EU CONEXUS ENABLES

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Framework for knowledge transfer

D2.1 Specific challenges identification and comprehensive work plan

EU-CONEXUS ENABLES

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Acronyms

Acronym	Full Form
FredU	Frederick University
UTCB	Technical University of Civil Engineering Bucharest
UROS	University of Rostock
UNIZD	University of Zadar
SETU	South East Technological University
LRUniv	La Rochelle Université
UCV	Catholic University of Valencia
KU	Klaipeda University
AUA	Agricultural University of Athens

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1. Abstract

The EU-CONEXUS ENABLES project focuses on the integration of digital twin technologies to enhance Smart Urban Coastal Sustainability (SmUCS). This initiative targets urban coastal areas, recognizing their unique socio-economic and environmental challenges. The project emphasizes the necessity of forming a multidisciplinary workgroup to identify and address these challenges through innovative and sustainable solutions.
Deliverable 2.1 of the EU-CONEXUS ENABLES project involved a comprehensive assessment of the current and potential applications of digital twin technologies across all partner institutions. The primary objective was to identify unique challenges and requirements within each partner's domain, with a particular emphasis on SmUCS. This task aimed to gather a diverse team of experts capable of developing integrated, challenge-based topics to advance SmUCS goals.
The outcomes of Deliverable 2.1 include the following key elements:

- Comprehensive review of challenges – a detailed inventory of challenges specific to SmUCS was created. This inventory provides a nuanced understanding of the multifaceted issues faced by urban coastal environments, facilitating targeted interventions.
- Establishment of specialized sub-workgroups - sub-workgroups and task forces were formed, each equipped with defined objectives and strategic frameworks tailored to effectively address the identified challenges. These sub-workgroups bring together experts from various fields to foster collaborative and innovative solutions.
- Foundation document - this deliverable serves as a foundational document encapsulating the findings and strategic plans developed throughout Deliverable 2.1. It provides essential guidance for informing and guiding subsequent project activities, ensuring a structured and systematic approach to addressing urban coastal sustainability.

By addressing specific challenges within SmUCS and establishing specialized sub-workgroups, Deliverable 2.1 lays the groundwork for advancing sustainable solutions in urban coastal environments. The integration of digital twin technologies plays a pivotal role in this endeavour, offering real-time data insights, predictive analytics, and simulation capabilities to optimize the design, construction, and maintenance of coastal infrastructure.

1. Introduction

Smart Urban Coastal Sustainability (SmUCS) means for EU-CONEXUS to focus its education, research & innovation, and knowledge-sharing activities on defining, understanding and addressing societal challenges that are experienced by communities from urban and semi-urbanised coastal regions (rivers, seas and oceans) [1].
Smart Urban Coastal Sustainability (SmUCS) is not a subject-driven thematic framework, but a challenge-driven education and research domain. Coastal environments are interfaces between inland areas and marine offshore parts where social and economic activities interact with highly valuable and unique coastal ecosystems. Socio-economic activities along our coasts have a direct and indirect connectivity and impact on these ecosystems through the provision of goods and services. The functioning and evolution of urban coastal societies and environments in the context of climate change and increasing anthropogenic pressure are major challenges that are addressed in the framework of Smart Urban Coastal Sustainability. By providing sustainable, smart, nature-based solutions, EU-CONEXUS can achieve key sustainability goals, reduce the impact on the coastal ecosystems, respond to present challenges and anticipate future ones.

Examples for domains for research and education as covered in the Joint Research Institutes are:

- Coastal governance and coastal engineering (cultural heritage, ecological justice, fisheries policy, understanding of coastal uses, on-/off-shore renewable energy – construction and operation of facilities, legislation…)
- Coastal ecosystems with its social and natural components and stakeholders (defence of biodiversity, improvement of water quality, water resources management, sustainable tourism, logistics, water lifecycle, SMEs, circular economy…)
- Wellbeing of coastal communities and improvement of the quality of life (civic education and awareness of naturally available resources, prevention of physical and mental diseases, healthy habits …).

The partners involved in this project share overlapping research interests, thus facilitating, and encouraging the exchange of insights related to the deployment of digital twins across various research fields. This mutual exchange is both feasible and desirable within the context of the project.

The primary objective of this report is to document the findings and strategic plans developed in Task 2.1 of the EU-CONEXUS ENABLES project. Task 2.1 focused on forming a multidisciplinary workgroup to identify integrated challenge-based topics, facilitating a comprehensive assessment of the current and potential applications of digital twin technologies across various fields of study represented by the project partners.
Task 2.1 involved a detailed evaluation of the unique challenges and requirements inherent in each partner's domain, with a particular focus on SmUCS. This assessment aimed to gather a diverse team of experts capable of developing integrated, challenge-based topics to advance SmUCS goals. The outcomes of Task 2.1 are expected to lay the groundwork for addressing critical issues and advancing sustainable solutions in urban coastal environments.
The key areas of focus involved:

- Identification of Challenges: A comprehensive enumeration of challenges specific to SmUCS was conducted. This involved creating a detailed inventory of issues faced by urban coastal environments, providing a nuanced understanding of the multifaceted problems these areas encounter.
- Formation of Specialized Sub-workgroups: Specialized sub-workgroups and task forces were established, each with defined objectives and strategic frameworks tailored to effectively address the identified challenges. These sub-workgroups bring together experts

from various fields to foster collaborative and innovative solutions.
- Creation of a Foundational Document: This report serves as a foundational document encapsulating the findings and strategic plans developed throughout Task 2.1. It provides essential guidance for informing and guiding subsequent project activities, ensuring a structured and systematic approach to addressing urban coastal sustainability.

The report is structured as follows:
- Theoretical Background: An overview of digital twin technologies, their components, and functionalities, and their applications in various sectors, particularly in coastal environments.
- Methodology: A detailed description of the methodological approach used to assess digital twin applications in SmUCS, including data collection, stakeholder engagement, and scenario planning.
- Identification of Challenges: A comprehensive analysis of the challenges identified across different domains such as buildings and infrastructure, agriculture, and life sciences.
- Selection of Experts and Team Formation: The process of selecting experts and forming multidisciplinary teams to address the identified challenges.
- Conclusions: Summarizing the key findings and outlining the next steps for advancing SmUCS objectives through the application of digital twin technologies.

