as tourist visit volumes, expenditures, crowding effects, and spatial-temporal profiles or concentrations of tourists are observable. The synthesis of this two-part tourist constellation forms the foundational dataset requisite for mapping the local tourism sector (see Figure 9).

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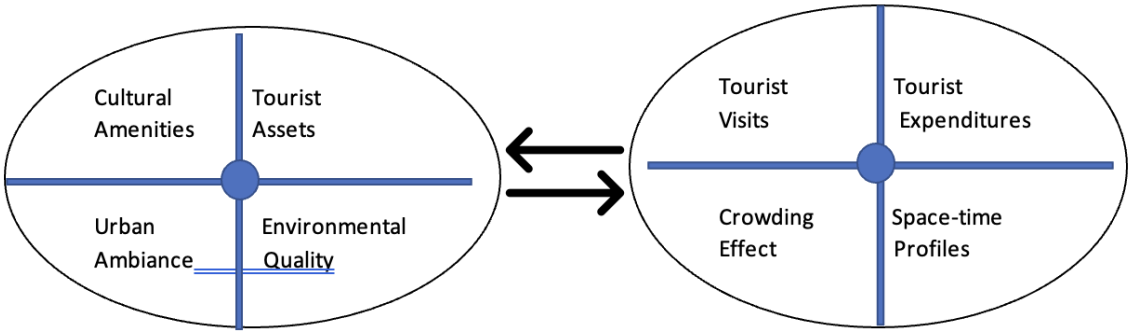

Figure 9 - The supply-demand nexus of local tourism

Source: Kourtit et al. (2024), p. 3

Effectively mapping such a complex system necessitates both a data-centric approach and a 2D - preferably 3D - geoscience visualization approach. One of the contemporary techniques for delineating the space-time intricacies of spatial systems, particularly a local tourist system, is through digital twinning. Digital twinning has garnered considerable attention in recent years as a fashionable geoscience approach. Examples of its application can be found in works by Scholten (2017), Micheli et al. (2018), Craglia et al. (2021), and Ivanov & Dolgui (2021). This approach is increasingly finding practical applications in the tourism sector and further discussed in Section 7 of this report.

6.2 Visualizing Complex Realities

A digital twin of the physical environment serves as a robust tool to visualize intricate realities, as depicted in Figure 10. Through 3D simulations and data-driven representations, stakeholders gain insights into complex urban landscapes, environmental systems, and infrastructure networks. This visualization capability allows stakeholders to grasp the current state of the environment and envision desired changes effectively.

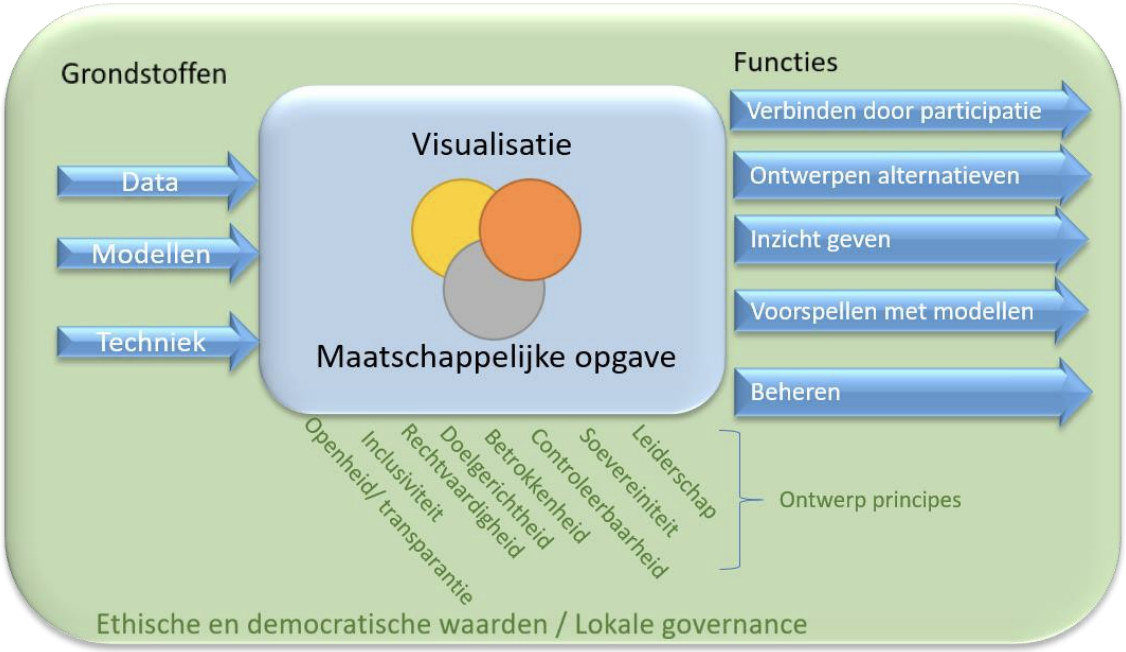

Figure 10 - Digital twin of physical environment

Source: Bruijn & Padding (2021), p.18 [6]

6.3 Supporting Informed Decision-Making

Figure 11 illustrates how digital twins support informed decision-making by evaluating the consequences of various interventions. By simulating different scenarios, stakeholders can assess the potential impacts of policy changes, infrastructure projects, and urban development initiatives. This proactive approach enables stakeholders to make evidence-based decisions that align with societal goals and environmental sustainability targets.

[6] https://www.geonovum.nl/uploads/documents/20210401%20investeringsvoorstel%20DRFL%20versie%200.86.pdf

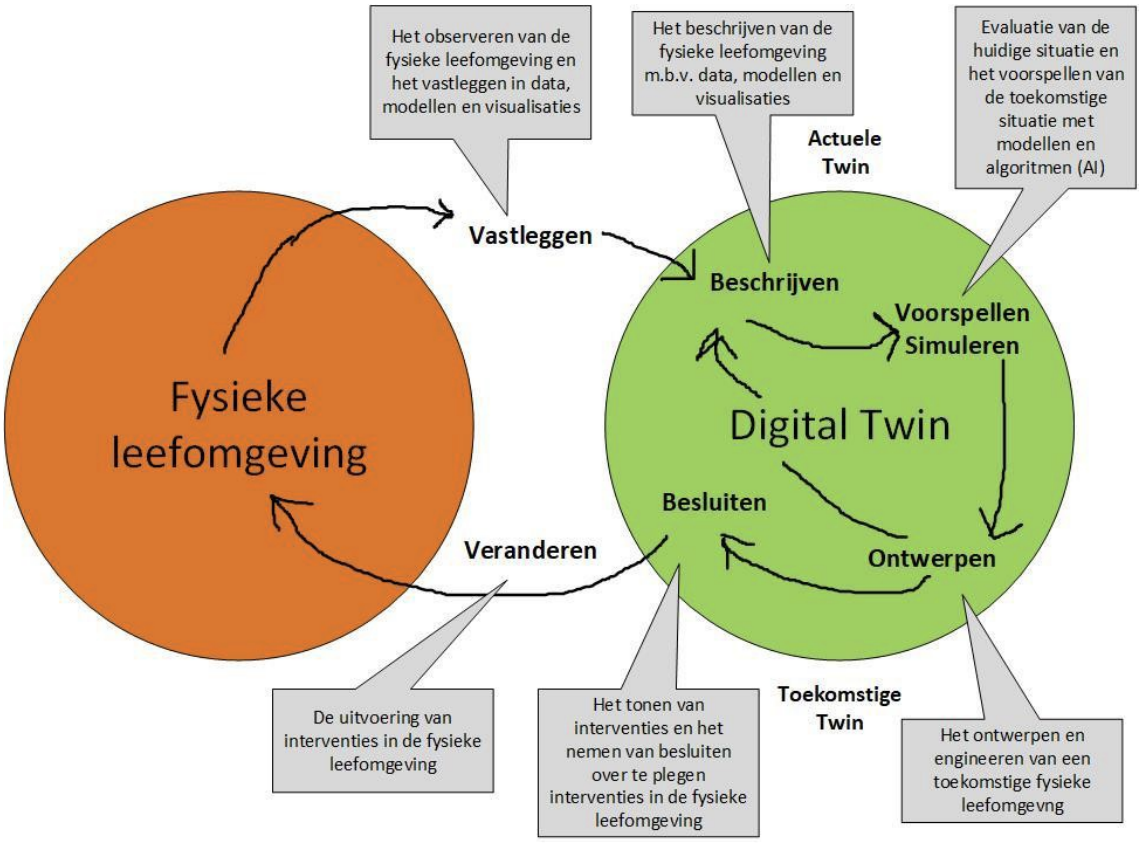

Figure 11 - The interaction between the actual physical environment and the digital twin

Source: Bruijn & Padding (2021), p. 15[7]

6.4 Managing Physical Assets Efficiently

Digital twins facilitate efficient management of physical assets through smart monitoring. By integrating real-time sensor data and IoT technology, stakeholders can monitor asset performance, identify maintenance needs, and optimize resource utilization. This proactive asset management approach minimizes downtime, reduces operational costs, and extends asset lifespan, contributing to overall operational efficiency and sustainability.

6.5 Fostering Collaboration and Consensus-Building

Figure 12 showcases how digital twins foster collaboration and consensus-building among stakeholders.

[7] https://www.geonovum.nl/uploads/documents/20210401%20investeringsvoorstel%20DRFL%20versie%200.86.pdf

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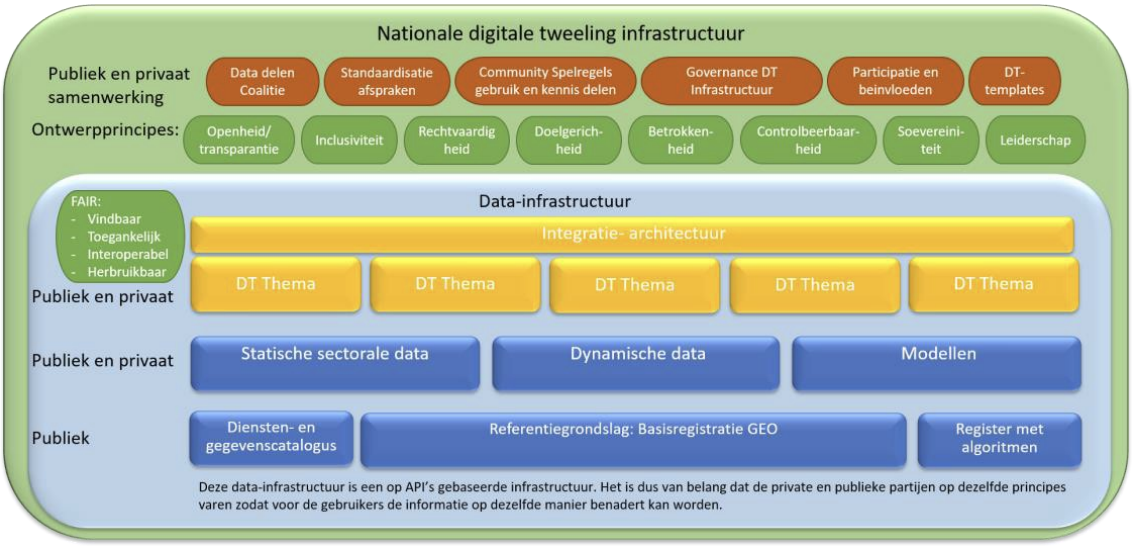

Figure 12 - Implementation of National Digital Twin Infrastructure

Source: Bruijn & Padding (2021), p. 26[8]

By providing a shared platform for data visualization and analysis, digital twins facilitate meaningful dialogue, stakeholder engagement, and participatory decision-making processes. This collaborative approach ensures that diverse perspectives are considered, leading to more inclusive and socially equitable outcomes.

6.6 Enhancing Research and Education

Digital twins serve as valuable tools for research, education, and training, as depicted in Figure 2. By incorporating simulation models and real-world data, digital twins enable researchers and educators to explore complex phenomena, conduct virtual experiments, and study environmental dynamics. This hands-on learning approach enhances the educational experience and equips future generations with the skills needed to address pressing societal challenges.

6.7 Strengthening Governance and Ethics

Ethical considerations, as outlined in Figure 13, are paramount in the development and use of digital twins. Legal frameworks and transparent data practices ensure that digital twins uphold ethical principles, safeguard data privacy, and maintain public trust. By promoting responsible decision-making and accountability, digital twins contribute to a more ethical and transparent governance framework.

[8] https://www.geonovum.nl/uploads/documents/20210401%20investeringsvoorstel%20DRFL%20versie%200.86.pdf

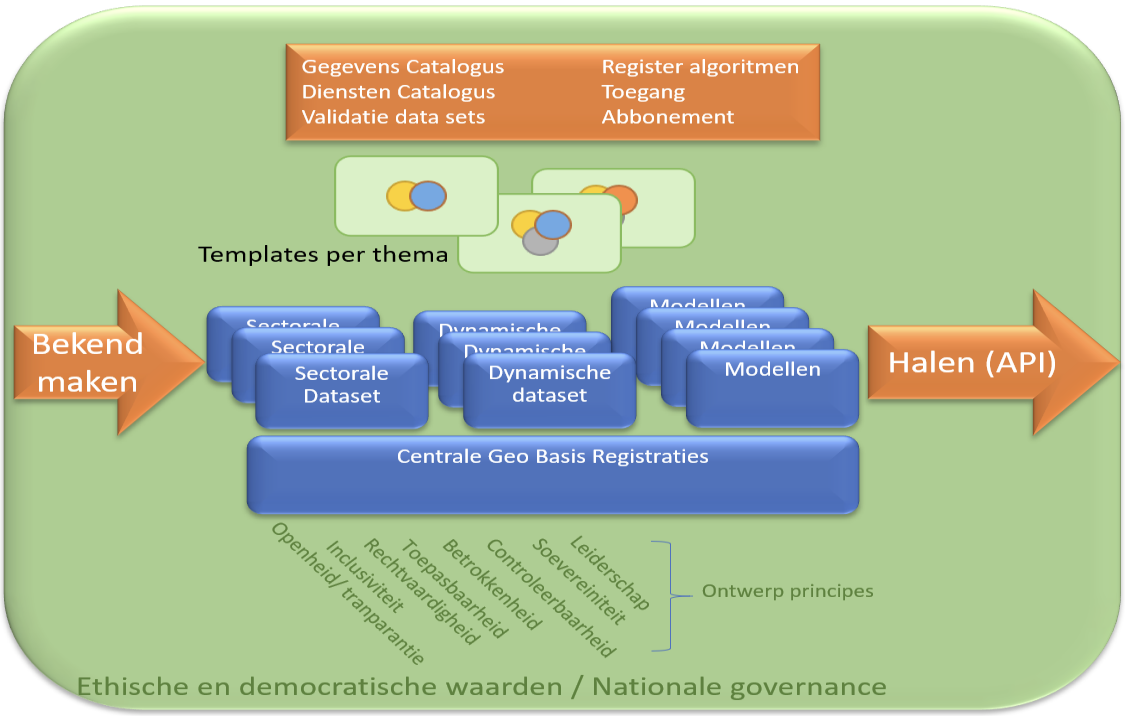

Figure 13 - National Digital Twin Infrastructure

Source: Bruijn & Padding (2021), p. 23[9]

6.8 Promoting Innovation and Efficiency

The national digital twin infrastructure fosters innovation and efficiency by providing a standardized framework for digital twin development and deployment. By streamlining data management, modeling techniques, and technological standards, digital twins can be created and scaled rapidly to address diverse societal needs and challenges. This interoperable approach enhances the value proposition of digital twins and accelerates their adoption across various sectors and industries.

6.9 Ensuring Technological Advancements

Align with e.g. societal and ecological Values: The national digital twin infrastructure ensures that technological advancements are aligned with ethical and societal values. By prioritizing transparency, accountability, and stakeholder engagement, digital twins contribute to more sustainable and socially responsible development practices. This alignment with societal values

[9] https://www.geonovum.nl/uploads/documents/20210401%20investeringsvoorstel%20DRFL%20versie%200.86.pdf

fosters public trust and confidence in digital twin technologies, paving the way for their widespread adoption and positive impact on society.

Society is digitizing, bringing forth numerous possibilities. A digital twin is a digital replica of the physical reality based on data and models. Digital twin technologies are increasingly employed as a cornerstone of data-driven approaches, as they provide a platform through which this digitization can be effectively leveraged. Making information accessible through a digital twin enhances citizen engagement. Informing citizens and incorporating their input (citizen participation) could be ensured through a digital twin.

The digital twin infrastructure represents a transformative tool for addressing complex societal challenges and driving sustainable development. By harnessing the power of data, visualization, and collaboration, digital twins empower stakeholders to make informed decisions, optimize resource management, and foster inclusive and resilient communities. Moving forward, continued investment in digital twin technologies and governance frameworks will be essential to unlocking their full potential and ensuring a more prosperous and equitable future for all.

8. Constructing a Digital Twin Prototype for Zuid-Limburg

8.1 Digital Twin Design

Cultural heritage encompasses a diverse array of historical urban and regional assets that reflect a rich past and retain their significance in the present (Angrisano et al., 2016). This heritage includes historical landscapes and cityscapes, both of which are integral components (UNESCO, 2011). The value of cultural heritage is multifaceted, offering economic, social, creative, financial, environmental, iconic, historical, aesthetic, and cultural benefits related to both built and natural environments (Throsby, 2001; Kourtit and Nijkamp, 2022, 2023). A critical question is identifying the key factors, or "X-Factors," that drive societal well-being in the context of cultural tourism and historical-cultural heritage. This necessitates an impact assessment and market potential analysis of sustainable, inclusive, and circular cultural tourism using a mix of quantitative and qualitative indicators. These indicators should be systematically organized into a decomposition scheme with measurable key performance indicators (KPIs).

To this end, a digital data toolbox using a digital twin approach proves invaluable. This approach can generate the necessary data for spatial digital planning support (DPS) tools, such as interactive user-oriented dashboards for sustainable cultural tourism at both urban and regional levels (see Figure 14).

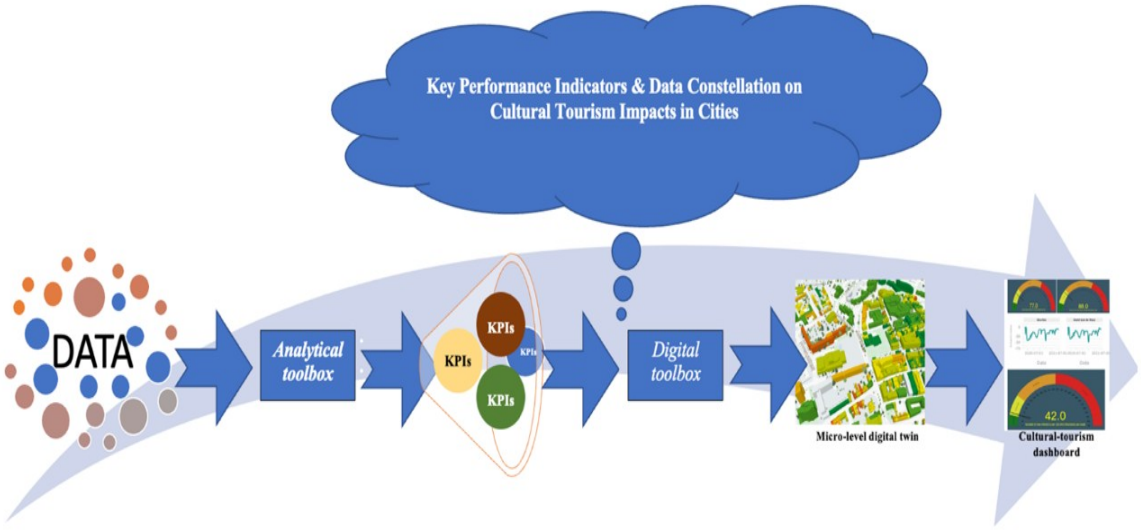

Figure 14 - A cascade of hierarchical data use and monitoring

Source: Kourtit et al. (2024), p. 4

This decomposed data structure can be integrated into a data warehouse from a multi-scalar perspective (see Figure 6), where the symbol XXQ represents the highest possible level of urban quality or well-being from a cultural-tourism performance perspective. Figure 15 illustrates the multi-scalar data needed to construct a digital twin for South Limburg. This model integrates cascading and decomposition principles into a hierarchically organized system for managing both quantitative and qualitative data. This system aims to create highly synergistic, human-centered actions and sustained value, leading to the highest possible quality of urban life (XXQ) in tourism destinations. Understanding the diverse impacts and market potential of various cultural tourism types is essential, achieved by developing an operational hierarchical framework at micro, meso, and macro levels for sustainable and circular cultural tourism, considering the rapid advancements in digital technology. Additionally, this approach will improve the understanding of cultural tourism's role in fostering cultural Europeanisation and contributing to economic and social development in Europe through co-created cultural experiences.

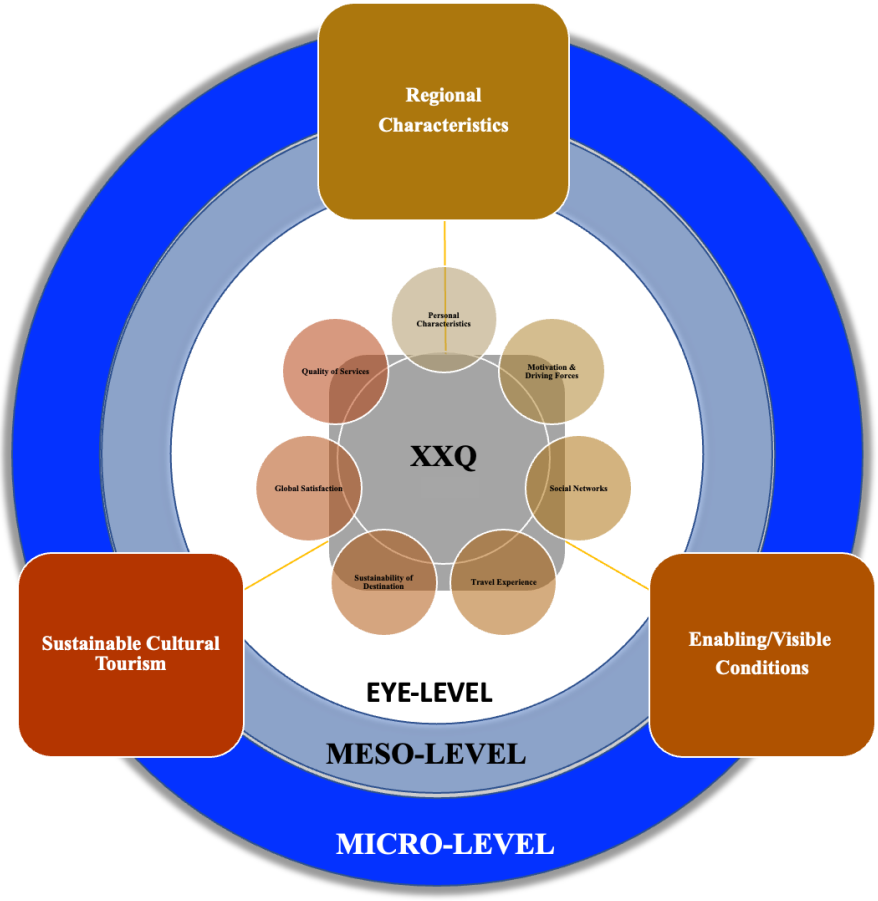

Figure 15 -Integrated data warehouse for sustainable & circular performance of cultural tourism

Source: Kourtit et al. (2024), p. 4

The database for the digital twin is multidimensional and multi-layered in nature. Given the need for a strict decomposition approach to complex datasets, a systematic presentation and interlinking of all necessary data are required. This is mapped out in the multidimensional internal and external explanatory factors (see Figure 16).