By addressing the specific challenges within SmUCS and establishing specialized sub-workgroups, the EU-CONEXUS ENABLES project aims to advance sustainable solutions in urban coastal environments. This report provides a detailed account of these efforts, setting the stage for future research, innovation, and knowledge-sharing activities focused on promoting excellence in Smart Urban Coastal Sustainability.

2. Theoretical background

2.1. Digital Twins

Digital twins are virtual replicas of physical systems, assets, or processes that utilize real-time data to mirror their real-world counterparts. These digital models integrate sensors, data analytics, and machine learning algorithms to create a dynamic representation that evolves with its physical twin. This technology provides a comprehensive view of a system's operational status, performance, and lifecycle, enabling predictive maintenance, optimization, and enhanced decision-making capabilities [2], [3].
A typical digital twin architecture consists of three main components: the physical entity, the virtual model, and the data connections between them. The physical entity is the real-world object or system being mirrored. The virtual model is the digital counterpart that represents the physical entity in a virtual space. Data connections are facilitated by sensors, IoT devices, and data integration platforms that enable continuous data flow between the physical and digital twins [4], [5].
Digital twins offer several core functionalities. Simulation allows virtual testing of scenarios without impacting the physical system, which is crucial for risk assessment and planning. Monitoring provides real-time insights into the system's operational status through continuous data updates. Predictive analysis uses machine learning algorithms to forecast potential issues and optimize performance. Visualization offers a graphical interface for interacting with and understanding the system's behaviour [6], [7].
Digital twins are employed across various sectors. In manufacturing, they are used for predictive maintenance, process optimization, and quality control. In healthcare, digital twins facilitate personalized medicine, patient monitoring, and surgical planning. In smart cities, they enhance urban planning, infrastructure management, and sustainability. In the energy sector, digital twins optimize the performance and efficiency of power plants and renewable energy sources [8], [9].

2.2. Coastal Applications

Digital twins play a pivotal role in optimizing the design, construction, and maintenance of coastal infrastructure, including buildings, piers, seawalls, and flood defences. By integrating real-time data, predictive analytics, and simulation capabilities, digital twins enable stakeholders to assess the performance of infrastructure assets, identify vulnerabilities, and implement proactive maintenance strategies [10], [11].
In the domain of buildings and infrastructure, digital twins facilitate the optimization of energy consumption and efficiency, especially in coastal regions where environmental considerations are paramount. By modelling energy flows, simulating alternative scenarios, and implementing predictive algorithms, digital twins help identify opportunities for energy savings, reduce carbon emissions, and enhance the sustainability of coastal developments [12], [13].
Digital twins are increasingly being utilized to enhance disaster preparedness and response efforts, particularly in coastal areas prone to extreme weather events and flooding. These digital models integrate real-time data from sensors, weather forecasts, and hydrological models to simulate and predict the impact of floods, enabling cities to anticipate flood events, manage reservoir levels proactively, and implement temporary flood defences. This real-time simulation capability is crucial for developing and refining evacuation plans, ensuring timely and effective responses to minimize damage and enhance safety. Additionally, digital twins aid in visualizing potential disaster impacts, which supports informed decision-making in urban planning and infrastructure development, thereby improving the overall resilience of coastal communities [14], [15].

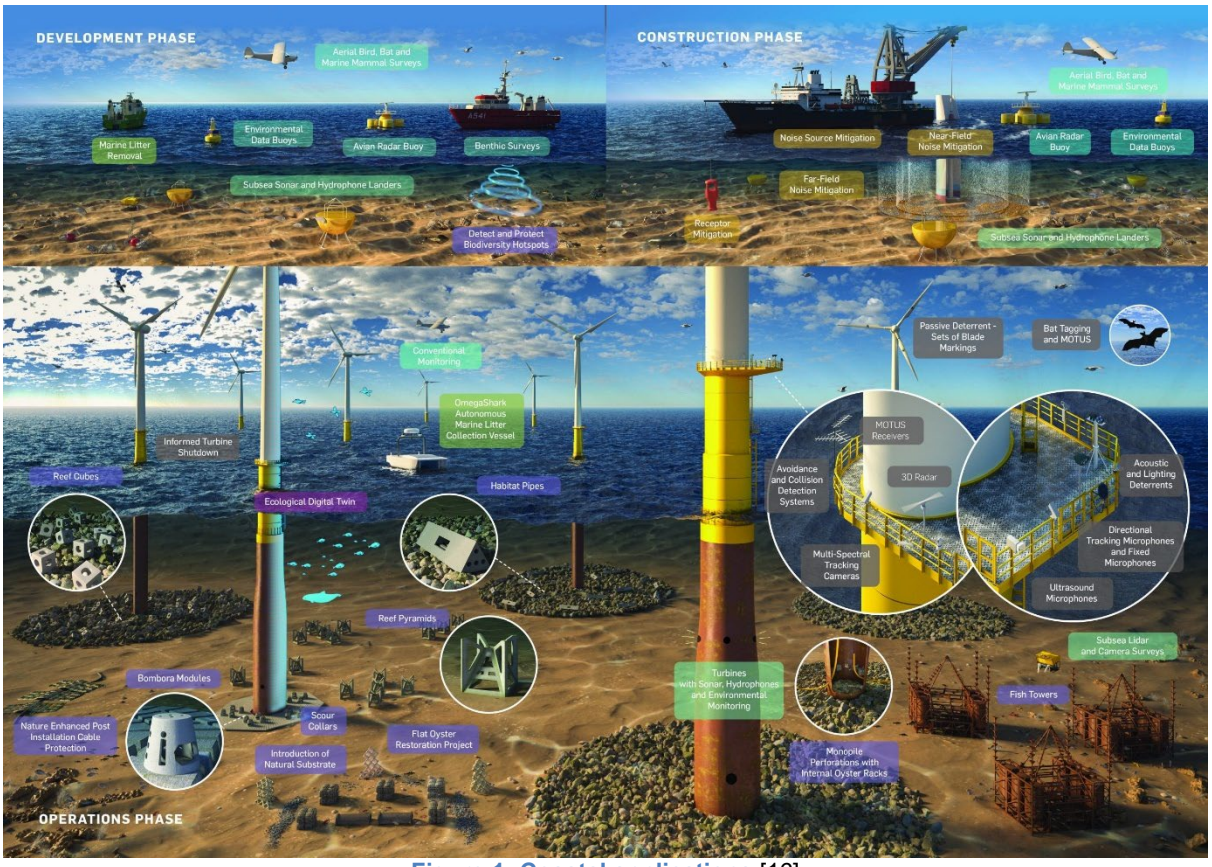

Figure 1: Coastal applications [16]