Multidimensional (Internal (X) and exogenous (X) External factors) assessment model of sustainable and circular cultural tourism in the six pilot regions

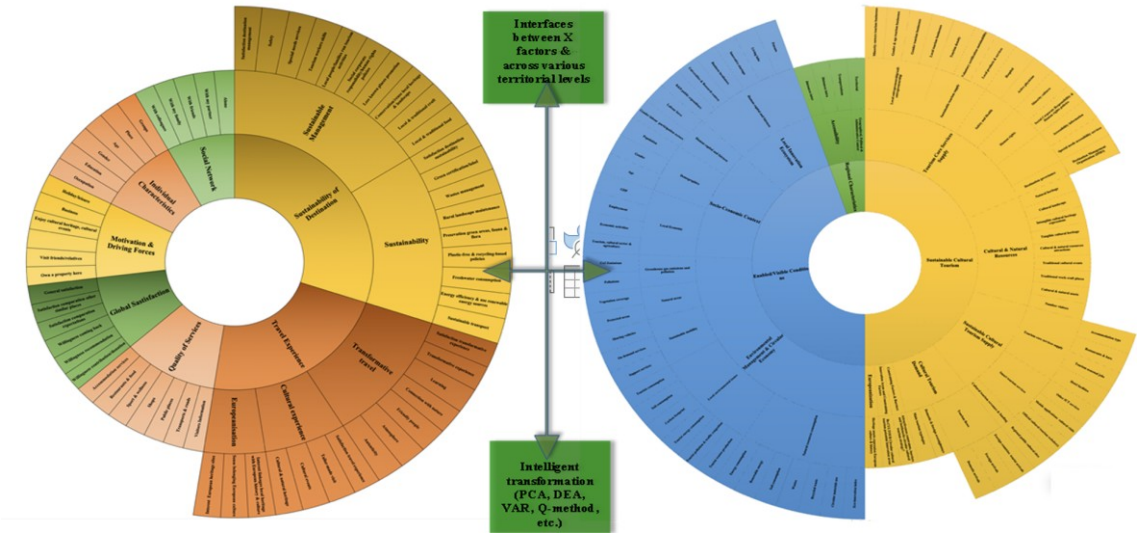

Figure 16 - Multidimensional (endogenous (X) and exogenous (X) explanatory factors) assessment model of sustainable and circular cultural tourism in the six pilot regions

Source: Authors' elaboration (see Be.Cultour D1.4, p. 14)

The key performance indicators (KPIs) database for sustainable cultural tourism impacts encompasses each of the pilot regions. It contains two primary types of information: (i) a function-specific database and (ii) an actor-specific database, detailed in Figure 16.

1. Function-specific database This database includes three main components, each with approximately 70 clear and systematically defined performance and attractiveness indicators across the pilot regions in the Be.CULTOUR project. These external indicators are:
    - Regional Characteristics
    - Enabled/Visible Conditions
    - Sustainable Cultural Tourism

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2. Actor-specific database This database outlines the value systems, preferences, and perceptions of three stakeholder groups who have visited the pilot heritage sites. These internal indicators are divided into seven components:
    - Individual Characteristics
    - Motivation & Driving Forces
    - Social Network
    - Travel Experience
    - Sustainability of Destination
    - Global Satisfaction
    - Quality of Services

Data for both databases are collected through extensive surveys in the pilot regions, involving three actor groups:

- Residents
- Visitors
- Proximity travelers

Based on the coherent visualization of the Be.CULTOUR database, we can now design the architecture of the KPIs for urban tourism in the Be.CULTOUR project (see Figure 17).

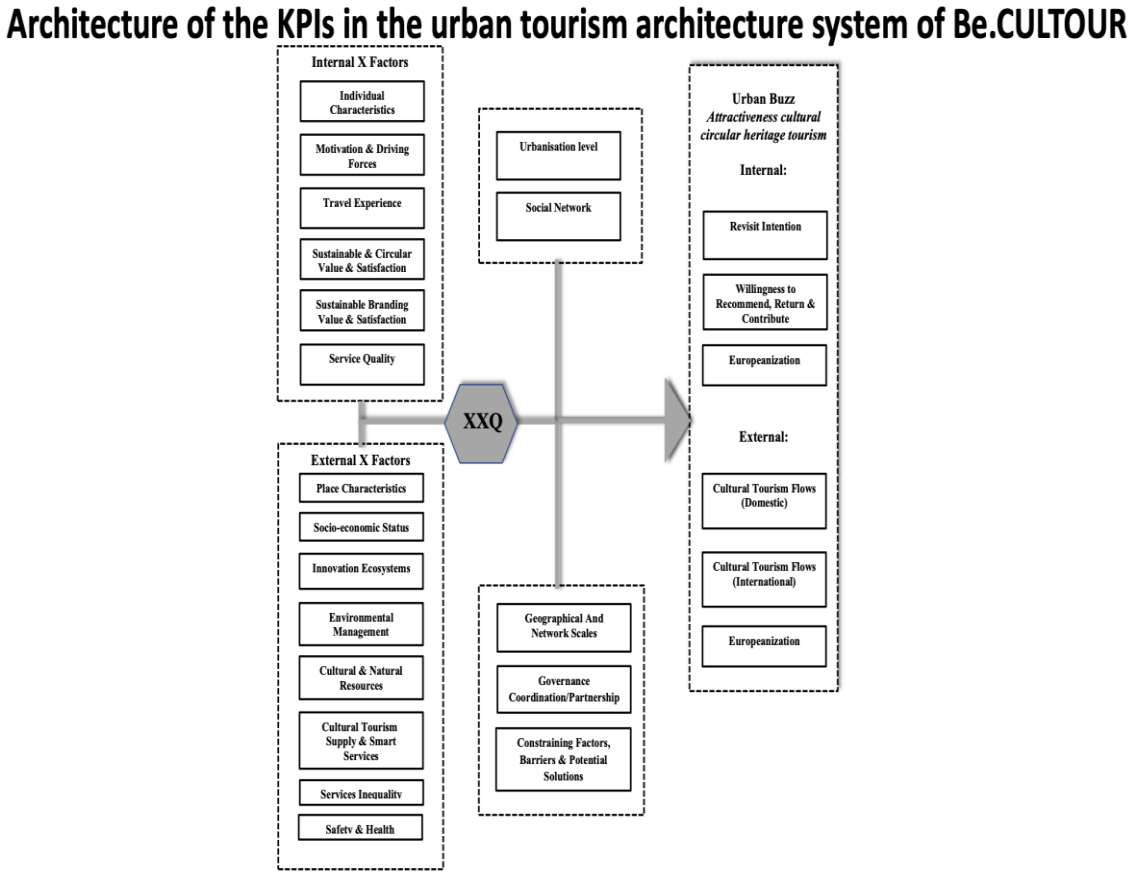

Figure 17 - Architecture of the KPIs in the urban tourism architecture system of Be.CULTOUR

Source: Authors' elaboration

The foundation for analyzing 'urban buzz' and its key factors in the pilot regions aims to position them as future socio-economic powerhouses. This involves creating favorable conditions for innovation and creativity, fostering local entrepreneurial dynamism, and developing smart technological, organizational, social, and economic solutions. The goal is to enhance the urban atmosphere and maximize contributions to productivity, smart innovations, democratized citizenship, knowledge sharing, quality, and profitability in the urban system, thereby improving the quality of urban life (XXQ).

As input for the digital twin, we will now provide a description of the critical variables that compose the digital twin for Parkstad/Heerlen.

The current study focuses on designing a digital twin prototype for the sustainable and circular development of Heerlen, the tourist hub of the Parkstad region in South Limburg.

Parkstad is part of the region of South Limburg, which is located in a 3 country border region (see Figure 18).

Figure 18 - Parkstad is part of the region of South Limburg

Source: The Story of Parkstad, and its implementation within the Customer Journey Model, a presentation by Anya Niewierra, General Director Visit Zuid Limburg, on 8 September 2022 (pp. 2).

This effort required extensive data collection, including municipal statistics, cadastral data, place-specific tourist data, and relevant land-use data. A crucial step in creating a reliable 3D thematic image of the area is accurately specifying the points of interest and obtaining precise coordinates. This precision is essential for a reliable and quantitative representation of spatial phenomena related to cultural tourism and sustainable urban development.

Aside from national open datasets, internal data sources can be added for the specific purpose of this project. Through data fusion techniques, multiple datasets can ultimately be combined to gain new insights. For instance, a dataset has been developed containing energy labels for each address (see Figure. 8); these data are also accessible in the digital twin. In the preliminary phase, several Key Performance Indicators (KPIs) have been established for this to guide the collection of energy data. The KPIs are categorized based on the geographical data being linked to geographical objects. This information is gathered from various sources for different types of objects.

The sources utilized during data collection and processing, as well as conversions, are documented to ensure traceability of quality to the sources and facilitate easier implementation of future updates. The data is structured and stored in a spatial database (PostGIS). The data structured in the database can be accessed via standard tools using maps and analysis tools. The data is stored in a way that in subsequent phases, it can also be accessed through a digital twin.
The objective of this research and design was to establish a prototype digital twin based on open-source technology. This Heerlen/Parkstad digital twin aims to organize relevant data and provide support for visualization in a web portal. Building upon Geodan's (data expert) existing infrastructure and knowledge, the goal was to create a functional and accessible digital twin environment. Key principles include:

1. user-friendliness of the digital twin concerning user interfaces and performance, ii) traceability of data and visibility of metadata (e.g., origin, quality, acquisition date), iii) adequate security of infrastructure and data according to ISO standards, and iv) utilization of open standards, open data, and open-source as much as possible. To achieve this, various components will be developed, which can be categorized as follows:

    - Back-end:
        - Data storage
        - Hosting
        - Security
    - Front-end: 3D data room for visualization and data management system
        - 3D visualization of data based on CesiumJS
        - Portal based on CKAN
        - References to (3D) project data
        - Metadata registration
        - Direct integration with the 3D environment
        - Adherence to FAIR principles (Findable, Accessible, Interoperable, Reproducible)
    - Data:
        - Implementation of 3D Tiles (1.1) standard

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- Documentation:
    - Descriptions of used datasets including any conversions
    - Architecture diagram of the Be.CULTOUR project for Zuid-Limburg.

To appreciate the application potential of the Digital Twin for Cultural Tourism, two important observations are to be made:

1. The concept of a digital twin is very broad. Therefore, when developing new digital twin applications, it is always important to focus on relevant user stories through time and space (see also Figures 2 and 3). This mainly revolves around determining which processes the digital twin should support. Through requirements analyses of various use cases, it is determined what data and information are needed and what functionalities and tools may need to be developed. We aim to work in such a way that the tools initially become available for the Be.CULTOUR project.
2. Modeling the local tourism sector can occur at different levels. In phase 1 of the be-CULTOUR project, we developed a conceptual framework in the context of 'story-telling' and then collect the necessary data primarily at an aggregated level. From the evaluation of the results of phase 1, it has emerged that there is a need for more detailed data and models that can also address the demand and modeling at the level of individual homes.

8.2 Constraints

Care has been taken to provide relevant data sources and datasets, preferably in the following file formats:

- File Geodatabase (.gdb);
- Layer files (.lyr), provided that the files they refer to are included;
- Shapefile (.shp), with the z-coordinate and height (from z-coordinate) in the attributes in case it contains a 3D model;
- Geopackage (.gpkg);
- (Geo)JSON (.json)/(.geojson);
- BIM models (e.g., .dwg, .dxf, .ifc), provided they are georeferenced (not using a local coordinate system);
- 3D models (e.g., Collada, GLTF, FBX, OBJ, 3D tiles);
- Rasters (e.g., .asc, .(geo)tiff, .csv), provided with accompanying descriptions of how they should be structured;

- Point clouds (e.g., PLY, LAZ, XYZ).

8.3 Operational Twin Architecture

For the vision regarding the aforementioned question, a pilot twin architecture[10] has been outlined to further elaborate on it. To clarify, such an architectural diagram often looks like the one depicted in Figure 19. In further elaborating on the project, this reference architecture guides the chosen solution. Components/parts of the solution must fit into the architecture and can be tested and explained accordingly. In this project, fruitful use can be made of the architecture developed by Geonovum for the National Digital Twin of the Physical Environment.[11]

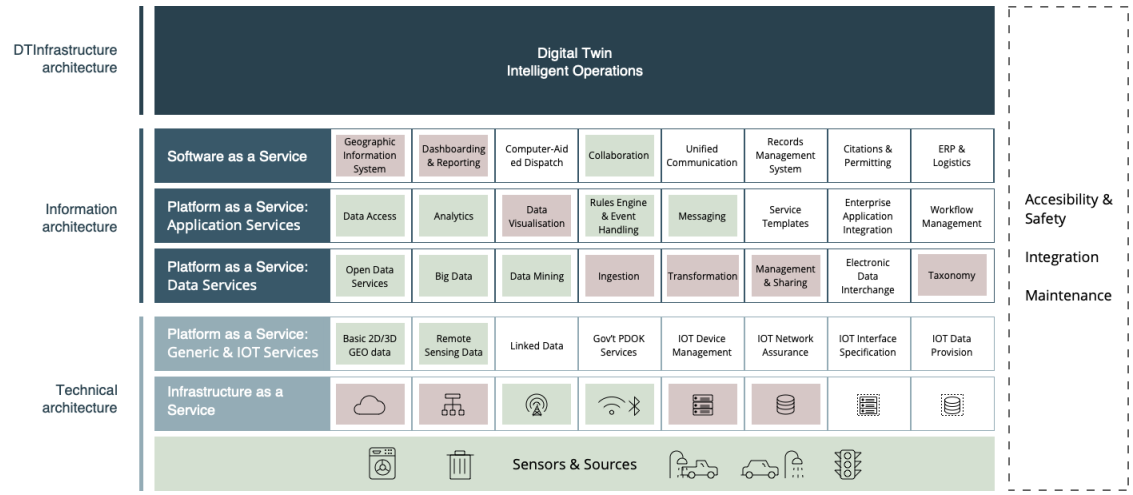

Figure 19 - Proposed reference architecture Digital Twin

Source: Geonovum 2021[12]

Within this architecture, we find the components necessary for the architecture of the digital twin, which require further elaboration/implementation for Parkstad/Heerlen. The orange, 1st priority, and green blocks represent the fulfillment of components for the Digital Twin Parkstad/Heerlen. If these are further described in text, it is useful to integrate them into a cloud infrastructure where all components are offered as a service. In this case, no requirements are imposed on the project's use other than having an internet connection with a browser. The components are hosted on a platform, in this cast on the Geodan platform[13]. The implementation can be based on Open Source software, Open standards, and as much as possible on Open data.

[10] What is a reference architecture? Reference architectures are reusable architectures based on best practices . They provide a template for developing specific enterprise architectures and solution architectures. Developing a specific architecture thus becomes a matter of selecting reusable principles and models and adapting them to the specific situation. This greatly accelerates the architecture design process.

[11] https://www.geonovum.nl/over-geonovum/actueel/consultatie-referentiearchitectuur-stelsel-digitale-tweeling-fysieke

[12] https://www.geonovum.nl/over-geonovum/actueel/consultatie-referentiearchitectuur-stelsel-digitale-tweeling-fysieke

[13] https://parkstad.beta.geodan.nl

Privacy aspects also play a role in some project components, in which case the Open data principle is deviated from, and privacy aspects are ensured. For further description of the digital twin infrastructure, the following diagram (Figure 20) helps.

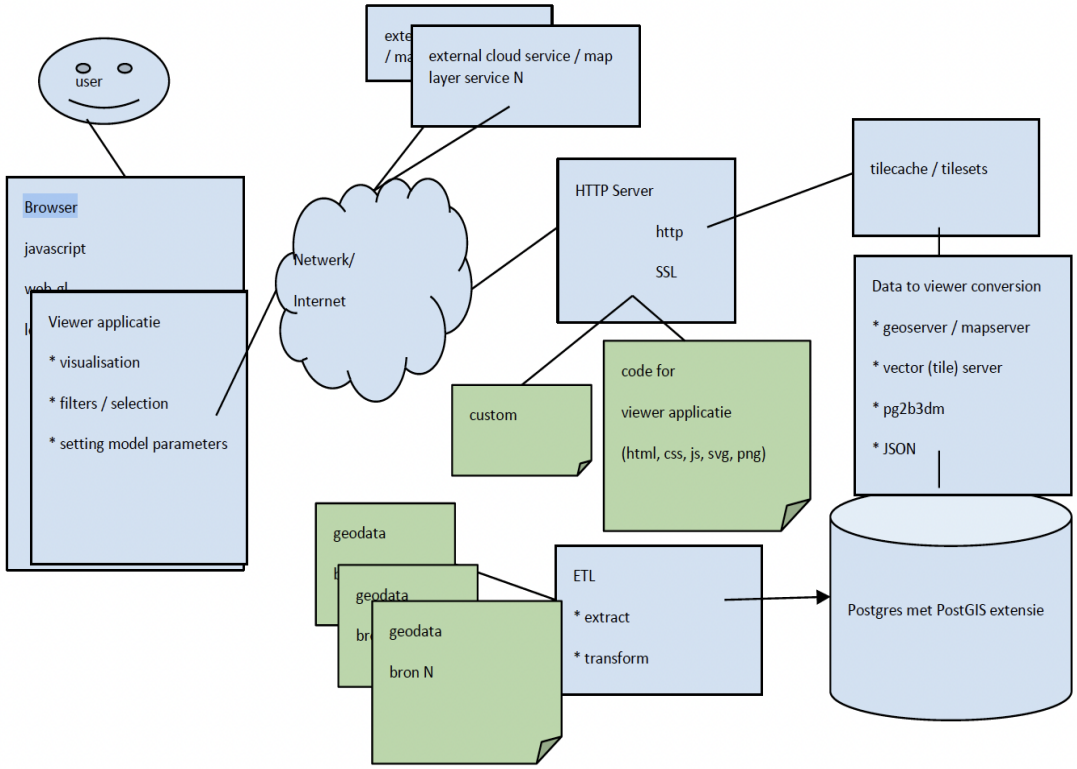

Figure 20 - Further elaboration of the architecture

Source: Geonovum (2021)

The architecture as depicted in Figure 20 can be further translated into technical components:

- The database environment: The database consists of a Postgres database with PostGIS facilities. Both the geo-components (topography) and the corresponding attribute data are stored here. Subsequently, this database is accessed in various ways.
- Visualization/viewer: The data is displayed in both a 2D visualization and a 3D visualization. For the 3D environment, this requires further development of the database. This can build upon the existing experience and tools available to Rotterdam. The Cadastre is also working on making 3D data available, based on the basic registrations.

The first outcome consists of the development of a prototype viewer and digital twin environment for use by the OU in the Be.CULTOUR project. This involved building upon the application based on the outcomes of Phase 1, visualizing various key performance indicator (KPI) datasets in a 3D

environment. Throughout the process of the Be.CULTOUR project, the development of digital tool for Parkstad/Heerlen was frequently discussed at various scientific meetings, conferences and workshops, and updated.

There exist various technologies capable of facilitating the development of digital twins, and it is essential to select the most suitable ones according to the specific Parkstad/Heerlen case study in the current Be.CULTOUR project. Gaming engines like Unity[14] have demonstrated their ability to render 3D digital twins and conduct crowd simulations[15]. Furthermore, this technology provides the opportunity for interaction with simulations, unlike more traditional parameterized simulations, enabling end-user engagement and scenario modeling.

This step-wise methodological framework has demonstrated that this methodology is well-suited to address crowd modeling inquiries while fully adhering to the privacy and other ethical boundaries of the modeled public.

As an introductory example of the spatially varying tourist amenities in Heerlen, we present a GIS map of hospitality provisions, including hotels, restaurants, bars, and cafés (see Figure 7). The city center and main axes emerge as popular locations for these visitor facilities.

[14] Unity, "Unity - Manual: Inner Workings of the Navigation System," Unity Documentation, 2021. [Online]. Available: https://docs.unity3d.com/Manual/nav-InnerWorkings.html. [Accessed: 14-Dec-2021].

[15] G. White, A. Zink, L. Codecá, and S. Clarke, "A digital twin smart city for citizen feedback," Cities, vol. 110, 2021, doi: 10.1016/j.cities.2020.103064.

Figure 21 - Location of hospitality amenities in the centre of Heerlen

Figure 21 illustrates the comprehensive architecture for generating a digital twin using open GIS data. Spatial data sourced from the Dutch cadastre and OSM are stored in a geodatabase (PostgreSQL database with PostGIS). These data undergo processing to generate additional 3D datasets, specifically 3D terrain and buildings, employing methods akin to the 3dfier reconstruction algorithm[16] for terrain and Geoflow for buildings[17]. The resulting enhanced dataset is then retrieved based on a specified bounding box and processed using Trimesh[18], a Python library designed for loading and manipulating triangular meshes, to create a COLLADA file [45], an open standard schema for interactive 3D applications. This file comprises distinct layers corresponding to each topographic layer and the buildings, making it compatible with the Unity game engine, allowing for the loading of all layer meshes. It's important to note that while there may be no restrictions on the extent to which a digital twin can be generated, it remains

[16] H. Ledoux *et al.*, "3dfier: automatic reconstruction of 3D city models," *J. Open Source Softw.*, vol. 6, no. 57, p. 2866, 2021, doi: 10.21105/joss.02866.

[17] H. Ledoux, R. Peters, B. Dukai, and Commandeur Tom, "geoflow3d/geoflow: flowchart tool for geo-spatial data processing." [Online]. Available: https://github.com/geoflow3d/geoflow. [Accessed: 12-Nov-2021].

[18] Dawson-Haggerty et al., "mikedh/trimesh: Python library for loading and using triangular meshes." [Online]. Available: https://github.com/mikedh/trimesh. [Accessed: 12-Nov-2021].

constrained by hardware and software limitations. For instance, a bounding box of 2x2km will yield a digital twin of approximately 50MB (size may vary based on location). Consequently, there may be memory issues when querying excessively large digital twins. Furthermore, while the Unity game engine is efficient, its performance is constrained. Loading a large digital twin can significantly impact the performance of crowd simulation.

The subsequent phase involves presenting digital twin prototypes for Heerlen's central area. We will showcase initial results from an empirical proof-of-concept experiment focusing on two KPIs: (i) the spatial sustainability/circularity dimension of the housing stock, measured by energy efficiency as a proxy for favorable conditions of the built environment, and (ii) the density and spatial distribution of urban greenery relative to the buildings' construction years, serving as a proxy for neighborhood quality of life. Detailed spatial 3D images of these KPIs for Heerlen's city center are shown in Figures 22 and 23, respectively.

Figure 22 - Prototype digital twin of Heerlen for energy efficiency of buildings at micro scale

Figure 22 illustrates a 3D map of energy labels for individual buildings, highlighting a wide range of energy efficiency outcomes from highly efficient in the city center to significantly inefficient elsewhere. This indicates a substantial variation in ecological energy performance within Heerlen, with an irregular distribution of trees. Notably, tourist attractions such as hospitality amenities and shopping areas are located in regions with relatively high energy performance.