In the context of smart cities and urban coastal sustainability, digital twins support data-driven decision-making and holistic urban planning approaches. By integrating diverse datasets, including demographic trends, environmental parameters, and infrastructure assets, digital twins provide insights into urban dynamics, facilitate scenario modelling, and inform policies for sustainable growth and development. This is exemplified in the application of urban digital twins for the town of Herrenberg, Germany. The Herrenberg digital twin combines various urban data, including 3D models, street networks, mobility simulations, and environmental data. It is implemented in a visualization platform for virtual reality to support participatory and collaborative urban planning processes. This approach enhances the ability of urban planners, designers, and the public to engage in decision-making, ultimately promoting more sustainable and intelligent urban development [17].

Digital twins contribute to the resilience of coastal infrastructure by enabling adaptive planning, risk assessment, and scenario analysis. By simulating the impacts of climate change, sea-level rise, and extreme events, digital twins help stakeholders identify vulnerable areas, prioritize investments, and implement resilience measures to safeguard coastal assets and communities.

The concept of smart agriculture involves the use of information technologies, sensors, autonomous vehicles, data analytics, predictive modelling, and other digital technologies to enhance agricultural activities. It is argued that smart agriculture can significantly contribute to increased food security, reduced water consumption, reduced fertilizer and pesticide input, and increased farm profitability. However, the adoption rate of these technologies remains low and varies significantly by technology and geographical area [18].

In terms of health and medical applications it is highlight the critical need for integrating design thinking and specialized training into the development of complex medical devices. (Neil J. Rowan, 2024) emphasizes the importance of digital innovations and multi-actor collaborations, including academia, industry, healthcare, regulators, and society, to enhance the entire lifecycle of medical devices, from production to sustainability. The paper also addresses the gap between academic research and practical application in Artificial Intelligence /Machine Learning and Augmented Reality /Virtual Reality-enabled medical devices, underscoring the potential for significant advancements in the field [19].

3. Methodology

In the realm of coastal development and sustainability, the integration of digital twin technology stands as a pivotal frontier, offering innovative solutions to the complex challenges posed by coastal environments. As part of a comprehensive methodology aimed at elucidating the practical applications and challenges of digital twins in coastal settings, a detailed questionnaire approach was meticulously crafted and employed. The questionnaire was disseminated through work package members in EU-CONEXUS ENABLES partner universities. This methodological framework, comprising various structured sections, served as a robust tool for gathering insights from experts and stakeholders across diverse projects. By delving into the nuances of digital twin applications in coastal environments, examining related projects, profiling experts, and scrutinizing resources and infrastructure, this methodology aimed to unveil the multifaceted landscape of digital twin utilization.

Through open-ended inquiries and structured data collection, this approach sought to illuminate the specific challenges, benefits, and intricacies associated with leveraging digital twins in coastal contexts. Thus, this methodology served as a cornerstone for comprehensively understanding the role and potential of digital twins in fostering sustainability and resilience along coastal regions, paving the way for informed decision-making and future research endeavours in this vital domain. The respondents were required to provide insights across five key fields: digital twin applications in coastal environments, related projects, expert profiles, and resources and infrastructure, as follows:

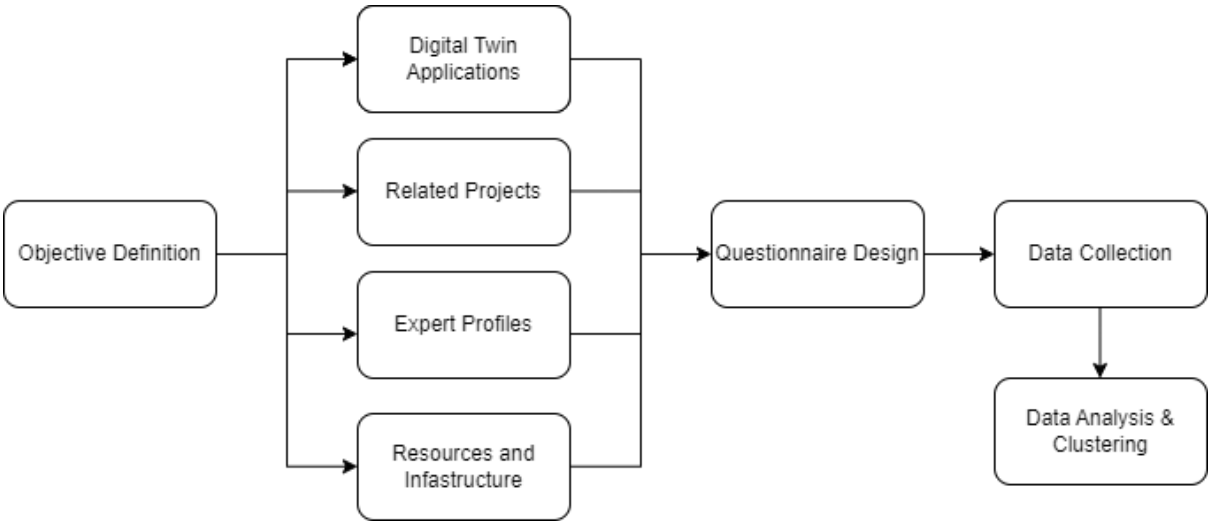

Figure 2: Methodology

The initial section of the questionnaire, titled “Digital Twin Applications in Coastal Environments - Related Field,” encompasses a table designed to capture specific elements

along with their corresponding descriptions. These elements include the specific application, which refers to the particular use case of the digital twin in the coastal environment. It also includes a detailed explanation of the role of the digital twin technology in the specific application. The relevance or connection of the specific application of the digital twin to the coastal environment is also captured. Lastly, the table outlines the advantages and potential difficulties or obstacles of using the digital twin in the specific application. This structured approach provides a comprehensive understanding of the application of digital twins in coastal environments, including their roles, relevance, benefits, and challenges, offering valuable insights for future research and development in this field.