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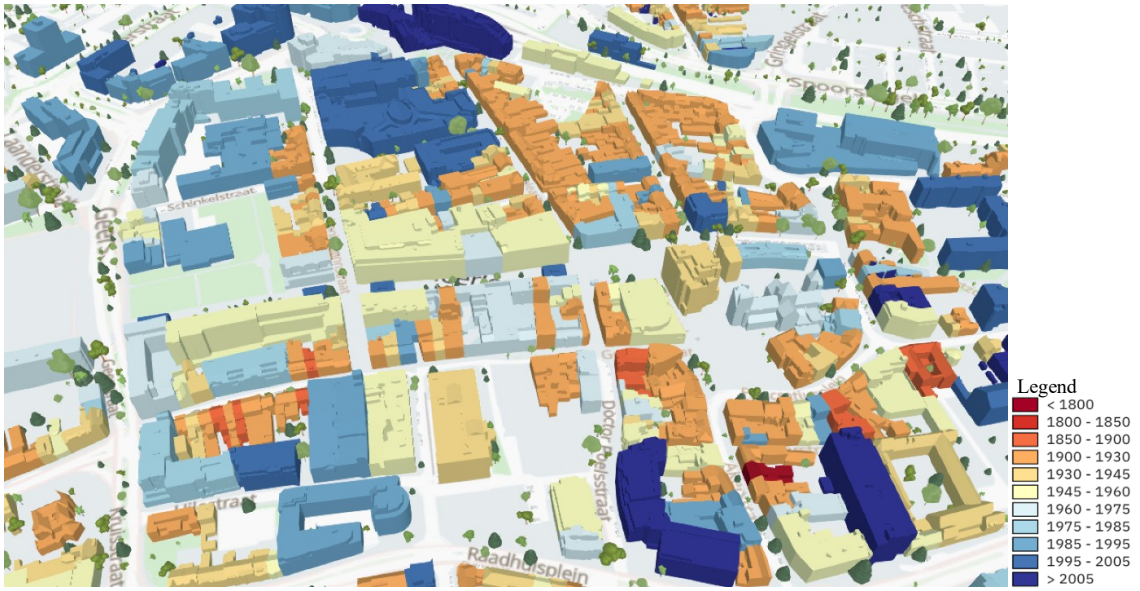

Figure 23 - Prototype digital twin of Heerlen for Age of Buildings at Micro Scale

Figure 23 presents another intriguing aspect of Heerlen's digital twin, displaying the construction years of inner-city buildings. The considerable variation, with few buildings constructed in recent decades, suggests an imbalanced attractiveness of the inner city from a tourist's perspective.

This digital twin experiment only scratches the surface of geoscience techniques' potential. Future research should explore deeper into creating digital twins for various attractiveness characteristics of the city, such as cultural amenities, entertainment venues, synergies among tourist attractions, and visitor accessibility. Additionally, analyzing the interactions between different thematic digital twins presents an exciting challenge for further exploration.

To further extend the scope of this prototype, more detailed and expansive datasets will need to be integrated. This includes real-time data from IoT devices, which can provide up-to-the-minute insights into visitor flows, environmental conditions, and infrastructure use. Such integration will allow for dynamic updates to the digital twin, making it an even more powerful tool for planners and stakeholders.

Furthermore, the development of user-friendly interfaces and visualization tools is critical to making the digital twin accessible to a broader audience. By enabling interactive exploration of the data, stakeholders from various sectors—including tourism, urban planning, and local government—can better understand and utilize the insights provided by the digital twin.

In addition to technical enhancements, the digital twin project should also incorporate participatory approaches. Engaging local communities and stakeholders in the development process can ensure that the digital twin reflects the needs and priorities of those who live and

work in the area. This participatory approach can also help build local capacity for using digital tools in cultural heritage management and sustainable tourism planning.

Ultimately, the goal is to create a comprehensive and adaptive digital twin that not only supports current planning and management efforts but also anticipates future needs and challenges. By continuously updating and refining the digital twin, we can ensure that it remains a valuable resource for promoting sustainable and inclusive cultural tourism in South Limburg and beyond.

By embracing these advanced digital techniques, we can significantly enhance our understanding and management of cultural heritage sites. This not only preserves the past but also paves the way for innovative and sustainable tourism strategies that benefit local communities and economies.

9. Digital Twin Parkstad/Heerlen

9.1 Design

For the Be.CULTOUR project the OUNL has explored new technologies to improve the management of cultural tourism at heritage sites. The goal is to help policymakers and stakeholders make informed decisions for sustainable regional development. With today's technologies, we can create a "Digital Twin" of almost any object or territory, allowing us to simulate different project scenarios and present the results in an accessible way. This section introduces the Digital Twins to support innovative data management for Parkstad/Heerlen.

The Visit Zuid-Limburg Route agency assists in the enhancement of an ideal infrastructure for walking and cycling, including the implementation of long-distance cycling routes such as the newly introduced Leisure Lane (see Figure 24).

Figure 24 - Long distance cycling routes, including the new Leisure Lane

Source: Zuid-Limburg 2022, pp21

Foundational Phase (Phase 1): In the initial phase, efforts were made to integrate the five timelines into various aspects: Themed routes were organized through collaboration with the Route agency. Storytelling initiatives were implemented, including the creation of anecdotal

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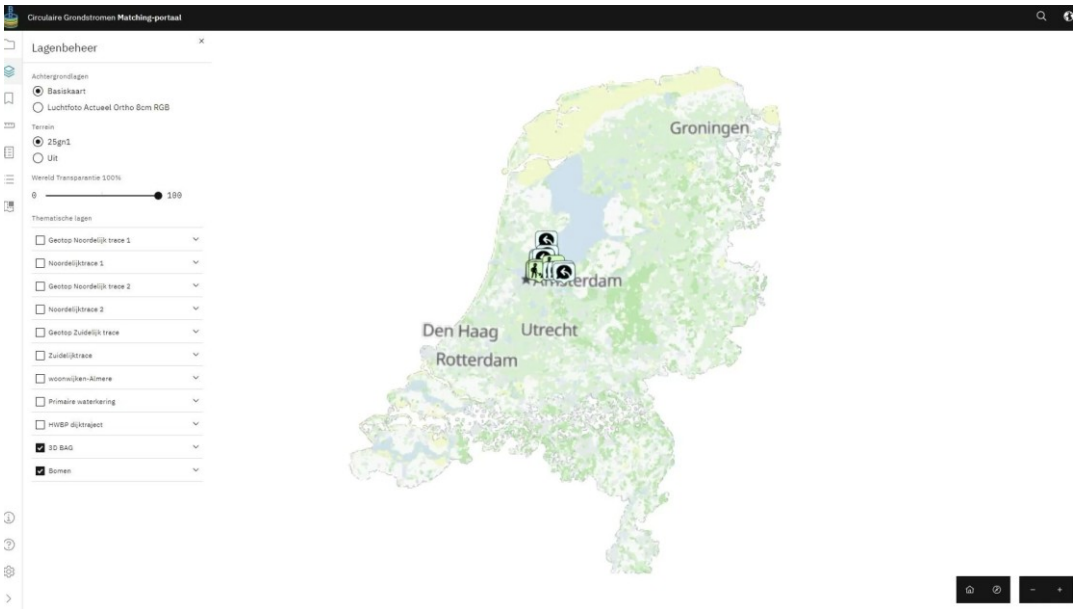
accounts for each timeline, which were disseminated through podcasts, maps, films, and other mediums. Community involvement was encouraged to collectively share the narrative across communication channels. Furthermore, the storytelling aspect extended to augmented reality experiences within the five timelines. Additionally, these timelines were translated into tangible elements such as maps, designed in alignment with the large wall in the Experience, and events that promoted activities corresponding to the timelines, with a focus on social media engagement.

Engagement Phase (Phase 2): Subsequently, efforts shifted towards attracting the attention of potential guests through a variety of methods, both traditional and modern. This involved utilizing advertising, online marketing, and PR activities tailored to the timelines or ongoing developments to increase awareness. Upon considering South Limburg and/or Parkstad, information was made readily available to guests in their preferred format. This included leveraging the Digital Twin incorporating the five timelines, seamlessly integrated into Visit South Limburg's offerings. Through the Digital Twin, residents and visitors could explore detailed views of the timelines, enabling them to craft their own narratives based on different routes and connections. Upon arrival in South Limburg, the focus was on providing inspiration, as information was already accessible through the Digital Twin and IZITRAVLE, guiding visitors through authentic stories and the historical periods.

This is the Digital Twin viewer for visualizing recreation locations in Parkstad Limburg (Figure 25).



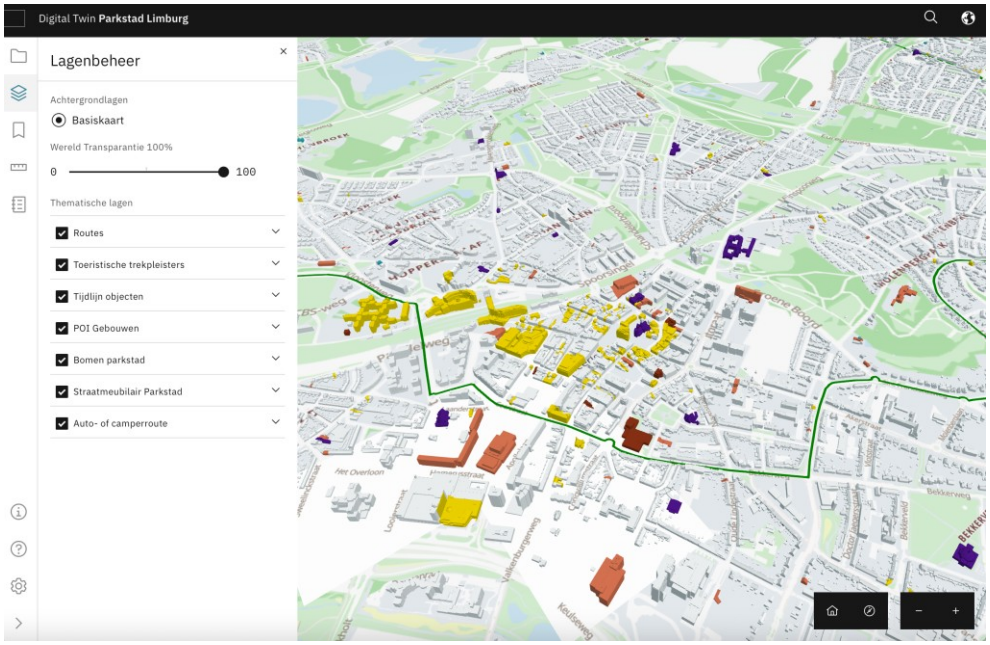


Figure 25 - Digital Twin viewer for visualizing recreation locations in Parkstad Limburg

9.2 Tourism and Digital Twins in Zuid-Limburg

The tourism sector has become one of the most important industries in Limburg. Nearly 40,000 people work in tourism every day. In 2023, there were 4.3 million tourists in Limburg. Tourists are drawn by the nature, culture, history, shopping, and entertainment (see Figure 26).

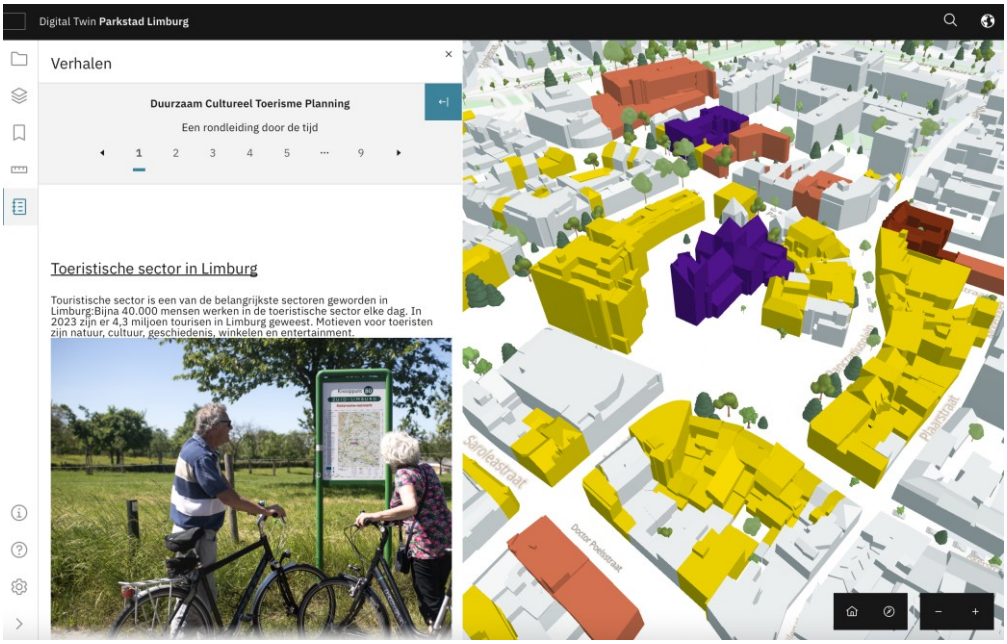


Figure 26 - Sustainable Cultural Tourism Planning A Journey Through Time

Tourism is, of course, an economic sector that can generate significant financial resources for the host area. However, in the era of mass tourism, an uncontrolled influx of visitors can lead to compensatory displacement effects that erode the cultural and ecological resources that are precisely the basis of tourism. In the case of Parkstad, it should be noted that cultural heritage is not merely a static asset from the past but a dynamic phenomenon influenced by different periods ('cultural-historical eras') (see Figure 27).

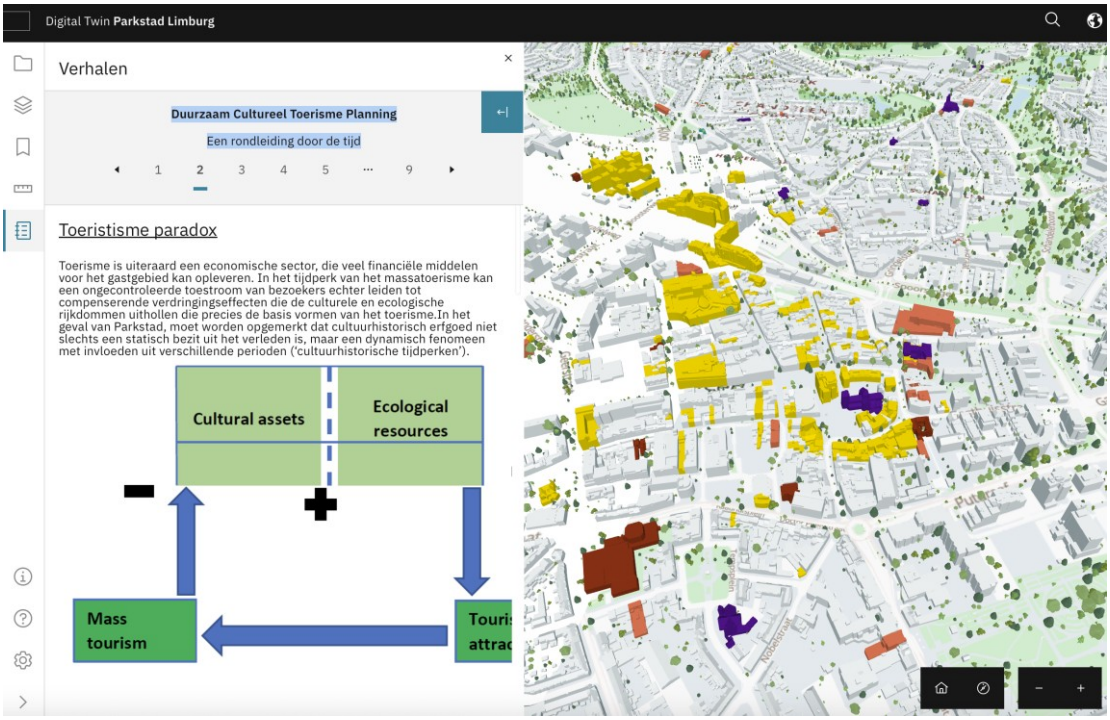


Figure 27 - Toeristisme paradox

9.3 Tourism: Travel Through Time

The historical, political, and cultural timeline of South Limburg can be divided into five distinct cultural-historical eras:

The Roman Era; 750 BCE – 500 CE ('Crossroads of the Romans')

The Middle Ages; 500 CE to the 17th century ('Knights and Bandits')

The Coal Mining Era; modern times to the 1970s ('Golden Mining')

The Interim Period; collapse period at the end of the last century ('Dramatic Transition')

The Modern Era; early 21st century ('New Awakening')

Each of these eras is part of the 'big story' of this region and has left significant characteristic footprints ('icons'). For each of these five eras, one can draw a map showing the location of

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cultural-historical monuments in the respective area. By using an overlay approach for each of these five maps, an integrated map of the entire region can be obtained, incorporating the cultural-historical values in an integrated manner (see Figure 28).

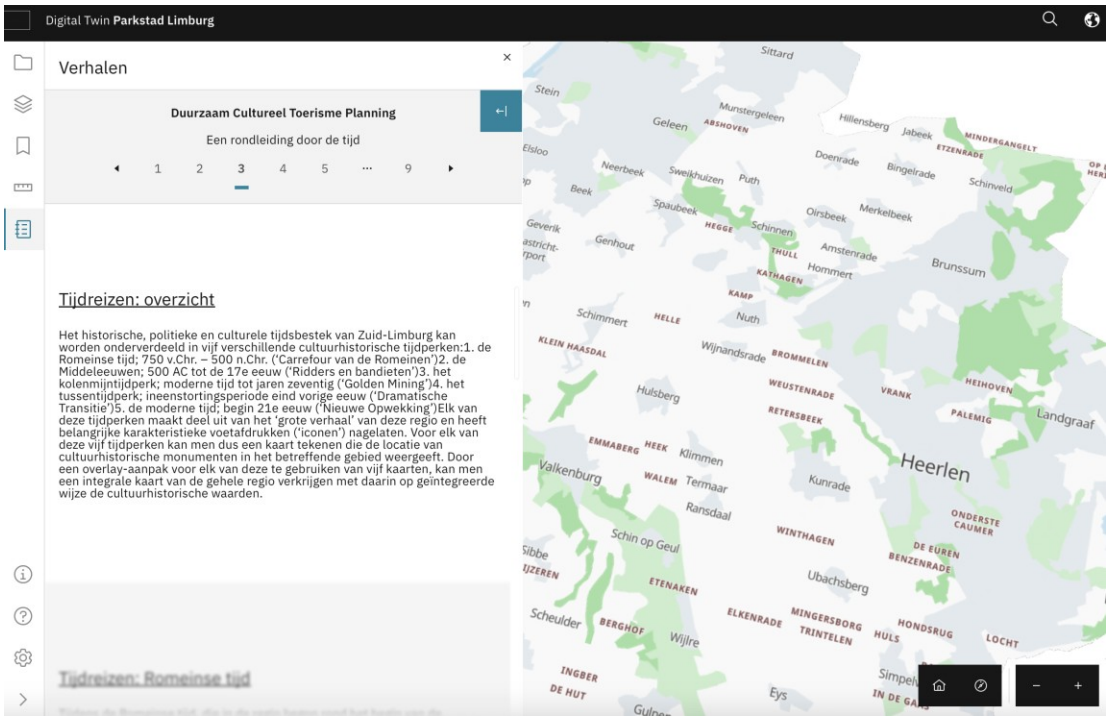

Figure 28 - Time Travel: Overview

9.3.1 Time Travel: Roman Era

During the Roman Era, which began in the region around the beginning of the Common Era (approximately 50 BCE) and lasted until around 400 AD, the area now known as Parkstad Limburg was part of the Roman Empire. The baths are the oldest building in the Netherlands. Around the year 100, Coriovallum transformed from a military camp into a real city. There were three Roman settlements in South Limburg: Maastricht-Heerlen-Rimburg. In Rimburg, remains of a Roman street village have been found. Various craftsmen worked here. Numerous archaeological finds have been discovered in Voerendaal and Simpelveld. Some of them are among the most important in the Netherlands. Wealthy farmers already enjoyed the rolling landscape and fertile soil, which provided them with everything they needed. In exchange for the grain they grew here, they built extensive villas, and riches from across the Roman Empire found their way to this area (Figure 29).

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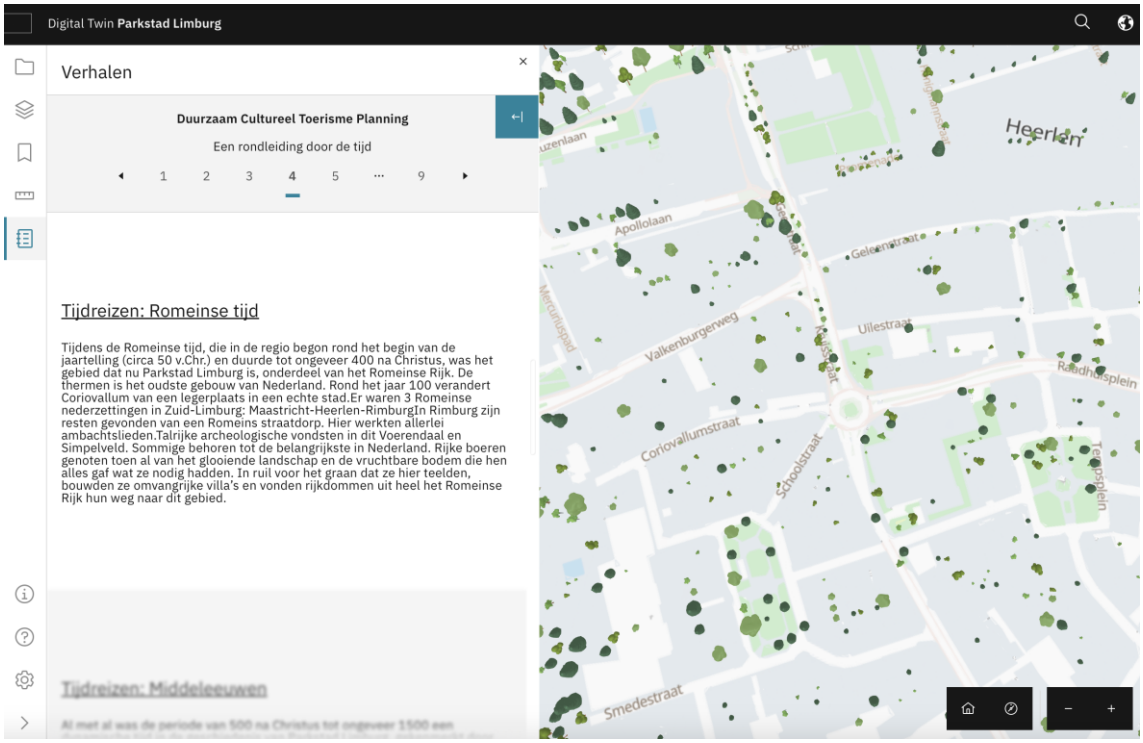

Figure 29 - Time Travel: Roman Era

9.3.2 Time Travel: Middle Ages

Overall, the period from 500 AD to approximately 1500 was a dynamic time in the history of Parkstad Limburg, characterized by political shifts, economic growth, and cultural developments. During this period, various churches and monasteries were built, shaping the religious landscape of the region. For example, Landsfort Herle: church, a cemetery, and about ten houses. Or other types of cultural buildings such as the Schelmentoren: originally a residential tower but also served as a prison tower during the time of the Bokkenrijders. Simpelveld originated in the early Middle Ages as a continuation of Roman settlement. Name from 1140 to 14th century: Simplevei (Figure 30).