In the context of “Digital Twin Applications in Coastal Environments”, a section of the questionnaire was dedicated to the gathering of information about related projects. This section required the respondents to provide the title of the project, a concise description of the project, and specific details about the application of digital twin technology within the project. This structured approach facilitated the systematic collection of data, providing valuable insights into the practical applications of digital twins in coastal environments. This information is crucial for understanding the current landscape of digital twin applications and identifying potential areas for future research.
A section was dedicated to collecting information about the experts. Respondents were requested to populate a table with specific details pertaining to each expert. The table was structured to capture the expert’s name, their institutional affiliation, area of expertise, role in the project, and contact information. This approach facilitated a systematic and comprehensive collection of expert-related data.
The questionnaire incorporated a section titled “Resources and Infrastructure,” which was structured as a table. This table was designed to capture four critical components, each accompanied by a corresponding description. These components included available technologies, required tools, data sources, and logistical needs. This structured approach facilitated a comprehensive and systematic collection of data, providing valuable insights into the resources and infrastructure applicable to the projects. This information clarifies the current landscape of resources and infrastructure and identifying potential areas for future research and development.
Aside the data collection using the developed questionnaire, several meetings with the EU-CONEXUS Joint Research Institutes’(JRIs) representatives (scientific managers or the coordinators) took place, to identify research topics and directions selected as priorities in the past activities of each JRIs. Key objectives and targets of EU-CONEXUS ENABLES project were presented to the representatives of the JRIs. Them and the WP2 core group brainstormed on other possible challenges.
The coordinators and the research managers were asked to correlate JRIs challenges and to propose experts for the thematic clusters and work groups.

4. Identification of challenges

4.1. Buildings and Infrastructure

Within this thematic cluster, various projects are dedicated to harnessing digital twin technology to enhance the energy efficiency, minimize environmental impact, and reinforce operational effectiveness of buildings and infrastructure within coastal regions. Notable initiatives undertaken by the partners underscore the pivotal role of digital twins in simulating and optimizing the sustainability and resilience of coastal edifices, urban infrastructures, and governance frameworks. These activities prioritize crucial facets such as augmenting energy efficiency, curtailing carbon emissions, and tackling the multifaceted challenges associated with coastal hazards, structural performance of buildings, and the dynamics of urban expansion.
The partners involved in this cluster include experts from UTCB, SETU, FredU, LRUniv, and KU. Each of these institutions brings unique expertise and perspectives to the table, contributing to a comprehensive approach in the development and application of digital twin technologies. These collaborations focus on projects that span various aspects of building and infrastructure management, from energy systems and structural integrity to urban planning and environmental sustainability. The collective efforts aim to create innovative solutions that not only improve the operational efficiency of coastal buildings and infrastructure but also enhance their resilience against environmental challenges.

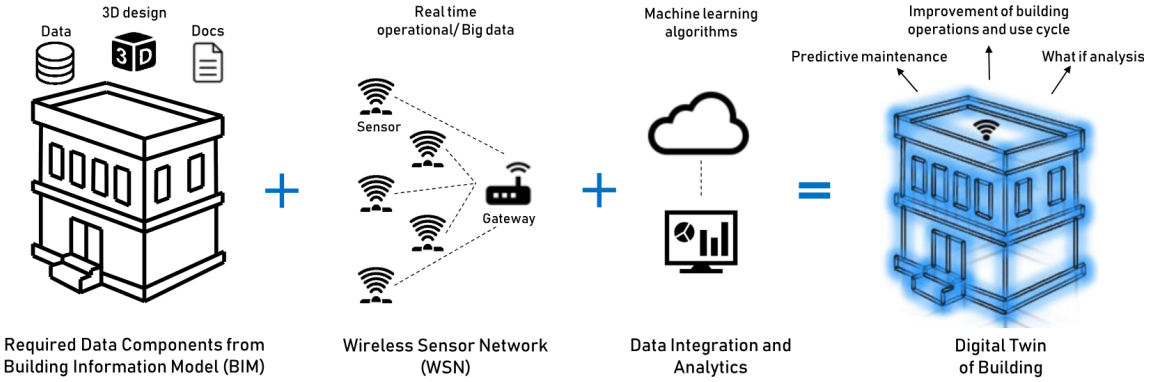

Figure 3: Essential components to create a digital twin of building and difference with BIM [20]

Buildings and Infrastructure challenges provided by FredU

The SmartLivingEPC project revolutionizes the energy performance certification by embracing digitization and integrating digital twins for buildings and their technical systems. This initiative extends the Building Information Modelling (BIM) framework to include detailed simulations of buildings' operational behaviours and technical systems, facilitating a comprehensive assessment of energy efficiency and sustainability. By incorporating a new rating scale, SmartLivingEPC evaluates life cycle performance, building smartness, and the real-world performance of building technical systems through technical audits. The project also broadens its scope to address water usage, noise pollution, and acoustics, ensuring compatibility with digital logbooks and renovation passports for seamless data integration into digital platforms. Focused on both individual buildings and complexes, SmartLivingEPC aims to pioneer energy certification at the neighbourhood level, employing an integrated, participatory approach. This collaborative effort, spanning 36 months with 16 partners from 12 European countries, sets the stage for new standards in smart energy performance certificates, emphasizing the digital twin's role in monitoring and improving the operational performance of buildings.
The challenges include the complexity of incorporating dynamic coastal environmental data

into the model, the necessity to guarantee data precision, and the need for advanced algorithms to manage extensive datasets. These challenges involve the detailed process of integrating fluctuating coastal environmental data into the model, ensuring the correctness of the data, and the demand for intricate algorithms to process large volumes of data.
These challenges can be addressed by using the appropriate tools, data sources and their respective logistics for optimal operation. Key tools include advanced analytics software, machine learning for predictive analytics and energy optimization, integration platforms for BIM, digital twins, IoT data streams, smart sensors, and big data management solutions. Utilized databases are enriched by BIM libraries, sustainability benchmarks, IoT and smart sensor data repositories, and big data sets including environmental conditions, occupancy patterns, and energy grid analytics. Logistics require scalable cloud computing infrastructure, professional training programs for staff, and technical support for IoT devices, smart sensors, and monitoring systems.

Buildings and Infrastructure challenges provided by SETU

The smartSE initiative is a transformative project set to establish a cutting-edge smart city experimental facility, spanning 2000 square meters across three floors in the historic coastal city of Waterford, Ireland. Functioning as a living lab, smartSE will provide a dynamic platform for innovation, facilitating the creation, testing, and implementation of novel solutions aimed at advancing the strategic objectives of the city and fostering growth in key areas of regional specialization. Anchored in the principles of data-driven decision-making, co-creation, and cross-sector collaboration, smartSE will offer a range of resources and services, including an Innovation Imaginarium for startup incubation, a Smart City Experimental Sandbox for testing concepts, advanced Data Analytic Services, Capability Development programs, and a Data Platform for facilitating data trading and sharing. By harnessing the power of data and technology, smartSE aims to drive sustainable development, promote citizen engagement, and stimulate economic growth while addressing key challenges such as governance, data management, initial investment, and stakeholder engagement.
The governance and management of the facility is a critical aspect that requires attention, particularly when it comes to handling sensitive data. It is essential to have robust policies and procedures in place to ensure the security and confidentiality of such data, as well as to comply with relevant regulations and standards.
The volume of available data is another significant factor. Managing this data effectively and efficiently, and turning it into actionable insights, can be a challenging task.
The initial capital expenditure is a crucial consideration in the planning and execution of any project. It involves the allocation of funds for the acquisition of the facility, purchase of necessary equipment, and other startup costs. Proper budgeting and financial management are key to ensuring the project's financial viability and success.
Lastly, mobilizing the enterprise to engage with the facility is an important task. This involves encouraging and facilitating the active participation of all stakeholders, including employees, management, and external partners. Engagement can be fostered through clear communication, training, and the creation of a collaborative and inclusive environment. This not only ensures smooth operations but also contributes to the overall success of the facility.

Buildings and Infrastructure challenges provided by UTCB

The Technical University of Civil Engineering of Bucharest (UTCB) has contributed three projects in the realm of digital twins. These projects, namely "WeGenerate," and "ReGreeneration," focus on urban development and environmental sustainability. Through these initiatives, UTCB demonstrates its commitment to leveraging digital twin technologies for addressing complex urban challenges and promoting sustainable practices. The "National Competence Centre and solutions for the development of Climate Neutral and Smart Cities"

(NetZeRoCities) project envisions a groundbreaking approach to urban development, leveraging advanced digital twin technology as a cornerstone of its strategy. By creating digital replicas of urban environments, the project aims to revolutionize how cities are planned, managed, and optimized for sustainability. These digital twins serve as dynamic platforms that integrate data from diverse sources such as geoportals, open-source geospatial data, IoT sensors, Big Data analytics, and artificial intelligence, enabling real-time monitoring, modelling, and simulation of urban systems.

ReGreeneration is a Horizon project aimed at spearheading the transformation of cities into green, resilient, and socially inclusive urban spaces. Collaborating with four leading cities in Europe—Bucharest, Paris, Alverca, and Barcelona—the project pioneers the implementation of nature-based solutions across diverse urban landscapes. The primary objectives revolve around demonstrating the positive impact of these solutions in mitigating urban climate change while enhancing urban living conditions. With a strong emphasis on citizen engagement and long-term social compromise, ReGreeneration seeks to empower municipalities to work towards climate neutrality. Moreover, it aims to develop smart digital city models that enable visualization of current and future city-states, including climate change, social aspects, air quality, and pollution. The project involves a public-private consortium comprising nine European cities, deploying a diverse set of skills encompassing architecture, landscape design, geomatics, digital twins, project value modelling, urbanism, nature, and public space facilities, sociology, and economics. Each city's project is complementary and contributes to generating replicable knowledge on various urban challenges, such as neighbourhood regeneration, carbon capture, biodiversity preservation, and citizen participation. One notable aspect of the project involves leveraging urban digital twins to inform decision-making processes, particularly in implementing solar energy solutions and monitoring their performance in real-time. Through comprehensive analysis and integration of local climate resilience challenges, ReGreeneration aims to drive sustainable urban development across Europe. ReGreeneration: The next generation of green, resilient and socially inclusive smart cities

"WeGenerate" is a collaborative endeavour dedicated to fostering sustainable and inclusive urban regeneration processes, placing a strong emphasis on citizen participation and co-creation. The project aims to shift from traditional urban development approaches to one where cities, citizens, communities, businesses, researchers, and practitioners collectively shape sustainable, people-centric, accessible, and aesthetically pleasing neighbourhoods. By drawing upon the stories and experiences of four neighbourhoods located across Europe, the project endeavours to reinvent these communities, instilling new values and opportunities while addressing various urban challenges. WeGenerate employs a highly participatory process, engaging closely with city administrations, citizens, local communities, and businesses to identify the right ingredients and recipes for sustainable and inclusive urban regeneration. Advanced digital applications, including Digital Twins, Metaverse, and extended reality, will be utilized to support decision-making processes and stimulate citizen engagement. Moreover, expertise in Social Science and Humanities will be leveraged to foster social innovation and participatory actions throughout the project. Through this collaborative effort, WeGenerate seeks to realize four sustainable and people-centric neighbourhoods, with a legacy upheld through replication by five Fellow Cities and others inspired by the project's stories. The project's Digital Twin aspect involves the development of a real-time digital representation of the city centre, facilitating data-driven analysis to support the development of sustainable mobility chains and participatory planning processes. Additionally, the Digital Twin will play a key role in stimulating social equality and cognitive change through constant awareness workshops, ultimately contributing to the transferability and scalability of project results.
The task of handling and deciphering the enormous quantities of data generated from multiple

sources and sensors presents a technical hurdle, necessitating the deployment of sophisticated analytical tools. The establishment and continuous upkeep of digital twin technology necessitates a substantial financial commitment, which could serve as a deterrent for certain stakeholders due to its potentially prohibitive cost.
The process of incorporating digital twins into pre-existing building management systems and protocols is a multifaceted task. It often demands a high degree of customization and extensive technical assistance, adding another layer of complexity. This integration process is not a straightforward plug-and-play scenario, but rather a complex undertaking that requires a deep understanding of both the digital twin technology and the existing systems. This complexity could potentially lead to increased costs and extended timelines, further emphasizing the need for careful planning and skilled technical support.