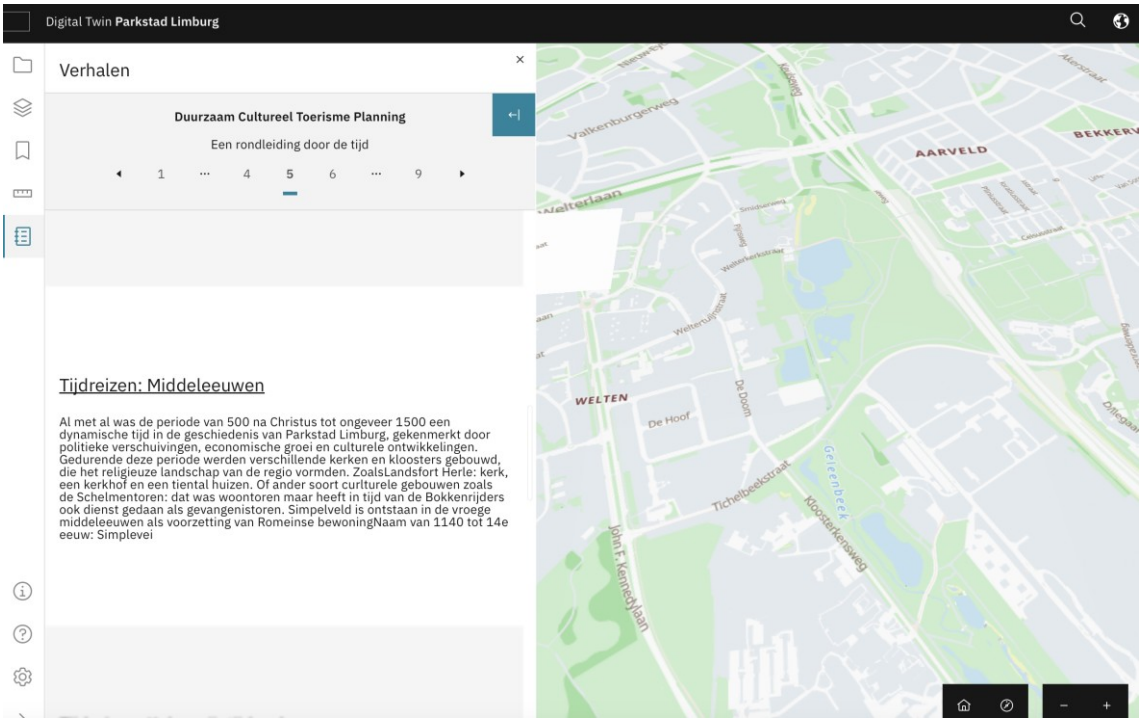

Figure 30 - Time Travel: Middle Ages

9.3.3 Time Travel: Coal Mining Era

Heerlen became a city with the arrival of the mines. The closure had as much impact as the arrival. Around the turn of the 20th and 21st centuries, mining brought about enormous changes within the current Landgraaf. In the former municipality of Schaesberg, the private mine Oranje Nassau II was first put into operation, followed a few years later by the oldest State Mine Wilhelmina. Until the beginning of the 20th century, Brunssum was a small village, and its residents mainly lived off agriculture. After the establishment of the state mines, the number of inhabitants increased rapidly due to the settlement of workers from other parts of the Netherlands and guest workers from Southern Europe and North Africa. Brunssum became an important center for coal mining. Additionally, silver sand was also excavated near Brunssum. Particularly for Brunssum, the state mine Hendrik (1915 - 1963/1973), which required the most Dutch miners, was the beating heart of urban development. The Hendrik had the deepest mine in the Netherlands. Shaft IV had a depth of 1,058 meters. The former site of State Mine Hendrik has been given a new function: NATO (how a coal mine became a barracks). Voerendaal was an important area in coal mining due to the high quality of the coal. A large part of the population worked in the mine. Million Line: a railway line built in 1934 for the transport of coal from the mines. The construction of the railway line led to the growth of Simpelveld (Figure 31).

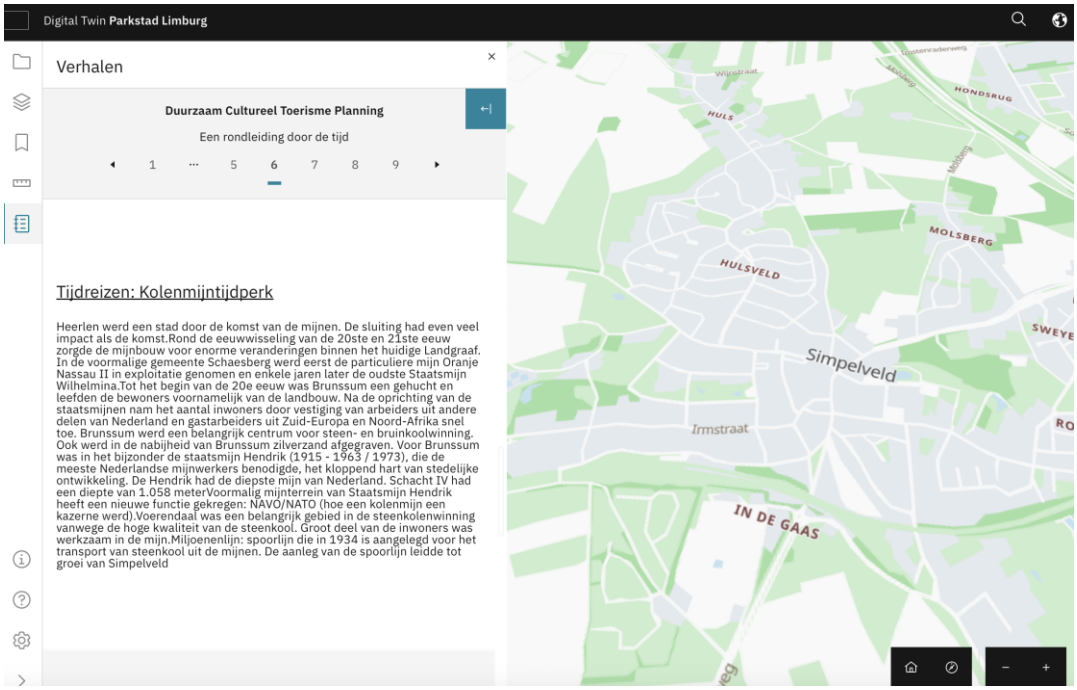

Figure 31 - Time Travel: Coal Mining Era

9.3.4 Time Travel: Demolition Era

The history of Parkstad Limburg between 1965 and 2000 reflects the challenges and opportunities faced by former industrial regions during a period of profound economic change. Efforts to diversify, restructure, and invest in culture and recreation have helped the region adapt to the new economic reality and embark on a new chapter in its history (Figure 32).

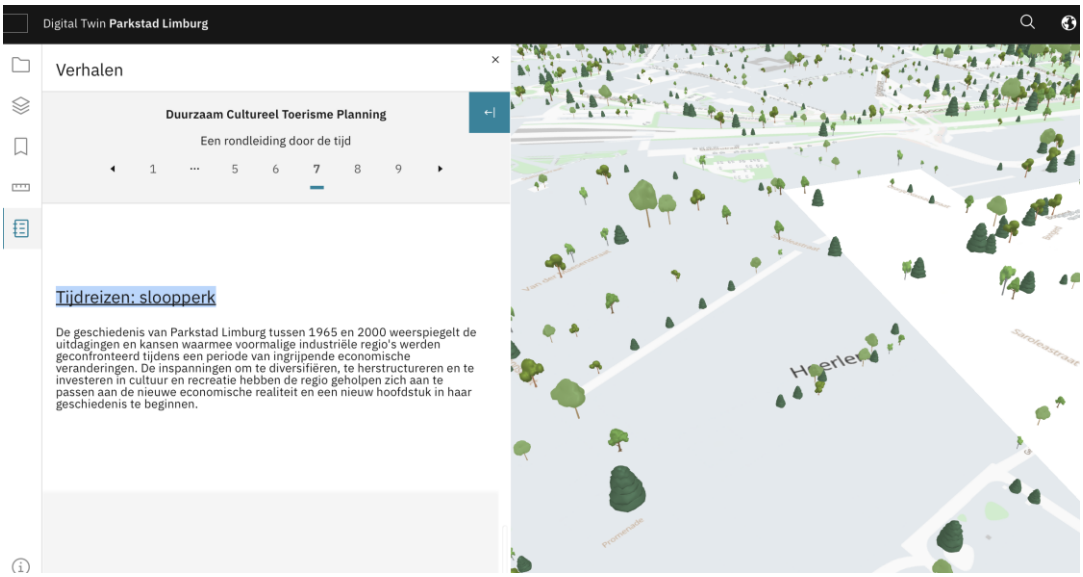

Figure 32 - Time Travel: Demolition Era

9.3.5 Time Travel: Modern Era

This new chapter in history often included initiatives aimed at improving quality of life, diversifying employment, and making the region more attractive to both residents and businesses. In addition, investments in infrastructure, urban renewal, cultural initiatives, and other projects were aimed at transforming the region and creating a sustainable and resilient future (Figure 33)

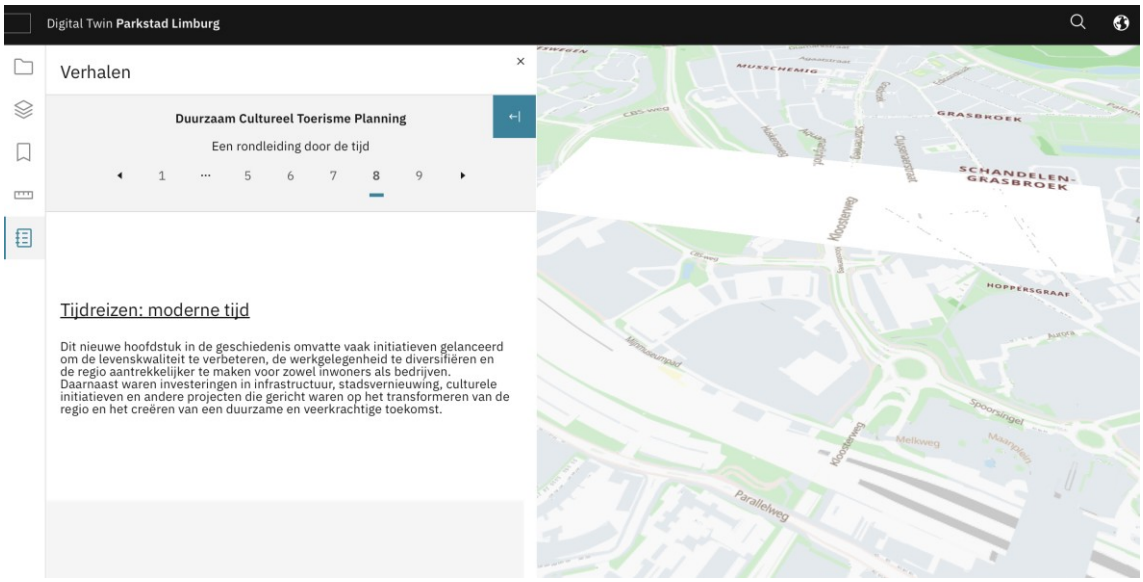

Figure 33 - Time Travel: Modern Era

9.4 Time Travel: User Interface App

In combination with a digital twin, which provides a virtual representation of the real environment, the IZI Travel app enhances interaction with this digital representation (see Figure 34). Users can discover information and stories linked to specific locations in the digital twin through the app. This not only enhances the educational value but also adds a deeper meaning to the physical environment. A test example has been created for the Roman era: link[19].

[19] https://izi.travel/nl/browse/9c4482fd-5d69-4f41-a54e-51bd04516252

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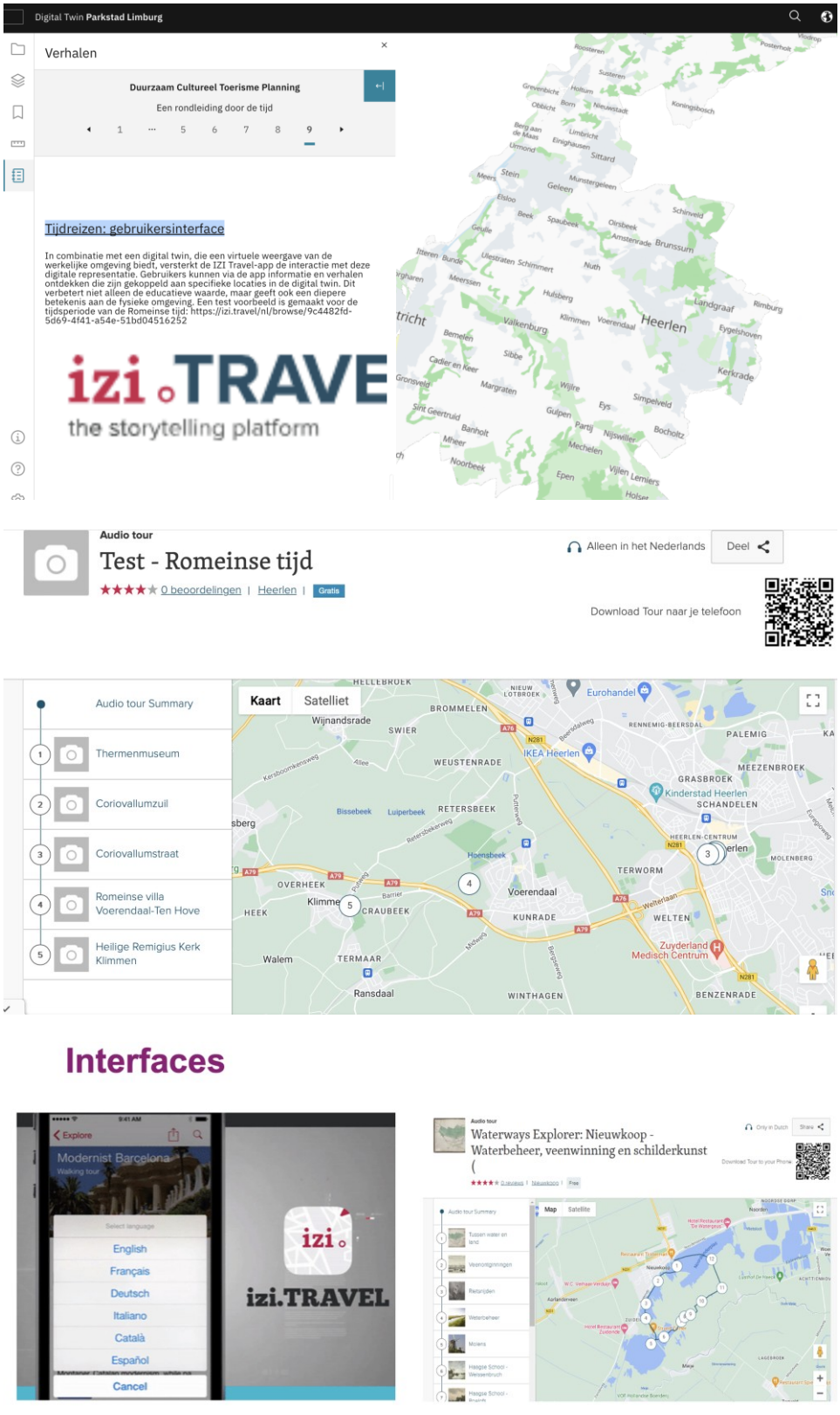

Figure 34 - Time Travel: User Interface App

9.5 Data Collection and geographical information for Be.CULTOUR Project

9.5.1 Digital Spatial Data Mapping

Planning for sustainable cultural tourism calls for a multidimensional and evidence-based perspective on place-based characteristics of a tourist destination. The Be.CULTOUR project – implemented in many pilot areas in Europe – has demonstrated that the data requirements for a balanced development of tourist areas may be immense. So there is a major information challenge, viz. the completeness of the data base and the systematic organization of data in geographical space. This will be illustrated here for the Heerlen/Parkstad area in Zuid-Limburg in the Netherlands.

In recent years, digital technology and geo-science developments have stimulated the development of visualized three-dimensional data representations in the form of digital twins, sometimes in combination with planning dashboards. A digital twin is essentially a data-rich and visual mapping (in 3 D) of the integration of different spatial data, either as stock data or as flow data in geographical space. They can also serve as interactive visualisation tools, for instance in the context of citizen participation, amongst others by using digital viewers. These opportunities have been developed and tested for the case of Zuid-Limburg. The technicalities of using digital twins for sustainable tourist planning from a cultural perspective have been documented in various background publications. Here we will only provide a data report on the distinct information items used in Zuid-Limburg case study.

Various datasets have been compiled, in the course of the Be.CULTOUR project integrating data from different sources within the database. These source data are available for each residential object, postal code, building, or grid cell in the Heerlen/Parkstad area (see Figure 35 and Annex 3).

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Figure 35 - Data Informartion on Digital Twin Viewer for Parkstad/Heerlen - Be.CULTOUR Project

9.5.2 Geographical Data and Object Types

Geographical data is linked to geographical objects. For the Be.CULTOUR project, data is collected for the following types of geographical objects (see Figure 36):

- Neighborhoods
- Residential objects
- Postal codes
- Buildings
- 3D buildings
- Roof sections
- Trees
- Underground (BRO registry)
- Background maps and aerial photographs
- Routes
    - Tourist attractions
    - Timeline objects
    - Car or camper routes
    - Bicycle routes
    - Other routes
    - Horse-riding routes
    - Sailing routes
    - Walking routes
- Points of Interest (POI) buildings
- Park city trees
- Park city street furniture (contains various sub-data sets)
- Background layers: BGT (BGT Grey, BGT Standard, BGT Pastel)
- Base map
- Basic registrations
- Basic registration underground (BRO)
- RGB aerial photos

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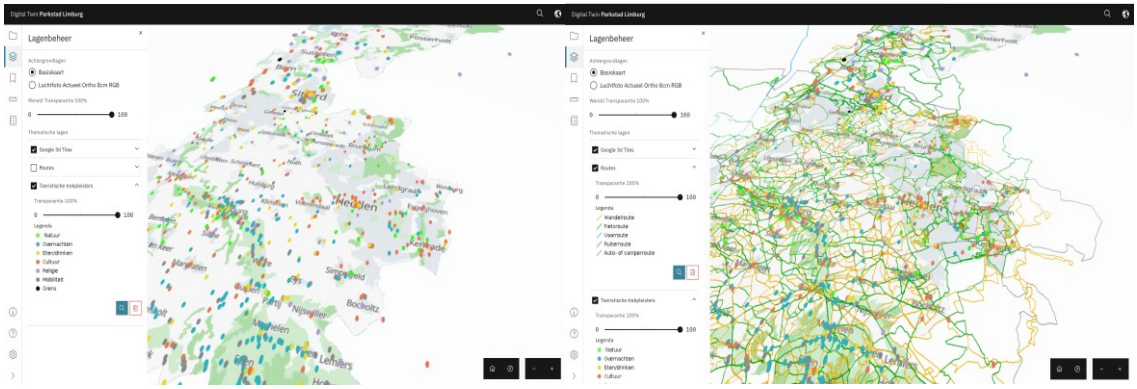


Figure 36 - Geographical Data and Object Types

9.5.3 Sources and Geographical Object Types

Information is collected from various sources for different object types. This information can also apply to other object types. For instance, data aggregated by CBS per postal code can be assigned to individual residential objects (addresses). This postcode information assigned to each residential object can then be aggregated for the entire building containing those addresses.

9.5.4 Geometries

Different geometries can also be assigned to geographical objects. Since the precise location of many residential objects in apartment building is not always known, many residential objects are grouped at a single location within the building. For visual purposes, it is then preferable to distribute the residential objects evenly throughout the building. Thus, one residential object can have an original point location (from the data source) and a generated point location (after distribution within the building).

9.5.5 Data Sources

- BAG (2022-11-08):
    - Residential objects with primary addresses and postcodes, without secondary addresses
    - Buildings
    - Standplaces
- CBS:
    - Neighborhood boundaries
    - Key figures per postcode 2020

- Publication on usage profile homes 2019-2020-2021 expansion
- Energy consumption per postcode (2014 - 2021)

- VVV Zuid-Limburg
  - Time-line objects

    The historical, political and cultural time frame of Zuid-Limburg can be subdivided into five distinct cultural-historical epochs (Visit Zuid Limburg 2022):
    - The Roman period; 750 BC – 500 AC ('Carrefour of the Romans').
    - The Medieval period; 500 AC till the 17th century ('Knights and Bandits').
    - The coal mine era; modern time till 1970s ('Golden Mining').
    - The intermediate era; break-down period end of last century the modern era; beginning 21st century ('New Revival').

Each of these epochs is part of the 'great story' of this region and has left behind important characteristic footprints ('icons'). So, for each of these five epochs, one can draw a map that presents the location of cultural-historical landmarks in the area at hand (see also Kourtit et al. 2024).

- RVO:
  - Energy labels and building type per residential object, v20230101_v2_csv.zip
- Geodan:
  - PC6 map
  - PC6 block map
  - PV panels on roofs (AI result)

- Pico / Geodan:
  - Roof sections

- PBL:
  - Labels for cooperatives and landlords, also information about building ownership (outdated? Replaced by RVO energy labels)
  - Geothermal contour

- Stedin:

    - Gas pipelines (description, file date January 28, 2021)
    - Electricity cables (file dates January 28, 2021, high voltage, medium voltage, low voltage)

- RIVM:
    - Urban Heat Island (UHI) effect June 2022, source Atlas Natural Capital RIVM, description (National Georegister)
    -
- Kadaster:
    - Ownership ratios of homes per postcode (2022-07-20, wfs pc6 area map, description)
    - 3D buildings (2020 v1)

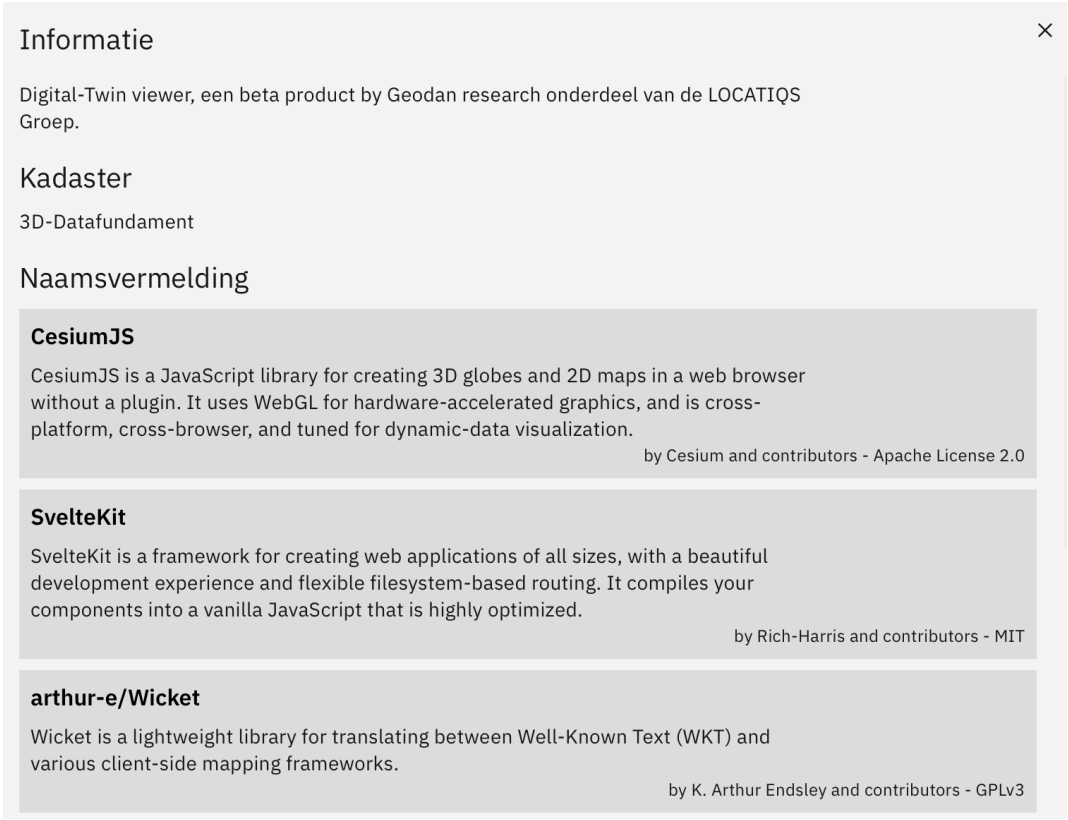
- PDOK:
    - Background map
    - OSM: Background map
- 3D Buildings
- The 3D buildings are based on the source file 2020_height_statistics_buildings from the Kadaster. This file is used for visualization and calculating the volume and floor area of a building.
- Link to the Digital Twin Parkstad: https://parkstad.beta.geodan.nl

9.6 Informartion on Digital Twin Viewer for Parkstad/Heerlen - Be.CULTOUR Project

The Digital-Twin viewer is a beta product developed by the OUNL team in collaboration with Geodan Research. It utilizes the following components (see Figure 37):

- Kadaster: Provides foundational 3D data.
- 3D-Datafundament: Forms the basis for the digital twin.
- Naamsvermelding: Attribution for data sources.
- CesiumJS: A JavaScript library for creating 3D globes and 2D maps in web browsers. It uses WebGL for hardware-accelerated graphics and is optimized for dynamic-data visualization.