Buildings and Infrastructure challenges provided by KU

The project “TechUPGRADE” at Klaipeda University focuses on developing a digital twin for a Thermochemical Heat Upgrade System. This digital twin serves as a comprehensive simulation model that represents the entire system, including components like heat exchangers, tanks, and pumps. By integrating these elements with thermodynamic parameters and specific design choices, the digital twin enables accurate analysis and evaluation of various application scenarios. This simulation capability ensures the system operates at maximum efficiency and effectiveness. In the context of coastal environments, the digital twin incorporates sustainable energy sources such as wind and wave energy, optimizing energy usage and enhancing sustainability. The digital twin will be instrumental in measuring thermophysical properties, developing robust control systems, and ensuring autonomous operation with minimal human intervention. Advanced technologies like artificial intelligence, data mining, and predictive control will be integrated into the digital twin software, facilitating high-resolution monitoring and rapid response to uncertainties. This implementation not only optimizes the thermochemical heat upgrade system but also aligns it with environmental sustainability goals, making it a vital tool for coastal applications.
One of the primary issues is the complexity of creating accurate simulations that can effectively represent all system components, such as heat exchangers, tanks, and pumps. Ensuring high-quality data is crucial for the reliability of these simulations, yet data quality issues frequently arise, complicating the integration of renewable energy sources like wind and wave energy. Additionally, there are uncertainties regarding the long-term environmental impacts of using digital twins in coastal contexts, which adds a layer of difficulty to their deployment. Regulatory hurdles also pose challenges, as compliance with environmental and safety standards must be meticulously maintained. Furthermore, the initial costs for developing and implementing these advanced digital systems are high, requiring substantial investment. The ongoing maintenance and the need for specialized technical expertise to operate and refine the digital twin systems add to the complexity.

Buildings and Infrastructure challenges provided by UROS

The NATURE-DEMO project aims to enhance sustainable infrastructure development by integrating advanced digital twin technologies, specifically within alpine areas, with a focus on methods transferable to coastal environments. The core intention of the project is to create accurate digital replicas of both built infrastructure and their natural surroundings using graph neural network (GNN) models. These digital twins facilitate better planning and management by automating the development and refinement of sustainable building designs and environmental models. By leveraging GNNs, the project seeks to capture complex causal relationships within the infrastructure and environmental systems, enabling more precise predictions and decision-making. The digital twins incorporate data from various sources, including remote sensing and high-precision 3D measurement systems, to monitor and

optimize operations, thus contributing to the sustainability and resilience of infrastructure against climate threats such as water stress, floods, and droughts.
Implementing digital twin technology within the NATURE-DEMO project involves several significant challenges. One primary challenge is automating the configuration of GNN models to accurately reflect the causal structures of real-world systems, as opposed to merely identifying correlations. This requires sophisticated methodologies for deriving semantic models from diverse data sources to ensure the digital twins are both accurate and useful. Another challenge is the integration of data from different sources into cohesive graph models, which is essential for effective behaviour predictions and actionable insights. Processing and managing large datasets necessitate advanced IT infrastructure and expertise, particularly in developing and deploying AI models. Additionally, the ongoing development and validation of the digital twins against real-world measurements require rigorous control measurements and continuous refinement, adding complexity and demanding a high level of precision and expertise. Addressing these challenges is crucial for leveraging the full potential of digital twin technology in promoting sustainable infrastructure development and environmental protection.

4.2. Agriculture

Within this thematic cluster, several projects are dedicated to leveraging digital twin technology to bolster sustainable agricultural practices, particularly within coastal regions. Initiatives spearheaded by partners are notable for their focus on cultivating digital twins tailored for agricultural purposes, encompassing water management, crop modelling, and environmental surveillance in Mediterranean coastal zones. Central objectives entail refining irrigation methodologies, reducing chemical inputs, and optimizing resource utilization to foster sustainable food cultivation and environmental conservation in coastal agriculture.
The partners involved in this cluster include UROS, UNIZD, SETU, AUA and LRUniv, each bringing valuable expertise and resources to the forefront of digital twin applications in agriculture. Together, these institutions collaborate on projects aimed at revolutionizing farming practices in coastal regions, emphasizing precision agriculture, resource efficiency, and environmental sustainability. By harnessing digital twin technology, these initiatives seek to address critical challenges faced by coastal farmers, such as water scarcity, soil degradation, and climate variability, while promoting innovation and resilience in agricultural systems.

Agriculture challenges provided by UROS

The LDAS-MV project in Mecklenburg Western Pomerania focuses on refining agricultural yield forecasts and managing the water cycle. Leveraging data assimilation techniques within a digital twin framework, it integrates land surface models, satellite remote sensing data, and near-seasonal weather predictions. This fusion allows for the accurate prediction of sub-daily surface conditions, facilitating informed decision-making for agricultural management practices and water resource allocation.
Furthermore, UROS is planning a project around genome-based crop modelling.

Agriculture challenges provided by UNIZD

The SAN (Smart Agriculture Network) project represents a pioneering endeavour aimed at revolutionizing agricultural practices, particularly in olive growing and viticulture within Mediterranean coastal regions. This comprehensive initiative integrates advanced technologies such as the Internet of Things (IoT) and artificial intelligence (AI) to create a sophisticated system for smart food production. Central to the SAN project is the deployment of digital twin technology, which creates virtual replicas of agricultural processes and

environments. These digital twins continuously collect real-time data from sensors and cameras monitoring various parameters like air and soil temperature, humidity, light intensity, photosynthesis, leaf humidity, soil chemical composition, and the presence of pests and diseases. By leveraging real-time data monitoring and analysis, the SAN project enables farmers to make timely and informed decisions throughout the agricultural process, from irrigation management to pest control. This approach aims to optimize resource utilization, enhance crop productivity, and minimize environmental impact, addressing key challenges faced by coastal farmers such as water scarcity, climate change, and sustainability concerns. Through collaboration and innovation, the SAN project paves the way for a more efficient, resilient, and sustainable agricultural sector in coastal regions.
The implementation of digital twin technology within the SAN project faces several significant challenges. Setting up the infrastructure to handle vast amounts of data from various sources is a complex task that requires expert knowledge in IT. Processing, transferring, and manipulating this data necessitates advanced skills in data management and analytics. These tasks are technically demanding and time-consuming, underscoring the importance of having skilled IT professionals involved in the implementation and management of digital twin technology. Additionally, ensuring data accuracy and reliability is crucial, as the quality of data directly impacts decision-making and agricultural outcomes. The integration of diverse data sources, such as climatological datasets and images of harmful organisms, requires sophisticated AI models and seamless hardware-software interactions. Developing user-friendly interfaces for farmers and agronomists to interact with the digital twin system is also essential to facilitate easier and faster decision-making. Overcoming these challenges is critical to fully realize the potential benefits of digital twins in enhancing agricultural productivity and sustainability in the Mediterranean region.

The PESCAR (Pesticide Control and Reduction) project is a comprehensive initiative aimed at promoting sustainable agricultural practices by minimizing the use of pesticides in the Mediterranean coastal region, particularly in Zadar County. At the core of this project is the digital twin technology, which supports food producers in making faster and simpler decisions. The digital twin integrates real-time meteorological data, such as air and soil temperature, humidity, light intensity, and photosynthesis levels, to monitor the health and growth of crops. It also tracks the appearance and population density of harmful organisms, including fungal diseases and pests. This technology enables the provision of timely and accurate recommendations for pesticide use, optimizing irrigation, and improving overall agricultural practices. The PESCAR project not only aims to protect the environment and human health by reducing pesticide usage but also supports sustainable use of natural resources and enhances the resilience of agricultural systems to climate change. Through the project, a sustainable internet platform, agroprognoza.eu, was established to offer real-time recommendations to farmers, ensuring the project's long-term functionality and impact.
Implementing digital twin technology in the PESCAR project presents several significant challenges. One primary challenge is the integration and management of large datasets from diverse sources, such as real-time meteorological data and pest monitoring systems. This requires advanced data processing and analytics capabilities, demanding the expertise of top IT specialists. Ensuring the technical accuracy and reliability of these data inputs is crucial for making effective recommendations. Another challenge is the scalability of the digital twin technology across different agricultural regions with varying environmental conditions and crop types. Overcoming adoption barriers among farmers, many of whom may be unfamiliar with advanced digital technologies, requires extensive education and training. Additionally, the digital twin system must maintain seamless data exchange and interoperability using standardized protocols and formats to function efficiently. Addressing these challenges is essential for leveraging digital twin technology to enhance sustainable agricultural practices and support informed decision-making in coastal regions facing unique environmental conditions and climate threats.

Agriculture challenges provided by LRUniv

The Urban and Coastal Lab La Rochelle (UCLR) project is in a very early stage and aims to create a comprehensive platform that centralizes data, models, and digital tools from LRUniv's research laboratories. This initiative supports research, innovation, and sustainable coastal management by developing scientific tools for analysis, simulation, and promotion of research results. Many aspects and parameters of the project are yet to be defined as it evolves, including specific data types and decision-making indicators. The platform will integrate digital twins for a holistic understanding and management of coastal zones, aiding in decision-making for the Charente coastline and demonstrating the benefits of a multidisciplinary approach.
The main challenge in implementing digital twins within the UCLR project lies in ensuring interoperability and integration across diverse data sources and models. Developing a common data management policy and establishing a robust infrastructure for real-time data processing and analysis are critical. Additionally, fostering collaboration among researchers and stakeholders to define relevant indicators and decision-support tools poses a significant challenge. The project's success depends on overcoming these technical and collaborative hurdles to create a functional and effective digital twin system for coastal management.

Agriculture challenges provided by SETU

Cúpla Trá: Combining digital twin technology with landscape biography for environmental analysis of a coastal region is a three-year project aimed at assessing the natural environment of County Waterford, Ireland. This project leverages digital twin technology within a landscape biography framework to create a comprehensive digital model of the region. The digital twin will integrate existing environmental datasets and socio-economic data from national and local bodies, community organizations, and publicly funded institutions. This holistic model will enable predictive analysis of the interplay between human activities and ecological factors, guiding future policies to protect and restore the coastal environment.
Although the "Cúpla Trá" project has just begun in 2024 and it's too early to fully detail all the challenges, initial insights highlight the complexities of integrating diverse datasets and ensuring their accuracy and compatibility within the digital twin framework. There may be additional obstacles that are not yet recognized at this stage of implementation. The employment of digital twins in the "Cúpla Trá" project is expected to face several challenges. One of the main obstacles is integrating diverse datasets, ensuring their accuracy, and making them compatible within the digital twin framework. The project focuses on the Back Strand area in Tramore, which faces increased vulnerability due to climate change, including extreme weather events, rising sea levels, and biodiversity changes. Balancing these environmental challenges with the growing local population and tourist influx adds complexity. Additionally, the project employs an eco-centric approach, combining digital twin technology with landscape biography, which necessitates novel methodologies and tools.