- SvelteKit: A framework for creating web applications, offering a seamless development experience and flexible filesystem-based routing.
- Wicket: A lightweight library for translating between Well-Known Text (WKT) and various client-side mapping frameworks.
- Carbon-components-svelte: Design System and components used in the application.
- Carbon-icons-svelte: Icons utilized within the application.
- Fontsource/open-sans: Font used in the application.
- Svelte-parts/zoom: Utilized in FeatureInfo popups containing zoomable images.
- Fuzzysort: Provides fast, tiny, and effective SublimeText-like fuzzy search capabilities for JavaScript.



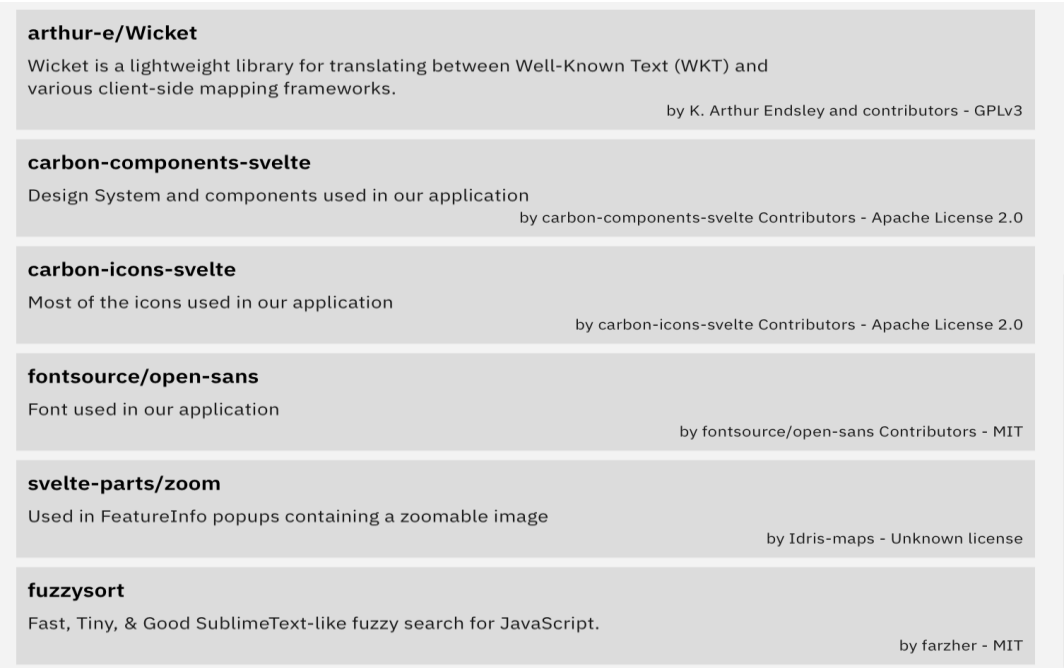


Figure 37 - Components Used in the Digital Twin Viewer for Parkstad/Heerlen - Be.CULTOUR Project

These components work together to create an immersive and informative digital twin viewer experience for Parkstad/Heerlen in the Be.CULTOUR project (see Figure 37).

9.7 Map Settings

The "Map Settings" section provides users with controls to adjust various parameters related to the rendering and environment of the digital twin viewer for Parkstad/Heerlen in the Be.CULTOUR project (see Figure 38). Under "Sun Position," users can specify the UTC hour and date to simulate different lighting conditions within the digital twin environment. The "Quality" settings offer options to adjust rendering quality, ranging from low to high, or customize settings according to specific preferences. "Rendering" settings allow users to fine-tune parameters such as MSAA (Multisample Anti-Aliasing), resolution scale, and level of detail to optimize performance and visual fidelity. The "Environment" section may include additional settings related to the virtual environment, such as ambient lighting, atmospheric effects, or skybox settings.

"Debug" options provide tools for developers or advanced users to troubleshoot and optimize the digital twin viewer's performance. Finally, "Point Clouds" settings allow users to control parameters related to the display of point cloud data, such as geometric error scaling, attenuation, and eye dome lighting.

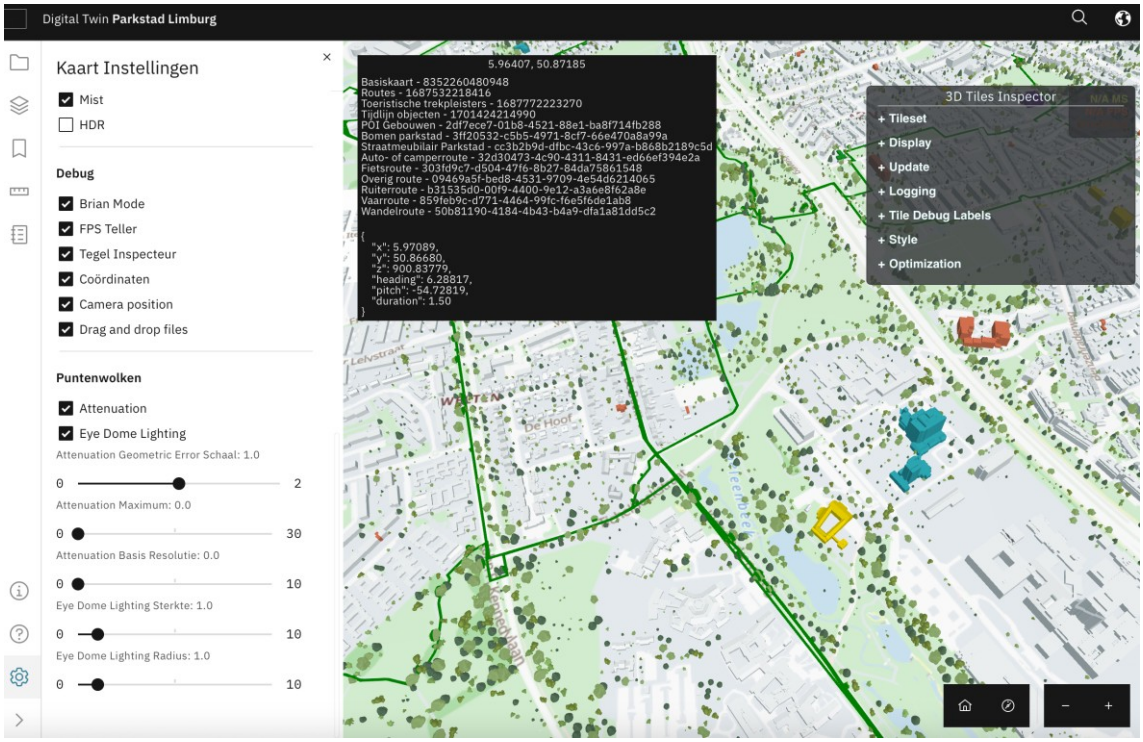


Figure 38 - Map Settings for Digital Twin Viewer in Parkstad/Heerlen - Be.CULTOUR Project

These settings offer customization options for the digital twin viewer in the Be.CULTOUR project, focusing on rendering quality, environment, and debugging. They empower users to personalize their viewing experience for Parkstad/Heerlen, ensuring an immersive exploration tailored to their preferences and needs.

9.8 Library

To add more layers on top of the configured layers in the viewer, users can use the library (see Figure 39).

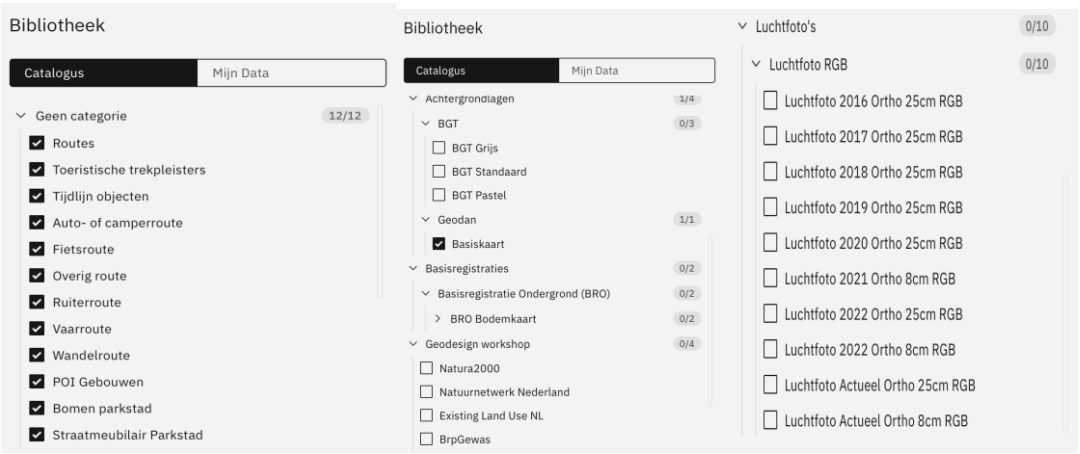


Figure 39 - Digital Twin Library

- Open the library To access the layer library, click on the "map" button on the left side.
- Using the library: Utilize the search bar at the bottom to find the desired layers or navigate through the displayed groups. Click on the layer to view more information about it, check the checkbox to add the layer to the map, or press the "Add to Map" button in the layer description view.

Thus, building a digital twin involves a comprehensive process of data integration and synthesis. Initially, diverse datasets are gathered, including geodata and open data from national and international sources, as well as models and simulations of new building shading formations. These datasets are then subjected to data fusion and linking procedures, allowing for the incorporation of additional layers such as building data and traffic patterns (see Figure 40).

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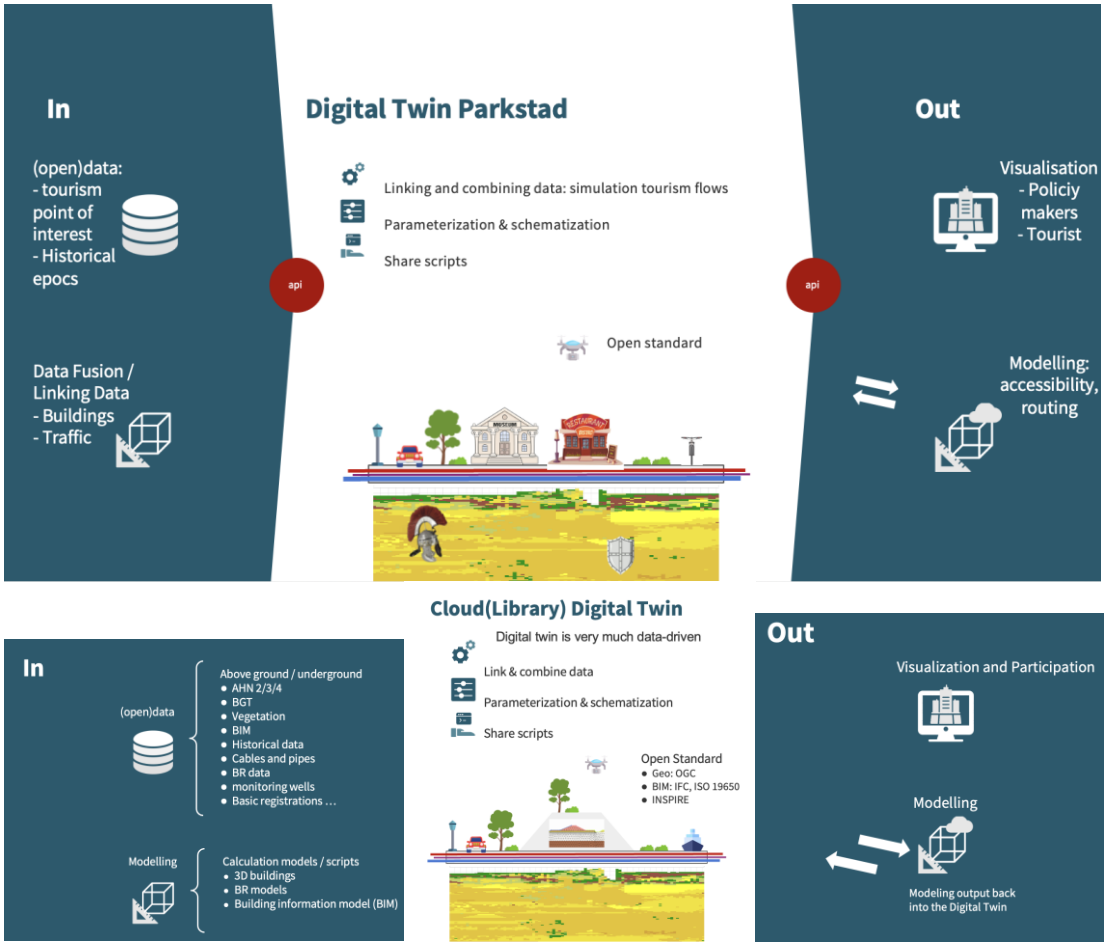

Figure 40 - Ins and Outs Digital Twin Parkstad

Once the data sources are linked and combined, various simulations can be conducted within the digital twin environment, including shading simulations for new building constructions. For instance, stakeholders can visualize how shading will form in different scenarios, facilitating informed decision-making.

To ensure accuracy and realism in these simulations, parameters and schemas are established, providing a framework for data interpretation. Moreover, the integration of open standards, such as those set by the European Commission and the Open Geospatial Consortium, is essential.

Furthermore, the sharing of scripts plays a crucial role in the digital twin construction process. By adhering to open standards, scripts can be easily exchanged and implemented across different platforms, fostering collaboration and innovation within the digital twin community.

In terms of output, the digital twin offers sophisticated visualization capabilities tailored to different user groups, including policymakers and citizens. Policymakers benefit from visualizations that provide insights into urban dynamics and historical trends, aiding in the formulation of effective policies and strategies. Similarly, citizens can engage in conversations and

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participate in decision-making processes related to sustainable cities and livable environments, as outlined in the Manifesto for Citizen Engagement by the European Commission.

Furthermore, modeling techniques are employed to analyze various aspects of the digital twin, such as accessibility and routing, contributing to a more comprehensive understanding of urban environments and informing future planning and development efforts.

10. Conclusion and Recommendations

For the Be.CULTOUR project several data and digital activities has been conducted in the broader context of the United Nations Sustainable Development Goals (SDGs) and the New Urban Agenda, with the aim of positioning cultural tourism within the framework of sustainable, inclusive, and circular urban development. Tourism is a significant resource for urban economies and cultures, and urban attractiveness can serve as a major magnet for enhancing the cultural development potential of cities and regions. However, the negative externalities associated with tourism, such as environmental degradation and overcrowding, can overshadow its benefits. Therefore, effective planning for balanced tourism is essential.

In this context, advanced digital planning support (DPS) tools are indispensable, particularly sustainability dashboards and digital twins. This study has presented an overview of the principles of modern geoscience techniques, with a specific focus on the potential offered by digital twins. These tools are critical for addressing the complex challenges associated with sustainable tourism and urban development.

The empirical illustration in this Be.CULTOUR project focused on a vulnerable tourist area in the southern Netherlands, specifically the Heerlen/Parkstad region. The findings highlighted the importance of systematic data collection, particularly in the form of a data warehouse that is hierarchically decomposed into relevant key performance indicators (KPIs), as a prerequisite for an evidence-based balanced tourism policy. Such a systematic approach ensures that all relevant aspects of tourism and urban development are considered, allowing for more informed decision-making.

Digital twins have the potential to provide comprehensive 3D insights into the fragility and development potential of urban tourist areas, provided the underlying database is current. These digital models can be instrumental in mapping citizens' interests regarding tourists' spatial choices in cities rich in cultural and touristic amenities. Furthermore, digital twins can support the interactive design of urban liveability scenarios, presenting these in an attractive and citizen-oriented manner. This interactive element is crucial for engaging stakeholders and ensuring that the perspectives and needs of local communities are considered in the planning process.

The study underscored the necessity of integrating modern ICT and digital technologies into cultural tourism planning. This integration not only enhances the effectiveness of planning processes but also fosters innovation and creativity, aligning with broader sustainability initiatives such as the Green Deal objectives and the New European Bauhaus programs. By leveraging these

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advanced tools, cities can better manage the delicate balance between promoting tourism and preserving the quality of life for residents.

Moreover, the development of digital twins and other DPS tools should be seen as a dynamic and ongoing process. Continuous updates and refinements are necessary to keep pace with changes in urban environments and tourism trends. This iterative approach ensures that the tools remain relevant and effective over time, adapting to new challenges and opportunities as they arise.

In conclusion, the study highlights the significant role that advanced digital planning tools can play in promoting sustainable cultural tourism. By providing detailed and actionable insights, these tools help cities and regions harness the benefits of tourism while mitigating its negative impacts. The case of the Heerlen/Parkstad region serves as an example of how systematic data collection and innovative digital technologies can inform balanced and sustainable tourism policies. As cities worldwide continue to grapple with the challenges of urban development and tourism management, the lessons from this study can provide valuable guidance for integrating digital tools into planning processes, ultimately contributing to more sustainable and resilient urban futures.

Furthermore, the research emphasizes the importance of stakeholder engagement and the inclusion of local communities in the planning process. Digital twins and DPS tools can facilitate a more transparent and participatory approach to urban planning, where citizens have a voice in the development and management of their cultural and tourist assets. This participatory approach not only enhances the relevance and effectiveness of tourism policies but also fosters a sense of ownership and responsibility among local stakeholders.

The integration of digital tools into urban and cultural tourism planning also supports the monitoring and evaluation of tourism impacts over time. By continuously collecting and analyzing data, cities can better understand the evolving dynamics of tourism and its effects on urban environments. This ongoing assessment allows for the timely identification of emerging issues and the implementation of adaptive strategies to address them, ensuring that tourism development remains aligned with sustainability goals.

Additionally, the research suggests that the collaboration between different cities and regions can be enhanced through the use of digital twins and DPS tools. By sharing data and best practices, urban planners and policymakers can learn from each other's experiences and develop more effective strategies for managing cultural tourism. This collaborative approach can lead to the creation of regional networks that support sustainable tourism development and cultural exchange.

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The methodological framework in this researchestablishes a robust foundation for comprehensive spatial behavioral modeling, spanning from macro to microscopic scales. By utilizing open data and microdata while ensuring privacy, the framework offers versatility in its applications without the need for laborious measurements.

In future research, the adaptability of the approach should be demonstrated through implementations across various domains such as health and safety, energy transition, and/or GHG emissions. Certainly, the methodology or certain components thereof can be applied to spatial behavioral studies that indirectly impact these themes.

Moreover, in line with the aforementioned case studies and domains, new scenarios and behavioral models need to be integrated. Therefore, additional efforts should focus on enhancing the rule engine at both macro and micro scales and seamlessly incorporating these new rules.

Since this framework is intended for use by policymakers, the user experience is an important aspect worth investigating. Through direct collaboration with municipalities, feedback should be gathered from stakeholders via surveys and/or interviews regarding the usability of the solution. This approach aims to establish Digital Twins as a benchmark for various stakeholders and policy-making.

From a morphological standpoint, the digital model of Parkstad/Heerlen stands as a reliable counterpart to its physical reference. Currently, the digital twin enables user groups to remotely explore this environment, with the potential to expand the visit to other contexts following similar management principles. This aspect, concerning the visualization and utilization of data, aligns with one of the key objectives of employing these digital resources. The technological allure provided by immersive visualization and the untapped potential of the digital twin philosophy remain largely unexplored within the cultural heritage and tourism sector. The fusion of physical objects with virtual reality enables the activation of data analysis and system monitoring, facilitating predictive operations to identify and address issues proactively. Beyond averting anomalies, downtime, and inefficiencies, leveraging appropriate simulations allows for the identification of new opportunities and the strategic planning of future sustainable tourism initiatives. Through the creation of a digital twin, a deeper understanding of operational optimization, efficiency enhancement, and the anticipation of potential problems and challenges can be gained before they manifest. Developing digital twins related to cultural heritage facilitates the construction of models that accurately represent reality, serving conservation purposes, fostering knowledge dissemination, and overcoming physical and cognitive barriers.

The advancement of 3D capabilities within the platform is essential, as the future development of sustainable tourism cities relies heavily on these capabilities. Without them, further progress

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on an operational level would be unfeasible. This entails utilizing Digital Twin 'explorations,' conducted through collaborative research with customers and partners. It is important to underscore that these ‘explorations’ are primarily driven by innovation and research and knowledge agendas, rather than predetermined, one-size directional objectives. Nonetheless, the outcomes frequently offer valuable inspiration and serve as proof of concept (POC) for initiating new and sustainable tourism city developments.

The digital transformation offers unprecedented opportunities for enhancing the management and planning of regional and urban environments, addressing complexities from population growth, climate change, and economic activities. Innovations like Artificial Intelligence (AI) and Machine Learning (ML) are gaining traction, providing predictive insights based on large datasets. Privacy concerns have led to the emergence of synthetic data, enabling analyses while safeguarding privacy.

The Digital Twin concept is rapidly evolving as a means to integrate data, models, and simulations into dynamic environments, serving as virtual counterparts to real-world regions and cities. Governments are implementing governance structures to facilitate efficient sharing of open data across borders, promoting data exchange and interoperability internationally.

Efficient data and model usage are crucial in regional and urban planning, addressing challenges such as climate impact reduction, housing development, and infrastructural asset management. Smart Cities leverage real-time sensor data for city administration, tackling complexities related to urbanization and sustainability. International initiatives in data spaces and standardization, coupled with advancements in data technologies, promise more efficient use of growing datasets and competing data sources.

Overall, the findings of this research approach underscore the transformative potential of digital planning tools in shaping the future of cultural tourism. By leveraging these technologies, cities can create more sustainable, inclusive, and vibrant urban environments that celebrate and preserve their cultural heritage while promoting economic and social well-being. As the global tourism landscape continues to evolve, the insights gained from this research can serve as a foundation for innovative and forward-thinking approaches to urban and cultural tourism planning.

The transition from existing tourism data to actionable insights marks a significant stride towards effective tourism management. As the digital twin, in conjunction with a tourism dashboard, nears completion, it heralds a new era of data-driven decision-making in tourism planning. Concurrently, the development of an interactive viewer promises to empower users with

immersive experiences, while the exploration of augmented reality opens up new vistas of engagement.

Looking ahead, the prospect of a tourism metaverse beckons, offering a futuristic dimension to tourism experiences. These advancements underscore the importance of multidimensional assessment models and open-source data infrastructures in fostering sustainable tourism practices. By providing comprehensive insights into cultural tourism impacts, these frameworks pave the way for informed decision-making in tourism planning.

Digital tools, notably digital twinning, emerge as pivotal instruments in fortifying cultural heritage management for circular tourism. Their innovative capabilities extend to assessment, management, and preservation, ensuring the longevity and vitality of cultural assets.

Furthermore, the integration of historical storytelling and interactive experiences serves to enrich tourist engagement and foster deeper connections with local communities and stakeholders. By leveraging real-time insights, predictive analytics, and compelling narratives, stakeholders can create tourism destinations that are not only inclusive and resilient but also enjoy robust support from the community.

In conclusion, the convergence of digital innovation and cultural heritage holds immense promise for the future of tourism. By harnessing these advancements judiciously, we can embark on a journey towards creating vibrant, sustainable, and community-centric tourism destinations that offer enriching experiences for all.

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ANNEX 1 - TOURISM IN SOUTH LIMBURG IN 2018

The distribution of the economic significance of tourism in South Limburg in 2018 across various municipalities is presented below in the table, indicating total expenditures. Distinctions have been made between overnight stays and day trips, categorized by municipality/subregion. For detailed input data (overnight stays and number of visits/day trips) as well as spending profiles per category, please refer to the separate table notes.

	Verblijfstoerisme	Dagrecreatie	Totaal	Totaal % (2018)	Totaal % (2014)
Beek	0,5	12,7	13,2	1,0%	1%
Echt-Susteren	15,0	22,0	37,0	2,7%	3%
Sittard-Geleen	18,5	87,4	105,9	7,8%	8%
Stein	15,8	18,4	34,2	2,5%	2%
Totaal Grensmaasvallei	**49,7**	**140,5**	**190,2**	**13,9%**	**15%**
Eijsden-Margraten	21,3	30,4	51,6	3,8%	3%
Gulpen-Wittem	60,9	25,4	86,3	6,3%	7%
Meerssen	2,9	9,6	12,5	0,9%	1%
Vaals	43,8	39,0	82,8	6,1%	6%
Totaal Heuvelland	**128,9**	**104,4**	**233,2**	**17,1%**	**17%**
Valkenburg aan de Geul	119,7	90,4	210,1	15,4%	16%
Totaal Valkenburg	**119,7**	**90,4**	**210,1**	**15,4%**	**16%**
Brunssum	6,6	34,8	41,4	3,0%	2%
Heerlen	34,1	103,7	137,8	10,1%	10%
Kerkrade	17,8	86,0	103,8	7,6%	8%
Landgraaf	12,1	54,6	66,7	4,9%	6%
Beekdaelen	7,2	18,4	25,6	1,9%	2%
Simpelveld	2,3	6,4	8,7	0,6%	1%
Voerendaal	2,5	8,8	11,3	0,8%	0%
Totaal Parkstad Limburg	**82,6**	**312,6**	**395,3**	**29,0%**	**29%**
Maastricht	178,8	156,4	335,2	24,6%	23%
Totaal Maastricht	**178,8**	**156,4**	**335,2**	**24,6%**	**23%**
Totaal	***559,8***	***804,2***	***1.364,0***	***100,0%***	***100%***

Table 1 - Expenditures in South Limburg (in millions of euros) for the year 2018

Source: Visit Zuid-Limburg (2018), p. 9

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	Verblijfstoerisme (x € 1 mln)	Verblijfstoerisme (%)	Dagrecreatie (x € 1 mln)	Dagrecreatie (%)
Grensmaasvallei	49,7	**9%**	140,5	**17%**
Heuvelland	128,9	**23%**	104,4	**13%**
Valkenburg	119,7	**21%**	90,4	**11%**
Parkstad Limburg	74,8	**15%**	312,6	**39%**
Maastricht	178,8	**32%**	156,4	**19%**
Totaal	**559,8**	**100%**	**804,2**	**100%**

Table 2 - Showcases Expenditures per region, categorized by overnight stays and day tourism

Source: Visit Zuid-Limburg (2018), p. 10[20]

[20] https://www.visitzuidlimburg.nl/media/874957/202002-notitie-bestedingen-toerisme-zuid-limburg-definitief-zka.pdf

ANNEX 2 - TIME TRAVEL: OVERVIEW

Heerlen

	Romeinse Tijd	Middeleeuwen	Mijntijd	Slooptijd	Nieuwe Tijd
Periode	753 voor Christus tot 476 na Christus	500 na Christus tot +/- 1500 Donkere Middeleeuwen: 400/1000 Late/hoge Middeleeuwen: 1000/1500 Vroeg Modern: 1500/1800	1900-1974 (officieel 1983/1986)	1965/1974-2000	Vanaf 2000
Geadviseerde namen	Romeins Knooppunt Coriovallum	Van Ridder naar Pruikentijd Land van Boeren, Ridders & Rovers Land van Kastelen en Heerlijckheden Land van Burchten en Kastelen Kastelen en leengoederen	Mijntijd	Traditie van/in transitie RESET Verandering Nieuwe kansen	Heerlen NU! Toekomst Een nieuwe ELAN
Verhaal	De thermen is het oudste gebouw van Nederland. Rond het jaar 100 verandert Coriovallum van een legerplaats in een echte stad.	Landsfort Herle: kerk, een kerkhof en een tiental huizen. Schelmentoren was woontoren maar heeft in tijd van de Bokkenrijders ook dienst gedaan als gevangenistoren	Heerlen werd een stad door de komst van de mijnen. De sluiting had even veel impact als de komst.	Negatieve periode, door de focus op transitie voorkom je dat het een negatief verhaal d wordt. Verhaal uitleggen om Heerlen	Verhaal over hervonden trots en waardering

				te begrijpen.	
Primaire iconen	- Thermenmuseum -De Vondst + escape game: schat van het verleden -Romeins keldertje - Coriovallum zuil -Via Belgica-bank	-Kasteel Hoensbroek -Sint Pancratiuskerk + Schelmentoren (gevangenis Bokkerijders) -1870 start Savelbergklooster -Middeleeuwse walmuur + replica van Landsfort Herle	Nederlands Mijnmuseum Parkstad Limburg Theater: 1965 verkondigd toenmalig Minister van Economische in de stadschouwburg de sluiting van de mijnen aan Mijnkolonie: Beersdal <u>Peutz:</u> 1932 Retraitehuis 1933 Warenhuis Schunck 1936/42 Raadhuis 1937 Royal 1959 Schouwburg <u>Stuyt:</u> 1913 Ambachtsschool 1920-1922 Vroedvrouwenschool 1913-1938 Wijk Molenberg	Verhalen van de straat Operatie Hartslag	-Schunck Glaspaleis -De Vondst -Parkstad Limburg Theater -StreetArt Openluchtmuseum van Architectuur -Mural op Carbon 6 gebouw: Heron *(de reiger) staat symbool voor de stad Heerlen die langzaam maar zeker herrijst uit de restanten van het verleden* -Nieuwe Nor -IBE -Cultura Nova -TeleFleur -Raboronde -ParkcityLive -Schrittmacher -Limburgs Mooiste - Brunssummerheide: natuurgebied (Brunssum, Heerlen en Landgraaf) Natura 2000 gebied.
Secundaire iconen	-Luciushof -Mural in thema Romeinen	-Kasteel Terworm (picknick in Kasteeltuin op reservering) -Weltermolen -Loorenhof met Bakhuis	-Monument Lange Jan en Lange Lies -Begraafplaats Akerstraat: graven van belangrijke personen Mijntijd	-Aambos	-Carbon 6 gebouw -Aambos -Relimarkt in Hoensbroek

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		-Auberge de Rousch (kloosterhoeve) restaurant+hotel -D'r Kueb va Hehle: standbeeld van Heerlensen soldaat in het leger van Napoleon(1883)	-Technische school: Mijnschool/ambachtsschool (Burg. De Heselleplein) -Escape Room Heerlen in thema Mijnen -Murals in thema mijnen ABP/APG tuin -Joodse Synagoge Heerlen: gedenkplaat zichtbaar. Gebouwd in 1936 ter vervanging van de te klein geworden synagoge aan het Wilhelminaplein. Uit een Keuls document (1270) blijkt dat er in de Middeleeuwen al Joden in Heerlen gevestigd waren. Joodse begraafplaats Akerstraat		-Brasserie de 2 gezusters bij de Luciushof -Koffiebranderij met rondleidingen -Woonboulevard -Hoeve de Aar -Kinderstad Heerlen
Ambassadeurs	Karen Jeneson (conservator Thermenmuseum) Elise (gids van Thermenmuseum) Museumdocenten van Romeins Kwartier Conservator RMO John vd Berg	Anne Rose Orbons (Historisch Goud) Bram de Groot (Gemeente Heerlen) Joep van Wijck (Gemeente Heerlen) Hilde Vanneste (Regioarcheoloog Parkstad)	Digitaal: demijnen.nl en heerlenvertelt.nl Frans Timmermans Sjeng Kremers Oud-koempels	Maurice Hermans Fiedel van der Heijden Michel Huisman Ton van Mastrigt Rob Heuperman	Michel Huisman Aart Zeeman Merlijn/Nina Jop Vermeesch Bart Temme Rianne/ Sanne Gijsbers Lars Ickenroth Raenys Martin Toon Hezemans Aline Ploeg Jeroen Arons

	Frits Kluitmans Walter Uithoven Hilde Vanneste (Regioarcheoloog Parkstad) Kathleen van den Branden				
Producten	-Voettocht door het Romeins Kwartier (wandeling 2,8 km) -Fietsen door het Romeins verleden (fietsroute 44,2 km) - Stadswandeling 2000 jaar Heerlen	-Rondleiding Schelmentoren met VVV gids (Bram de Groot en Winkbulle zijn in overleg) -Kastelenroute (fietsroute 35 km) - Stadswandeling 2000 jaar Heerlen -Bloesemtocht: Fruitlinten in het Geleenbeekdal Zuid (wandelroute 7 km)	-Mijnroute door Heerlen (Serge Langeweg Continium: Dag van de architectuur) -Wandeling met VVV gids -Groenroute (fietsroute 30 km) -Mijn fietsroutes M2015 (4 fietsroutes) -Stadswandeling 2000 jaar Heerlen		-Plattegrond Heerlen met stadsgeheimen -StreetArt plattegrond -Enne - StreetArtwandeling via Tickli - Maankwartierwandeling via VVV - Architectuurwandeling 1 t/m 4 (Schunck) - Architectuurfietsroutes 1t/m7 (Schunck) Geen knooppunten + enkele reis
Nieuwe producten		Sint Pancratius in het hart van Heerlen: M. van Waveren Hogervorst Kasteel Hoensbroek – Heemkundevereniging Hoensbroek Bokkenrijders in Zuid-Limburg en omstreken 1730-1748, deel 1: Rein	Het geluk van Limburg : Marcia Luyten De geur van kolen : Joep Dohmen Zwarte droom : Ivo Senden In en onder het dorp: Wiel Kusters Weet je nog, koempel – 19 magazines ook verschenen in boekvorm,	De Antistad: Maurice Hermans The post-industrials, de subculturen van	Maankwartier: Het wonder van Heerlen: Joos Philippens (verschijnt ~~25-08-2020~~) Treurtips: Mark van Wonderen Modernisme in Parkstad: Schunck publicatie Royal 1938 – 2008, de

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		van Lieshout Bokkenrijders in Zuid-Limburg en omstreken 1730-1748, deel 2: Rein van Lieshout In De Voetsporen Van De Bokkenrijders 15 rondwandelingen van het Bokkenrijdersgenootschap: Rob Hamers Suske en Wiske en de Bokkenrijders: Willy Vandersteen De bende van de Bokkenrijders: Ton van Reen (kinderboek) Kastelen in Limburg (1000 – 1800): W. Hupperetz	uitgeverij Waanders Ach, lieve tijd editie Oostelijke Mijnstreek – verschillende magazines, uitgeverij Waanders Limburg kolenland – samengesteld door SHCL Het dwaallichtje: Pieter Jan Rijken (kinderboek) Tien torens diep: Jacques Vriens (kinderboek) Oranje Nassau, een pionier in de Nederlandse steenkolenmijnbouw, 1893-1974 :Jan Peet Onder onze voeten: Evert van Ginkel Zwarte sneeuw: Simone van der Vlugt (kinderboek) Mijnwerkers in Limburg, een sociale geschiedenis: Ad Knotter	Heerlen en omstreken: div. auteurs (verschijnt voorjaar 2020)	fascinerende geschiedenis van Heerlens mooiste bioscoop: Ivo Senden

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Kerkrade

	Romeinse Tijd	Middeleeuwen	Mijntijd	Slooptijd	Nieuwe Tijd
Periode	753 voor Christus tot 476 na Christus	500 na Christus tot +/- 1500 Donkere Middeleeuwen: 400/1000 Late/hoge Middeleeuwen: 1000/1500 Vroeg Modern: 1500/1800	1900-1974 (officieel 1983/1986)	1965/1974-2000	Vanaf 2000
Geadviseerde namen	Romeins Knooppunt	Van Ridder naar Pruikentijd Land van Kastelen en Heerlijckheden Land van Burchten en Kastelen	Mijntijd		
Verhaal					
Primaire iconen	-Villa Krichelberg: Romeins villacomplex aan de Krichelstraat (QR-code scannen en dan verschijnt de reconstructie van de archeologische vindplaats)	-Abdij Rolduc (gesloten op dit moment) -Kasteel Erenstein	-Schacht Nulland -Botanische tuin - De Hopel: Mijnwerkerskolonie (Eygelshoven/Landgraaf/Kerkrade)		-Continium -Columbus -Cube -GaiaZoo -Halte ZLSM -Parkstad-Limburg Theater Leisure Dome: -Laser Game Kerkrade -VUE -Bowlo -Glowgolf Kerkrade -Parkstad Plaza

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					-Dartel dome -Gamestate -Soccer Arena -Space Jump -Happy Italy -Clip'n Ckimb Parkstad -Adrenaline Xperience
Secundaire iconen			-Standbeeld d'r Joep (Mijnwerkersmonument) -Mijnmonument: Mijnlamp in Terwinselen		Park Gravenrode: natuurgebied op voormalig mijngebied op grens Kerkrade en Landgraaf
Ambassadeurs			Digitaal: demijnen.nl en heerlenvertelt.nl Frans Timmermans Sjeng Kremers Oud-koempels		
Producten		-Grensroute (fietsroute 36 km) -Wandeling 3: Erenstein Route, Langs oude hoeves en kastelen (6 km) Ook Duitstalig! -Hertog Limburgpad (lange afstandswandeling 139 km	-Mijnroute door Kerkrade (Serge Langeweg Continium: dag van de Architectuur) -Mijn fietsroutes M2015 (4 fietsroutes) -Wandeling 5: In de voetsporen van het Carboon (12 km) Ook Duitstalig! -Wandeling 7: Van steenberg naar steenberg (14 km) Ook Duitstalig!		

		start bij Abdij Rolduc)	-Route 8: Route voor rolstoelers (9km) Ook Duitstalig!		

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Landgraaf

	Romeinse Tijd	Middeleeuwen	Mijntijd	Slooptijd	Nieuwe tijd
Periode	753 voor Christus tot 476 na Christus	500 na Christus tot +/- 1500 Donkere Middeleeuwen: 400/1000 Late/hoge Middeleeuwen: 1000/1500 Vroeg Modern: 1500/1800	1900-1974 (officieel 1983/1986)	1965/1974-2000	Vanaf 2000
Geadviseerde namen	Romeins Knooppunt	Van Ridder naar Pruikentijd Land van Boeren, Ridders & Rovers	Mijntijd		
Verhaal	Er waren 3 Romeinse nederzettingen in Zuid-Limburg: Maastricht-Heerlen-Rimburg In Rimburg zijn resten gevonden van een Romeins straatdorp. Hier werkten allerlei ambachtslieden.		Rond de eeuwwisseling van de 20ste en 21ste eeuw zorgde de mijnbouw voor enorme veranderingen binnen het huidige Landgraaf. In de voormalige gemeente Schaesberg werd eerst de particuliere mijn Oranje Nassau II in exploitatie genomen en enkele jaren later de oudste Staatsmijn Wilhelmina.		
Primaire iconen		-Slot Schaesberg (Bokkerijderskelder)	-Wilhelminaberg - De Hopel: Mijnwerkerskolonie (Eygelshoven/Landgraaf/Kerkrade)	- Megaland (1995) terrein	-SnowWorld -Adventure Valley (klimpark)

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		-Beschermd dorpsgezicht Rimburg -Kasteel Strijthagen ArtLand	-Lauradorp: Mijnwerkerskolonie	is voormalige steenberg van de Oranje Nassau ll Pinkpop sinds 1988	-Adventure Trail (2019!Gratis! Langs het klimpark en vertelt je de geschiedenis over het mijnverleden van de Wilhelminaberg) -Mondo Verde: gebouwd op een steenberg van een voormalige kolenmijn - Brunssummerheide: natuurgebied (Brunssum, Heerlen en Landgraaf) Natura 2000 gebied.
Secundaire iconen		-Landgoed Overste Hof (nu hotel) Vroeger boerderij, oudste delen uit 1749 - Natuurgebied Strijthagen	-Watertoren in Rimburg		-Minli: schaatsbaan + indoor camping tijdens Pinkpop + VVV servicepunt -Theater Landgraaf - Park Gravenrode: natuurgebied op voormalig mijngebied op grens Kerkrade en Landgraaf

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					- Oefenbunker
Ambassadeurs		Tim Vaessen (gemeente Landgraaf)	Digitaal: demijnen.nl en heerlenvertelt.nl Sjeng Kremers Oud-koempels	Jan Smeets	Jan Smeets
Producten	-Via Belgica: de helft van Romeins Rimburg ligt nu op Duits grondgebied. In de Romeinse tijd was de brug geen grensovergang. Nu het begin van de Via Belgica. - Watertorenlandgraaf (wandelroute 10 km) -Rimburg en over de grens (wandelroute 11 km)	-Park Gravenrode (wandelroute 10 km) - Watertorenlandgraaf (wandelroute 10 km) -Rimburg en over de grens (wandelroute 11 km) - Kastelenroute (fietsroute 35 km) -Grensroute (fietsroute 36 km)	-Watertorenlandgraaf (wandelroute 10km) -Groenroute (fietsroute 30 km)		-MTB-route Parkstad Landgraaf door Strijthagerbeekdal

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Brunssum

	Romeinse Tijd	Middeleeuwen	Mijntijd	Nieuwe tijd
Periode	753 voor Christus tot 476 na Christus		1900-1974 (officieel 1983/1986)	
Geadviseerde namen	Romeins Knooppunt		Mijntijd	
Verhaal			Tot het begin van de 20e eeuw was Brunssum een gehucht en leefden de bewoners voornamelijk van de landbouw. Na de oprichting van de staatsmijnen nam het aantal inwoners door vestiging van arbeiders uit andere delen van Nederland en gastarbeiders uit Zuid-Europa en Noord-Afrika snel toe. Brunssum werd een belangrijk centrum voor steen- en bruinkoolwinning. Ook werd in de nabijheid van Brunssum zilverzand afgegraven. Voor Brunssum was in het bijzonder de staatsmijn Hendrik (1915 - 1963 / 1973), die de meeste Nederlandse mijnwerkers benodigde, het kloppend hart	

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			van stedelijke ontwikkeling. De Hendrik had de diepste mijn van Nederland. Schacht IV had een diepte van 1.058 meter Voormalig mijnterrein van Staatsmijn Hendrik heeft een nieuwe functie gekregen: NAVO/NATO (hoe een kolenmijn een kazerne werd)	
Primaire iconen		-Clemensdomein(Rijksmonument): Oude Clemenskerkje Lourdesgrot *Grafmonument van de baron de Negri* *Stukje oude kloostermuur*	-Schutterspark	Schutterspark: -Blotevoetenpad -Park het Plateau 4 klimroutes: Wilhelmina, Hendrik, Emma en Maurits + steunpunt van Cycle Center Valkenburg) -Schutterhuuske -Pompgebouw -Speeltuin -Kinderboerderij -MiniHaven Schutterspark -Stoombaan Limburg Resort Brunssummerheide: natuurzwembad-Brunssummerheide: natuurgebied (Brunssum, Heerlen en Landgraaf) Natura 2000 gebied.

Secundaire iconen	- Brunssummerheide: klei van de Brunssummerheide was geschikt voor industriële doeleinden. Er ontstond een keramische industrie. Handel tot in Duitsland en Frankrijk		-Beeld Koelpiet (d'r Huub) van Sjef Drummen -Origineel schachtwiel bij voormalige hoofdingang van de Hendrik	-Yaka-Art: Beeldentuin en workshops beeldhouwen - Openluchttheater in het Vijverpark
Ambassadeurs			Digitaal: demijnen.nl en heerlenvertelt.nl Sjeng Kremers Oud-koempels	-Golfclub Brunssummerheide
Producten			Groenroute (fietsroute 30 km) 'Mijn' Geschiedeins in Brunssum: wandel- en fietsroute met tijdvensters!) Mijn fietsroutes M2015 (4 fietsroutes)	

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Voerendaal

	Romeinse Tijd	Middeleeuwen	Mijntijd	Nieuwe tijd
Periode	753 voor Christus tot 476 na Christus	500 na Christus tot +/- 1500 Donkere Middeleeuwen: 400/1000 Late/hoge Middeleeuwen: 1000/1500 Vroeg Modern: 1500/1800	1900-1974 (officieel 1983/1986)	
Geadviseerde namen	Romeins Knooppunt Coriovallum	Van Ridder naar Pruikentijd Land van Boeren, Ridders & Rovers Land van Kastelen en Heerlijckheden Land van Burchten en Kastelen	Mijntijd	
Verhaal	Talrijke archeologische vondsten in dit gebied. Sommige behoren tot de belangrijkste in Nederland. Rijke boeren genoten toen al van het glooiende landschap en de vruchtbare bodem die hen alles gaf wat ze nodig hadden. In ruil voor het graan dat ze hier teelden, bouwden ze omvangrijke villa's en vonden rijkdommen uit heel het Romeinse Rijk hun weg naar dit gebied.		Voerendaal was een belangrijk gebied in de steenkolenwinning vanwege de hoge kwaliteit van de steenkool. Groot deel van de inwoners was werkzaam in de mijn.	
Primaire iconen	Kunradersteengroeve: bouwproduct kalk werd al door de Romeinen toegepast Villa de Proosdij	Kunradersteengroeve (rondleidingen voor groepen)		-Wijngoed Fromberg in Ubachsberg (hoogst gelegen wijngaard

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	Heilige Remigius Kerk Klimmen (voormalige Romeinse wachttoren + hoogste punt van Klimmen)			van Nederland) -Wijngaard Kruisboom in klimmen - Kersenbedrijf Jo en Monica Schaepkens met kersenpluktu in in Klimmen -Landgoed Overst Voerendaal (wijngaard)
Secundaire iconen	Romeinse Villa Voerendaal-Ten Hove (alleen informatiebord, doorsnede staat in Thermenmuseum)	Bernardushoeve	Voormalige mijnkolonie aan Laurentiusplein	
Ambassadeurs	Jasper Habets (Villa de Proosdij) Mark Hermans (Land van Kalk) Pastoor Crutzen	Bas Vervuurt (Kunradersteengroeve)	Digitaal: demijnen.nl en heerlenvertelt.nl Sjeng Kremers Oud-koempels	
Producten	Via Belgica Fietsen door het Romeins verleden (fietsroute 44,2 km)	Kastelenroute (fietsroute 35 km) Ridder Kunoroute: Voerendaal-Aken-Voerendaal (wandelroute 45,8 km)		

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Simpelveld

	Romeinse Tijd	Middeleeuwen	Mijntijd	Nieuwe tijd
Periode	753 voor Christus tot 476 na Christus	500 na Christus tot +/- 1500 Donkere Middeleeuwen: 400/1000 Late/hoge Middeleeuwen: 1000/1500 Vroeg Modern: 1500/1800	1900-1974 (officieel 1983/1986)	
Geadviseerde namen	Romeins Knooppunt	Van Ridder naar Pruikentijd Land van Boeren, Ridders & Rovers Land van Kastelen en Heerlijckheden Land van Burchten en Kastelen	Mijntijd	
Verhaal	Talrijke archeologische vondsten in dit gebied. Sommige behoren tot de belangrijkste in Nederland. Rijke boeren genoten toen al van het glooiende landschap en de vruchtbare bodem die hen alles gaf wat ze nodig hadden. In ruil voor het graan dat ze hier teelden, bouwden ze omvangrijke villa's en vonden rijkdommen uit heel het Romeinse Rijk hun weg naar dit gebied.	Simpelveld is ontstaan in de vroege middeleeuwen als voorzetting van Romeinse bewoning Naam van 1140 tot 14e eeuw: Simplevei	-Miljoenenlijn, spoorlijn die in 1934 is aangelegd voor het transport van steenkool uit de mijnen. De aanleg van de spoorlijn leidde tot groei van Simpelveld	

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	Romeins naam: Simploviacun of Sempervivetum			
Primaire iconen	REPLICA: De sarcofaag van Simpelveld: bijzonder omdat binnenkant in reliëf is gebeeldhouwd. Deze kist was graf van rijke vrouw	-Museum de schat van Simpelveld	-ZLSM (aansluiting op het kolenspoor van de Aachen-Maastrichter Eisenbahn)	
Secundaire iconen	-Weg die leidde naar Heerlen (Coriovallum) en naar de Romeinse Villa's in Bocholtz. -Romeins keldertje bij Scholtissenhof(geen lid meer)-(Via Belgica) Expositie in Bocholtz: Romeins verleden uit eigen bodem (april t/m oktober alleen op zondag) Via Belgica Nog controleren: Hoogstamfruit	-halte van ZLSM (bij Scholtissenhof = geen lid meer) in Bocholtz	-Koeltoren van voormalige brikettenfabriek. De grondstof werd verkregen van de Domaniale Mijn in Kerkade. Bijzonder: de toren is vierkant i.p.v. rond. -Gasstation van Limagas uit 1937 Historisch monument op markt voor het gemeentehuis	
Ambassadeurs			Digitaal: demijnen.nl en heerlenvertelt.nl Sjeng Kremers Oud-koempels	
Producten	Via Belgica Vlengendaalroute, sporen in de Romeinse Vallei (Bocholtz: wandelroute 5 km) Romeinse hoogtepunten in Simpelveld (wandelroute 8,5km) Het Romeinse landschap in	Mergellandroute	Mergellandroute	-Mergellandroute -Koe-knuffelen in Simpelveld (Land van Kalk)

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	Bocholtz (wandelroute 14 km) Wandelen met ezels door de Romeinse Vallei (Hof Krichelberg) Mergellandroute Fietsen door het Romeins verleden (fietsroute 44,2 km) Geocache: Slenteren door de Romeinse Vallei Wandelen in Simpelveld-Bocholtz (Slenteren door de Romeinse Vallei 4 km)			
Evenementen	Sempervivetum: 2-daags Romeins festival in Bocholtz (volgende editie: zomer 2020) Nationale Romeinenweek: 25 april t/m 3 mei 2020 Nationale Archeologiedagen 9 t/m 11 oktober 2020			

Beekdaelen

Onderbanken: Schinveld , Merkelbeek, Bingelrade en Jabeek

Nuth: Nuth, Hulsberg, Schimmert, Wijnandsrade en Vaesrade

Schinnen: Amstenrade, Doenrade, Oirsbeek, Puth, Schinnen en Sweikhuizen

	Romeinse Tijd	Middeleeuwen	Mijntijd	Slooptijd	Nieuwe Tijd
Periode	753 voor Christus tot 476 na Christus	500 na Christus tot +/- 1500 Donkere Middeleeuwen: 400/1000 Late/hoge Middeleeuwen: 1000/1500 Vroeg Modern: 1500/1800	1900-1974 (officieel 1983/1986)	1965/1974-2000	Vanaf 2000
Geadviseerde namen	Romeins Knooppunt	Van Ridder naar Pruikentijd Land van Kastelen en Heerlijckheden Land van Burchten en Kastelen	Mijntijd		
Verhaal					
Primaire iconen	- Archeologisch rustpunt Steenland (provinciale weg tussen Schimmert en Arensgenhout)	-Alfa Bierbrouwerij start in 1870. Joseph Meens breidt zijn boerenbedrijf uit met een kleine bierbrouwerij. 1925 Mijnbouw brengt welvaart, heeft invloed op drinkgewoonten van de Limburgers en brouwerijen doen goede zaken. -Schinveldse bossen: schansen en	-Nonke Buusjke (openluchtmuseum in de Schinveldse Bossen) - Canisiusstroop fabriek, start in 1903 (rondleidingen mogelijk) Schinnen -De Eerste Limburgse Zweefvliegclub (opgericht in 1934 en sinds 1970 in		-Beukenberg in Oirsbeek: uitkijkpunt met schitterend panorama, 115 meter boven NAP. (van afvalberg tot natuur uitkijkpunt) populair in wielersport gemiddelde hellingsgraad 3,1% -Alfa Bierbrouwerij: start van 5e generatie

		motten (sage van de Witte Juffer) -Bokkenrijders (Schinnen wordt gezien als één van de centra van deze georganiseerde bende) -Kasteel Terborgh (Huis van Schinnen) aan de voorzijde ligt de watermolen Terborgh of Borgermolen. Rijksmonument. Gelegen in het dal van de Geleenbeek. Hier werden Bokkenrijders gevangen gezet, gemarteld en veroordeeld. -Fabritiushuis Wolfhagen: Bokkenrijders -Kasteel Etzenrade: Middeleeuws kasteel in de gemeente Onderbanken. De historische grachten van het kasteel zijn gereconstrueerd. Archeologische vondsten hebben een prominente plek gekregen en worden vertoond. Terstraten: beschermd dorpsgezicht	Schinveld gevestigd) -Alfa Bierbrouwerij start in 1870. Joseph Meens breidt zijn boerenbedrijf uit met een kleine bierbrouwerij. 1925 Mijnbouw brengt welvaart, heeft invloed op drinkgewoonten van de Limburgers en brouwerijen doen goede zaken.		-Corio-Glana: ontwikkeling Geleenbeekdal

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Secundaire iconen	-Plateau van Doenrade: oude Romeinse handelsweg	-Kasteel Doenrade (nu hotel en restaurant) -Kasteel Wijnandsrade + motte met Lourdeskapel: bezichtiging mogelijk. Brasserie kasteel Wijnandsrade. Wijnmakerij van Wijndomein Stokhem is gevestigd in kasteel. -Kasteel Amstenrade: rondleidingen op aanvraag. Engelse landschapspark (top 10 van Nederland) is open voor publiek. -Boerderij- en Heemkundemuseum schimmert: lid? 2020 gesloten	-Mulderplas: voormalige slikvijver van de Staatsmijn Emma en Staatsmijn Hendrik. In dit moeras werd het afvalwater van beide mijnen geloosd. -Feldbissbreuk: plek waar aardkorsten bij elkaar komen. Ontstane hoogteverschillen zijn duidelijk herkenbaar in het landschap. Aardkundig erfgoed speelt een rol bij Limburgse aardbevingen en in de Limburgse Mijnbouw. -Plinthos: voormalige steenfabriek met unieke ringoven in het natuurgebied Danikerbos (Schinnen) -Mariakapel (mariapark) in Schinnen:sinds 1999 rijksmonument. Kapel staat op de top van de met bomen begroeide heuvel. Bereikbaar via trappartij.		-Reus van Schimmert: eten en drinken van zover je kan kijken: open in 2020? -Kunstwerk Bovenmeer: kunstwerk op uitzicht heuvel -Paarden-sportevenementen: ruiter en menroutes + maneges

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			-Watertoren van Schimmert (bijnaam: De Reus van Schimmert) Rijksmonument. 38 meter hoge watertoren.		
Ambassadeurs					
Producten		-Wandel + fietsroute: langs schansen en motten -Wandelkaart Roode Beek -Schitterend Schinnen -Nuth heeft het! -In het spoor van de Bokkenrijders	-Mijnspoorpad: wandelpad ontwikkeld in het kader van het jaar van de Mijnen 2015. 8 mijnspoorbanken en een reuzenmijnlamp. Middels een drukknop hoor je kinderstemmen die over het Mijnverleden vertellen.		De Beekdaelenroute, in 2020 wordt gewerkt aan deze fietsroute van 53 km.

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ANNEX 3 - DATA from Vestigingenregister Limburg (VRL)

These data[21] are sourced from the Vestigingenregister Limburg (VRL):

SBI CODE	OMSCHRIJVING	SECTOR
5530	Kampeerterreinen	Logies-, maaltijd- en drankverstrekking
5590	Overige logiesverstrekking	Logies-, maaltijd- en drankverstrekking
5630	Cafés	Logies-, maaltijd- en drankverstrekking
5914	Bioscopen	Informatie en communicatie
9103	Monumentenzorg	Cultuur, sport en recreatie
9604	Sauna's, solaria, baden e.d.	Overige dienstverlening
55101	Hotel-restaurants	Logies-, maaltijd- en drankverstrekking
55102	Hotels (geen hotel-restaurants), pensions en confer.-oorden	Logies-, maaltijd- en drankverstrekking
55201	Verhuur van vakantiehuisjes en appartementen	Logies-, maaltijd- en drankverstrekking
55202	Jeugdherbergen en vakantiekampen	Logies-, maaltijd- en drankverstrekking
56101	Restaurants	Logies-, maaltijd- en drankverstrekking
56102	Cafetaria's, lunchrooms, snackbars, eetkramen e.d.	Logies-, maaltijd- en drankverstrekking
85521	Dansscholen	Onderwijs
85522	Kunstzinnige vorming van amateurs (geen dansscholen)	Onderwijs
90041	Theaters en schouwburgen	Cultuur, sport en recreatie
90042	Evenementenhallen	Cultuur, sport en recreatie
91011	Openbare bibliotheken	Cultuur, sport en recreatie
91012	Kunstuitleencentra	Cultuur, sport en recreatie
91019	Overige culturele uitleencentra en openbare archieven	Cultuur, sport en recreatie
91021	Musea	Cultuur, sport en recreatie
91022	Kunstgalerieën en -expositieruimten	Cultuur, sport en recreatie
91041	Dieren- en plantentuinen, kinderboerderijen	Cultuur, sport en recreatie
91042	Natuurbehoud	Cultuur, sport en recreatie

[21] The provided data are to be used only for the requested Be.CULTOUR purpose, user conditions of Etil.

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92001	Loterijen en kansspelen (geen amusementsautomaten)	Cultuur, sport en recreatie
92009	Exploitatie van amusements- en speelautomaten	Cultuur, sport en recreatie
93211	Pret- en themaparken	Cultuur, sport en recreatie
93291	Jachthavens	Cultuur, sport en recreatie
93299	Overige recreatie n.e.g.(geen jachthavens)	Cultuur, sport en recreatie
94911	Religieuze organisaties	Overige dienstverlening

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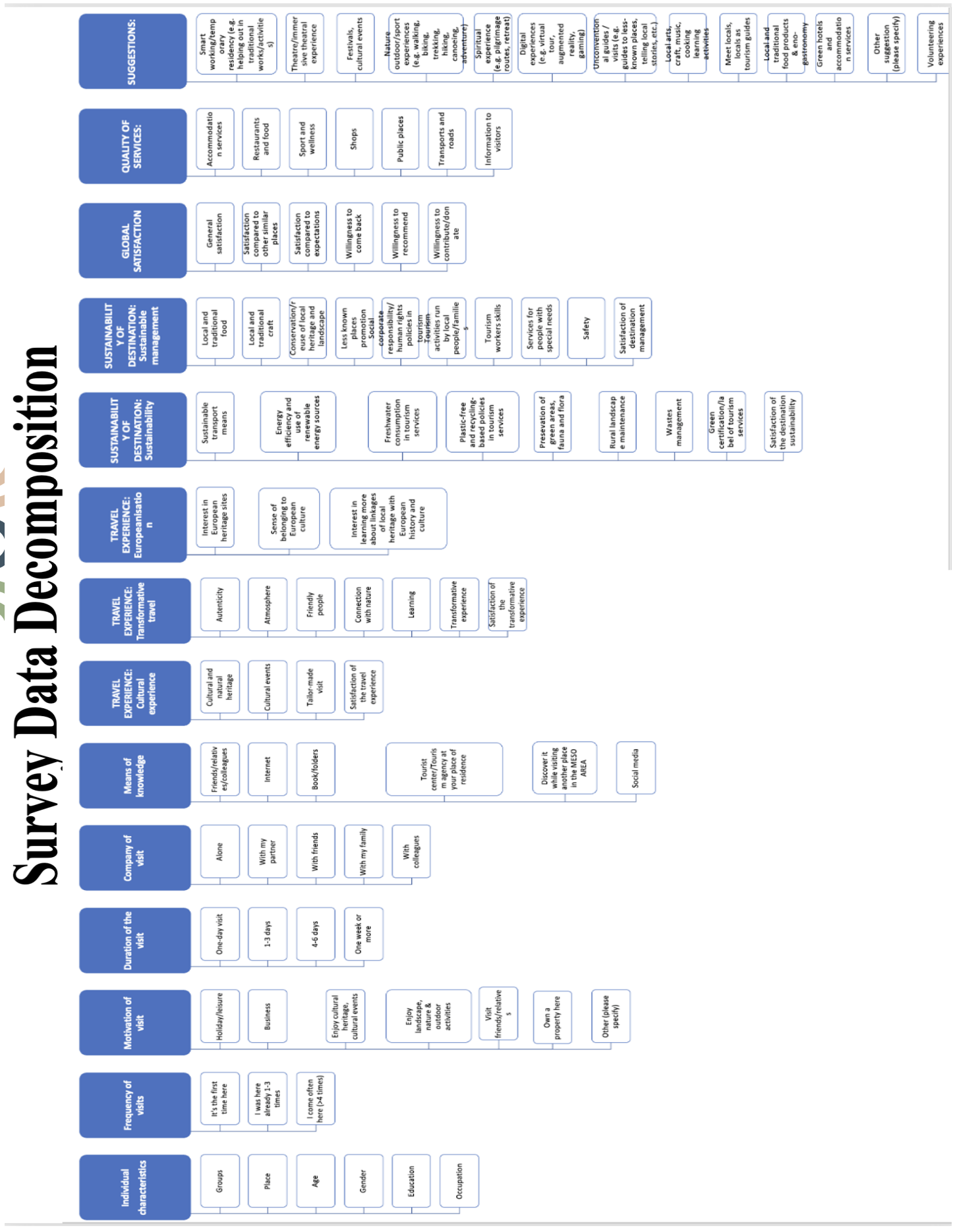

Survey Data Decomposition
Individual characteristics
Groups
Place
Age
Gender
Education
Occupation
Frequency of visits
It's the first time here
I was here already 1-3 times
I come often here (>4 times)
Motivation of visit
Holiday/leisure
Business
Enjoy cultural heritage, cultural events
Enjoy landscape, nature & outdoor activities
Visit friends/relatives
Own a property here
Other (please specify)
Duration of the visit
One-day visit
1-3 days
4-6 days
One week or more
Company of visit
Alone
With my partner
With friends
With my family
With colleagues
Means of knowledge
Friends/relatives/colleagues
Internet
Book/folders
Tourist center/Tourism agency at your place of residence
Discover it while visiting another place in the MESO AREA
Social media
TRAVEL EXPERIENCE: Cultural experience
Cultural and natural heritage
Cultural events
Tailor-made visit
Satisfaction of the travel experience
TRAVEL EXPERIENCE: Transformative travel
Autenticity
Atmosphere
Friendly people
Connection with nature
Learning
Transformative experience
Satisfaction of the transformative experience
TRAVEL EXPERIENCE: Europeanisation
Interest in European heritage sites
Sense of belonging to European culture
Interest in learning more about linkages of local heritage with European history and culture
SUSTAINABILITY OF DESTINATION: Sustainability
Sustainable transport means
Energy efficiency and use of renewable energy sources
Freshwater consumption in tourism services
Plastic-free and recycling-based policies in tourism services
Presevation of green areas, fauna and flora
Rural landscape maintenance
Wastes management
Green certification/label of tourism services
Satisfaction of the destination sustainability
SUSTAINABILITY OF DESTINATION: Sustainable management
Local and traditional food
Local and traditional craft
Conservation/reuse of local heritage and landscape
Less known places promotion
Social corporate responsibility/human rights policies in tourism
Tourism activities run by local people/families
Tourism workers skills
Services for people with special needs
Safety
Satisfaction of destination management
GLOBAL SATISFACTION
General satisfaction
Satisfaction compared to other similar places
Satisfaction compared to expectations
Willingness to come back
Willingness to recommend
Willingness to contribute/donate
QUALITY OF SERVICES:
Accommodation services
Restaurants and food
Sport and wellness
Shops
Public places
Transports and roads
Information to visitors
SUGGESTIONS:
Smart working/temporary residency (e.g. helping out in traditional works/activities)
Theatre/immersive theatral experience
Festivals, cultural events
Nature outdoor/sport experiences (e.g. walking, biking, trekking, hiking, canoeing, adventure)
Spiritual experience (e.g. pilgrimage routes, retreat)
Digital experiences (e.g. virtual tour, augmented reality, gaming)
Unconventional guides / visits (e.g. guides to less-known places, telling local stories, etc.)
Local arts, craft, music, cooking learning activities
Meet locals, locals as tourism guides
Local and traditional food products & eno-gastronomy
Green hotels and accommodation services
Other suggestion (please specify)
Volunteering experiences

Q-Analysis

CULTURAL TOURISM, URBAN SUSTAINABILITY AND VISITORS' APPRECIATION FOR HERITAGE SITES IN EUROPE – APPLICATION OF Q-ANALYSIS

Travel experience and sustainability of Destination Area

Table 1. Average evaluation of travel experience and sustainability of destination area

Sets	Travel Experience and Sustainability of Destination	Average	Deviation
Experience	Cultural and natural heritage	2,24	0,96
	Cultural events	1,66	1,06
	Tailor-made visit	1,75	1,06
	Satisfaction of the travel experience	1,94	1,03
Transformative	Autenticity	1,72	1,03
	Atmosphere	2,02	0,98
	Friendly people	1,22	1,35
	Connection with nature	1,71	1,08
	Learning	1,72	1,03
	Transformative experience	1,30	1,12
	Satisfaction of the transformative experience	1,70	1,02
EU View	Interest in European heritage sites	1,52	1,13
	Sense of belonging to European culture	1,03	1,15
	Interest in learning more about linkages of local heritage with EU history	1,64	1,11
Environmenntal Sustainability	Sustainable transport means	0,18	1,50
	Energy efficiency and use of renewable energy sources	0,61	1,23
	Freshwater consumption in tourism services	0,49	1,12
	Plastic-free and recycling-based policies in tourism services	0,68	1,25
	Presevation of green areas, fauna and flora	1,24	1,11
	Rural landscape maintenance	1,12	1,13
	Wastes management	0,69	1,33
	Green certification/label of tourism services	0,44	1,10
	Satisfaction of the destination sustainability	0,94	1,09
Managerial Sustainability	Local and traditional food	1,49	1,15
	Local and traditional craft	1,37	1,15
	Conservation/reuse of local heritage and landscape	1,29	1,12
	Less known places promotion	1,24	1,14
	Social corporate responsibility/human rights policies in tourism activities	0,87	1,13
	Tourism activities run by local people/families	1,49	1,07
	Tourism workers skills	1,63	1,04
	Services for people with special needs	0,69	1,24
	Safety	1,87	1,08
	Satisfaction of destination management	1,40	1,10
Satisfaction	General satisfaction	1,88	0,98
	Satisfaction compared to other similar places	1,68	1,01
	Satisfaction compared to expectations	1,75	0,99
	Willingness to come back	1,95	1,07
	Willingness to recommend	2,17	0,98
	Willingness to contribute/donate	1,09	1,25
Quality	Accommodation services	1,31	1,08
	Restaurants and food	1,53	1,14
	Sport and wellness	1,07	1,06
	Shops	1,02	1,10
	Public places	1,31	1,06
	Transports and roads	0,75	1,42
	Information to visitors	1,21	1,20

ANNEX

- Table 1 summarizes evaluations from 840 responses, ranging from (-3 = Strongly Disagree) to (3 = Strongly Agree).
- Overall, positive ratings are observed for Cultural and Transformative Experience, with lower scores for environmental sustainability and quality, showing notable differences among respondents.

Empirical Results of Standard Q-Analysis

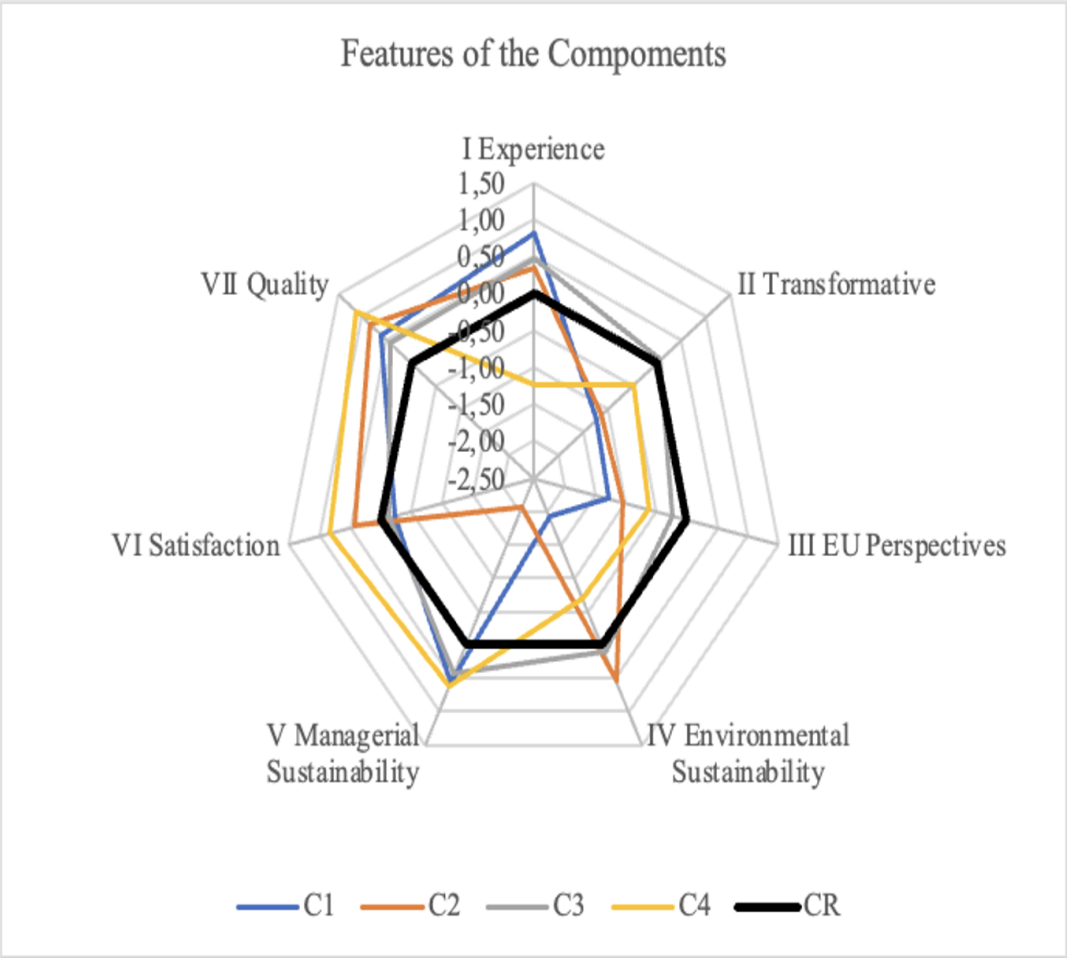


Figure 3. Features of the Components

- Basilicata: Component 1 favors Cultural Experience, Managerial Sustainability, and Quality but opposes others.
- Aragon and Karlsborg: Component 2 emphasizes Cultural Experience, Environmental Sustainability, Satisfaction, and Quality but criticizes others.
- Larnaka and Karlsborg: Component 3 maintains balance across all dimensions.
- Larnaka and Vojvodina: Component 4 values Quality, Satisfaction, and Managerial Sustainability but disregards others.

Table 2. Regression Results of the Component Scores on the Visited Places (with Romania-Moldova as the reference region)

R	R2	Z	Sig.	Intercept	Aragon	Basilicata	Larnaka	VGR Kar	VGR Mark	Vollvodin
,325[a]	,105	16,34	<,001	,266***	,064**	,153***	-,105***	-,072*	-,062*	-,012
,575	,331	68,66	<,001	,103***	,298***	,056***	-,001	,165***	,101	,004
,457	,209	36,70	<,001	,072***	,008	,069	,235***	,108***	,042	,009
,310a	,096	14,80	<,001	-,049**	056	043	187***	,037	-,005	,113***

mponent C1: Basilicata (Italy) emphasizes Cultural Experience, Managerial Sustainability, and Quality but rates other mensions lower.

mponent C2: Aragon (Spain) and Karlsborg (Sweden) prioritize Cultural Experience, Environmental Sustainability, tisfaction, and Quality, but score lower on other dimensions.

mponent C3: Larnaka (Cyprus) and Karlsborg (Sweden) offer balanced evaluations across all dimensions.

mponent C4: VGR Kar (Sweden) values Quality, Satisfaction, and Managerial Sustainability but scores lower on other mensions.

mmary, this analysis highlights visitor priorities across destinations, stressing the importance of aligning tourist experiences preferences for sustainable cultural tourism.

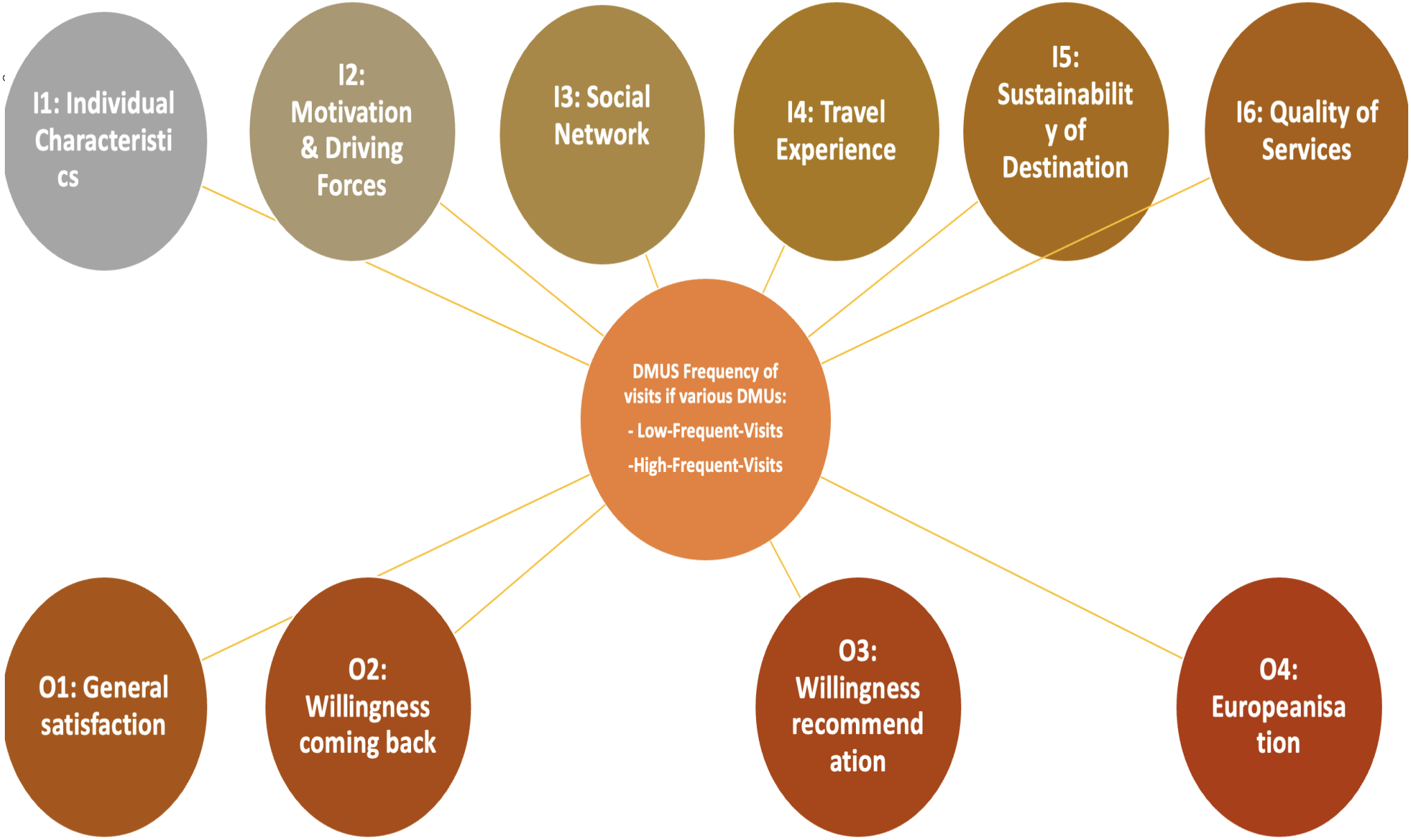
Main Conclusion

- The study highlights the nuanced preferences of visitors across different destinations, emphasizing the significance of understanding and justifying these attitudes by considering variations in cultural and natural contexts.
- Despite the presence of control variables, the study reveals that factors such as travel companions and destination proximity exert varying impacts on visitor attitudes, suggesting a complex interplay of influences.
- The research underscores the importance of balancing tourism services with the preservation of authenticity and place atmosphere for sustainable regional development, particularly emphasizing the potential of less-known and remote cultural heritage sites in contributing to cultural and eco-tourism destinations.

Data Envelopment Analysis

TRANSFORMATIVE CULTURAL TOURISM IN HERITAGE-LED REGIONS – A PERFORMANCE ASSESSMENT OF CULTURAL-ECOLOGICAL COMPLEXES BY MEANS OF CASCADIC DATA ENVELOPMENT ANALYSIS

EXAMPLE: Efficiency Options B1



Efficiency score and rank in the case of 6I-4O and 3I-3O in terms of 'visit frequent'.

Table 1. Efficiency score and rank in the case of 6I-4O and 3I-3O in terms of 'visit frequent'.

	Score		Rank	
DMU	Option-B1 (6I-4O)	Option-B2 (3I-3O)	Option-B1 (6I-4O)	Option-B2 (3I-3O)
Aragon-Low-Frequent-Visits	1.030	1.029	5	3
Aragon-High-Frequent-Visits	1.117	1.015	2	4
Basilicata-Low-Frequent-Visits	0.978	0.958	14	11
Basilicata-High-Frequent-Visits	1.029	0.981	7	8
Romania-Moldova-Low-Frequent-Visits	1.030	0.941	6	13
Romania-Moldova-High-Frequent-Visits	1.073	0.939	3	14
Larnaca-Low-Frequent-Visits	1.000	0.998	13	5
Larnaca-High-Frequent-Visits	1.017	0.965	10	10
Karlsborg-Low-Frequent-Visits	1.071	1.039	4	2
Karlsborg-High-Frequent-Visits	1.029	0.994	8	6
Mark-Low-Frequent-Visits	1.393	1.393	1	1
Mark-High-Frequent-Visits	1.016	0.950	11	12
Vojvodina-Low-Frequent-Visits	1.028	0.991	9	7
Vojvodina-High-Frequent-Visits	1.002	0.966	12	9

EXAMPLE: Efficiency score in the case of 6I-4O and 3I-3O in terms of 'visit frequent'

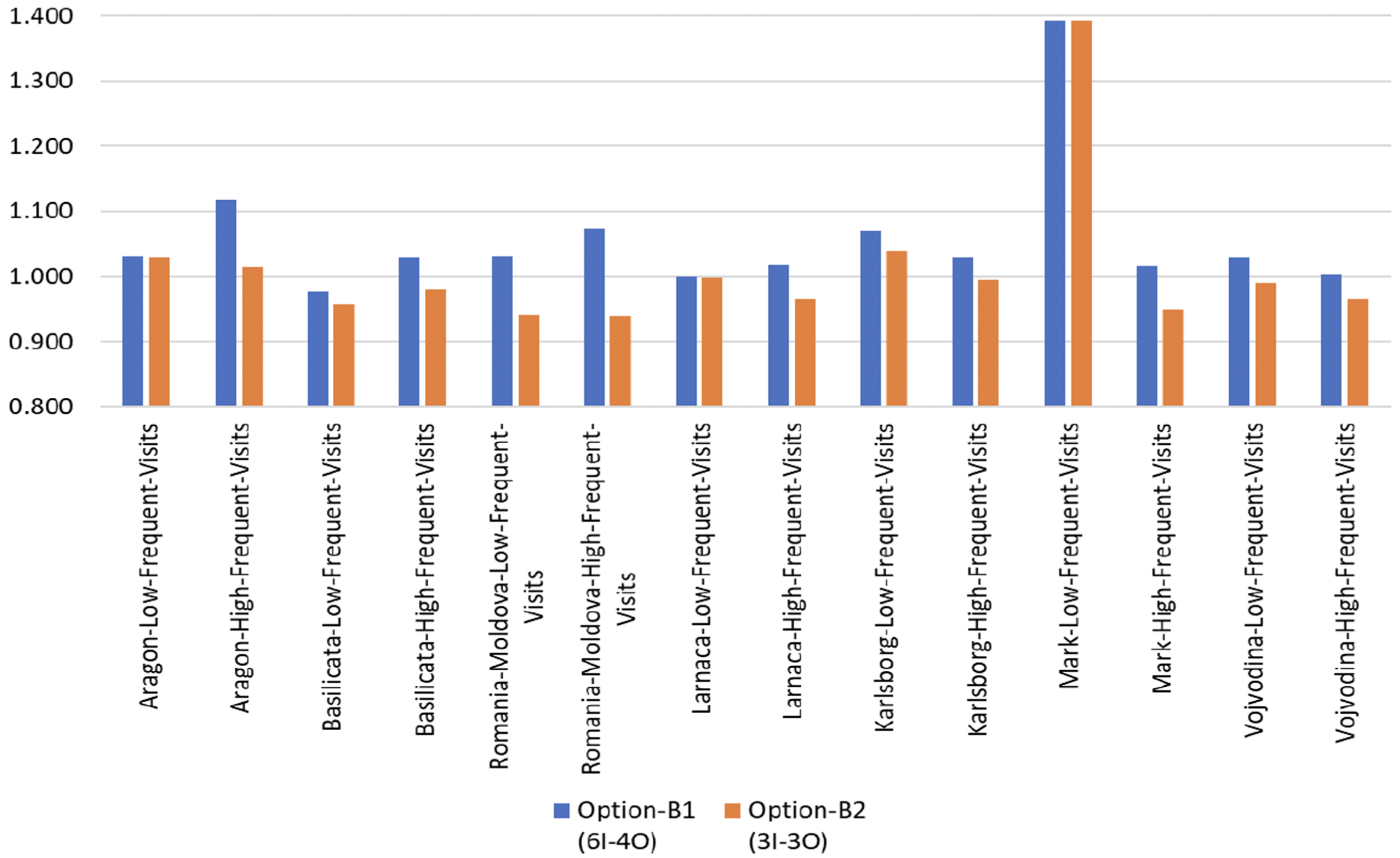
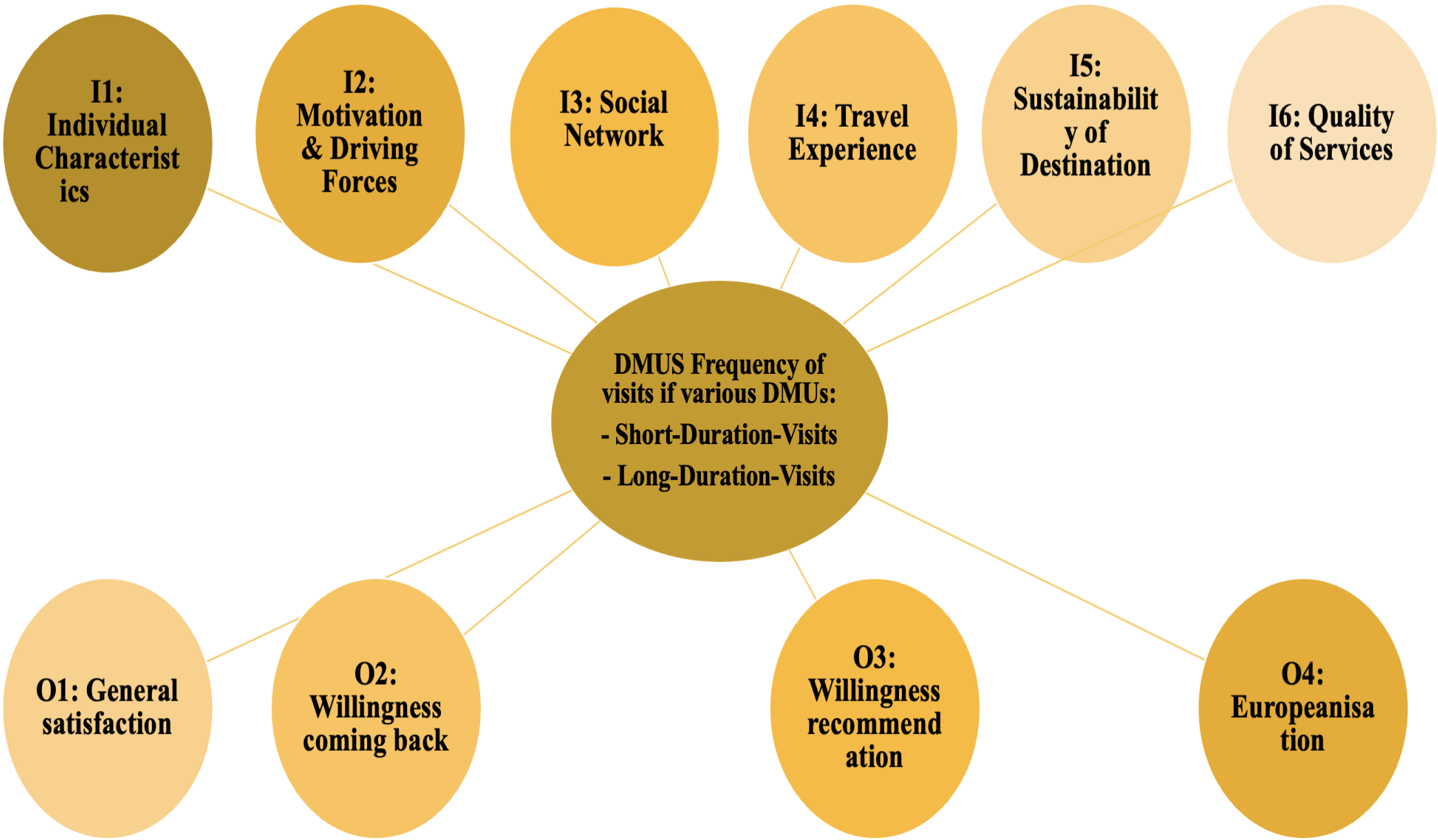


Figure 1. Efficiency score in the case of 6I-4O and 3I-3O in terms of 'visit frequent'.

EXAMPLE: Efficiency Options C1



EXAMPLE: Efficiency score and rank in the case of 6I-4O and 3I-3O in terms of 'visit duration'

Table 2. Efficiency score and rank in the case of 6I-4O and 3I-3O in terms of 'visit duration'.

	Score		Rank	
DMU	Option-C1 (6I-4O)	Option-C2 (3I-3O)	Option-C1 (6I-4O)	Option-C2 (3I-3O)
Aragon-short-Duration-Visits	1.048	1.042	8	3
Aragon-Long-Duration-Visits	1.070	0.993	6	6
Basilicata-short-Duration-Visits	0.991	0.972	14	8
Basilicata-Long-Duration-Visits	1.069	0.960	7	11
Romania-Moldova-short-Duration-Visits	1.071	0.920	5	14
Romania-Moldova-Long-Duration-Visits	1.087	0.921	3	13
Larnaca-short-Duration-Visits	1.004	0.967	12	9
Larnaca-Long-Duration-Visits	1.022	0.980	11	7
Karlsborg-short-Duration-Visits	1.078	1.011	4	5
Karlsborg-Long-Duration-Visits	1.031	1.031	9	4
Mark-short-Duration-Visits	1.334	1.334	1	1
Mark-Long-Duration-Visits	1.211	1.196	2	2
Vojvodina-short-Duration-Visits	1.004	0.956	13	12
Vojvodina-Long-Duration-Visits	1.024	0.963	10	10

EXAMPLE: Efficiency score in the case of 6I-4O and 3I-3O in terms of 'visit duration'.

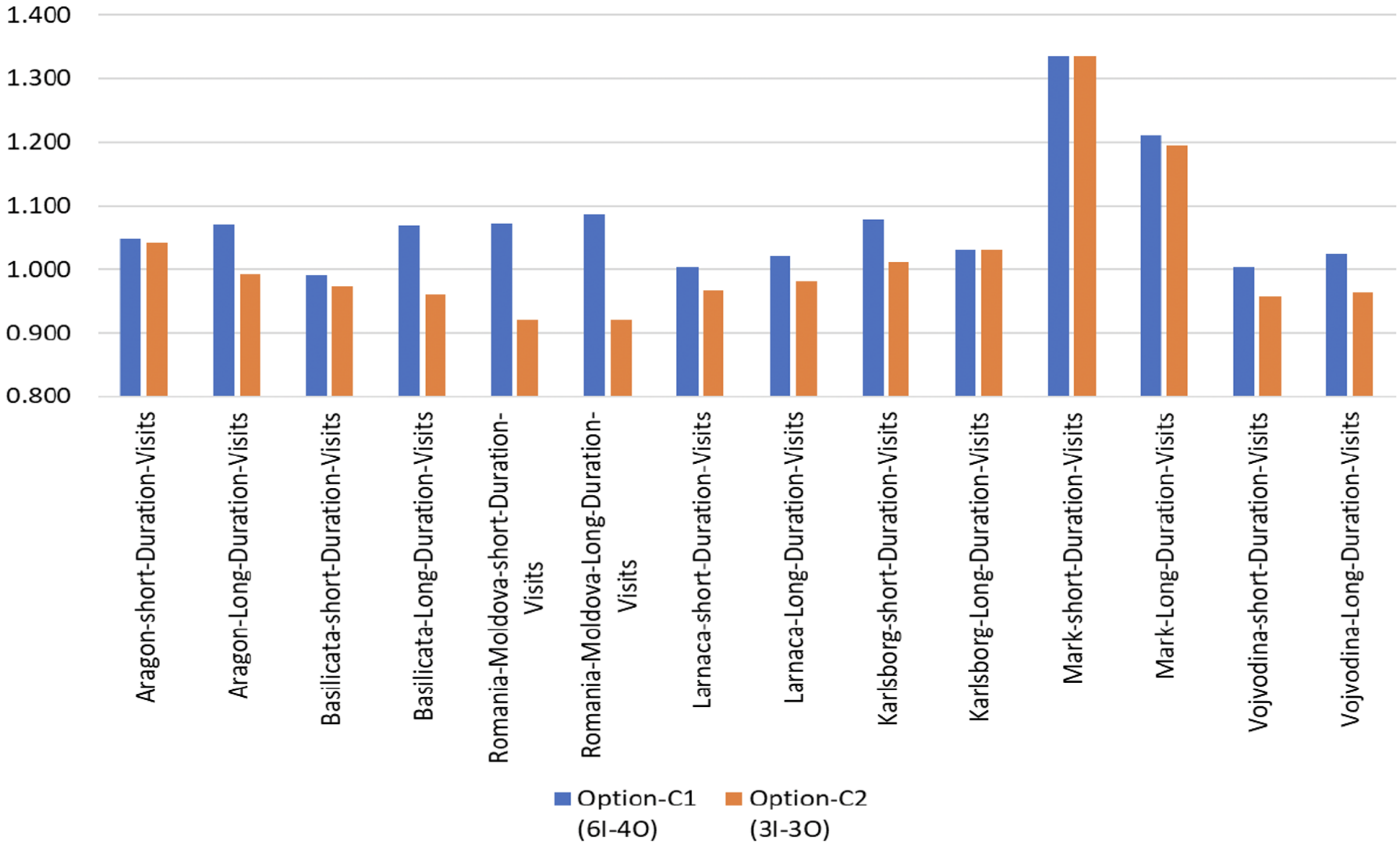


Figure 2. Efficiency score in the case of 6I-4O and 3I-3O in terms of 'visit duration'.

First Conclusions

- The analysis highlights DMU 'Mark' as a potential champion region due to its super efficiency and highest scores across various scenarios, indicating strong performance in terms of visit frequency and duration.
- However, DMU 'Mark-High-Frequent-Visits' shows lower performance and rank in both 6I-4O and 3I-3O situations, suggesting a need for improvement in attracting repeat visitors.
- Analysis of Option D, involving 28 DMU cases, reveals significant difficulties, particularly highlighted by irregular and infeasible results, such as the case of 'Karlsborg-Low-Frequent-Visits + Long-Duration Visits', warranting its elimination.
- Recommendations suggest utilizing Option B1, B2, C1, and C2 cases due to the interesting implications they offer from the results (**WORK IN PROGRESS**).

From Q Analysis and DEA to Digital Twin

- Transitioning Analysis Methods:

  Moving beyond Q Analysis and DEA towards Digital Twin technology.

- Digital Twin Advantages:

  1. Real-time monitoring.
  2. Predictive analytics.
  3. Optimization capabilities.

Shifting to Digital Twin enhances analysis depth and decision-making for improved operational efficiency and performance!

ANNEX 5 - Webinar 9 - 15 March 2024 10:00 - 11:30 CET

Smart data management for circular cultural tourism assessment and monitoring

Smart data management for circular cultural tourism assessment and monitoring

To reach sustainability and circularity goals, cultural destinations need effective data management tools.

In this webinar, a set of innovative smart data management and monitoring tools will be shared, towards better governance and assessment of the smart/circular destination. In particular, cultural heritage digitalisation can support circular cultural tourism destination managers and operators to manage and assess tourist flows, interest and appreciation in heritage sites integrating digital tools such as 3D visualization and Digital Twin in a human-centred and people-centred perspective.

Agenda:

10:00 - 10:05 Welcome and introduction

10:05 - 10:15 Peter Nijkamp and Karima Kourtit | Digital tools for Circular Cultural Tourism

10:15 - 10:35 Henk Scholten | The Governance of Digitally-transformed Society

10:35 - 10:55 Yneke van Iersel | Methodology and Application of 3D Visualization in Sustainable Cultural Tourism Planning

10:55 - 11:15 Maurice de Kleijn | A Digital Twin of the Via Appia Antica

11:15 - 11:30 Q&A and concluding remarks

Q&A

- 'Digital tools for Circular Cultural Tourism':

Question: What are some examples of the key performance indicators (KPIs) used in your database, and how do you collect the data to measure them?

- 'The Governance of Digitally-transformed Society':

Question: How does the use of digital twins contribute to improving decision-making processes in cultural tourism management?

- 'Methodology and Application of Digital Twinning and 3D Visualization in Sustainable Cultural Tourism Planning':

Question: How do you integrate historical, political, and cultural time frames into the digital twin model, and what challenges do you face in representing these complexities?

- 'A Digital Twin of the Via Appia Antica':

Question: What were some of the artistic and archaeological insights gained from integrating digital twinning technology with historical imagery and interactive experiences?

Concluding remarks

- The development of multidimensional assessment models and open-source data infrastructures provides a solid foundation for sustainable tourism planning, ensuring comprehensive insights into cultural tourism impacts.

- Digital tools, particularly digital twinning, show opportunities in enhancing cultural heritage management for circular tourism by offering innovative solutions for assessment, management, and preservation.

- Integration of historical storytelling and interactive experiences not only enriches tourist experiences but also fosters engagement with local communities and stakeholders.

- Stakeholders can employ real-time insights, predictive analytics, and engaging storytelling to create more inclusive, resilient, and community-supported tourism destinations, thus enhancing the overall tourism experience.