Agriculture challenges provided by AUA

The Smart Droplets HE Project aims to revolutionize agricultural practices by reducing the use of pesticides and fertilizers through the integration of advanced technologies. At the heart of this initiative is the creation of digital twins that provide real-time simulations of field conditions. These digital twins leverage AI, data analytics, and robotic systems to enhance crop monitoring, optimize resource usage, and ensure precise chemical application. By simulating various environmental conditions and integrating data from sensors, satellite imaging, and weather stations, the digital twins enable farmers to predict crop growth stages, potential diseases, and pest outbreaks. This allows for proactive management and informed decision-making, ensuring sustainable and resilient crop production. The Smart Droplets project aligns

with the EU Green Deal goals by promoting sustainable farming practices, reducing environmental impact, and improving agricultural efficiency.
Implementing digital twin technology in the Smart Droplets HE Project presents several significant challenges. One primary challenge is integrating diverse data sources, such as real-time sensor data, satellite imagery, and weather information, into a cohesive digital twin framework. Ensuring the technical accuracy of these data inputs is crucial for reliable simulations and predictions. Additionally, the scalability of digital twins across different regions with varying environmental conditions poses a significant hurdle. Overcoming adoption barriers among farmers who may be unfamiliar with advanced technologies is another challenge, requiring effective education and training initiatives. Ensuring interoperability and seamless data exchange using standardized protocols and formats is essential for the efficient functioning of the digital twin system. Addressing these challenges is vital for leveraging the full potential of digital twin technology to promote sustainable and resilient agricultural practices in coastal environments.

4.3. Life Sciences, Health, and Medical Applications

In the dynamic intersection of technology and healthcare, digital twin technology emerges as a transformative force, offering unprecedented opportunities for innovation and optimization across the life sciences, health, and medical domains. Digital twins, virtual replicas of physical entities or systems, have garnered significant attention for their capacity to simulate, monitor, and optimize processes in real-time. This introduction sets the stage for exploring the diverse applications and implications of digital twins in revolutionizing healthcare delivery, personalized medicine, disease modelling, and patient-centric care. Through an examination of notable projects and initiatives, the aim is to illuminate the profound impact of digital twins on reshaping the future of healthcare.

Life Sciences, Health, and Medical Applications challenges provided by UCV

The project "Analysis of respiratory and vascular pathologies in domestic and experimental species using advanced imaging techniques and computational fluid dynamics" employs digital twin technology to revolutionize veterinary medicine. By creating highly accurate virtual models of animals, the project aims to simulate and understand respiratory and vascular pathologies in various species, including canine, feline, equine, and experimental animals. Through computational fluid dynamics (CFD) simulations, the project can analyse phenomena related to respiratory mechanics, cardiovascular biomechanics, medical device interactions, and pathology treatments. These digital twins enable the exploration of in silico scenarios that are otherwise challenging to study experimentally, offering insights into disease mechanisms and treatment strategies. Additionally, the project incorporates innovative approaches such as developing biodegradable airway stents, leveraging digital design, computational simulations, 3D printing, and experimental animal models. The primary objective is to investigate the interaction between biodegradable stents and biological tissue for potential clinical applications.
Implementing digital twin technology in this project presents several challenges. Firstly, acquiring and processing high-quality medical images, such as computed tomography (CT) scans and magnetic resonance imaging (MRI), requires advanced imaging equipment and expertise. Converting these images into accurate three-dimensional geometries using software tools like MIMICS and Ansys demands significant computational resources and technical proficiency. Integrating real-time data from physical systems, such as force measurements from experimental setups, into the digital twins requires robust data integration mechanisms and continuous updates to maintain model accuracy. Furthermore, ensuring the reliability and validation of the digital twins against real-world data poses a significant challenge, requiring meticulous calibration and validation processes. Collaborating across

multidisciplinary teams and institutions adds complexity, necessitating effective coordination and communication among diverse stakeholders. Addressing these challenges is essential to harnessing the full potential of digital twins in advancing veterinary healthcare.

The “Brain Health and Resilience Valencia Challenge” project aims to establish Valencia as a global hub for brain health and resilience research. Coordinated by the Catholic University of Valencia (UCV), this initiative brings together universities, businesses, technological centres, and healthcare institutions to foster a collaborative ecosystem. Central to this project is the use of digital twin technology to study brain function and resilience under normal conditions and in the presence of neurological diseases. By integrating biometric and neuroimaging data, the digital twin provides a versatile platform for continuous monitoring and analysis of brain health. This integration allows for the identification of patterns and biomarkers from clinical, imaging, and genetic data, aiding in the diagnosis, prediction, and treatment of neurological disorders such as Alzheimer's, Parkinson's, and multiple sclerosis. Additionally, the project leverages advanced neuromodulation techniques like Transcranial Magnetic Stimulation (TMS) to explore direct modulation of brain activity, enhancing resilience and brain health.
Implementing digital twin technology in this project involves several significant challenges. Firstly, the collection and integration of comprehensive biometric and neuroimaging data require advanced imaging equipment and sophisticated data processing capabilities. Ensuring the accuracy and reliability of these digital twins necessitates ongoing validation against real-world clinical data. The development of predictive models based on complex genetic and clinical datasets requires substantial computational resources and expertise in data analytics and machine learning. Moreover, maintaining up-to-date digital twins with real-time data involves robust data integration mechanisms and continuous updates, demanding seamless interoperability between various technological and medical platforms. Collaboration across multiple institutions and disciplines adds another layer of complexity, necessitating effective coordination and communication among diverse stakeholders. Addressing these challenges is crucial to harness the full potential of digital twins in advancing brain health research and improving clinical outcomes.

The "In silico" analysis of Biomechanics models for long bones fractures orthogonal stabilization systems project aims to evaluate and optimize the mechanical behaviour of stabilization systems for long bone fractures in various species, primarily canines and felines. Utilizing digital twin technology, the project leverages digitized medical images to create highly accurate biomechanical models of bone structures. These digital twins allow for detailed simulations of clinical scenarios encountered in both veterinary and human medicine. By replicating the biomechanical behaviour of bones and testing different stabilization materials and methods, the digital twins facilitate the identification of the most efficient stabilization systems. This approach also adheres to the principles of reduction, replacement, and refinement (3R) in animal research, minimizing the need for physical testing and enhancing the applicability of findings to clinical practices.
Implementing digital twin technology in this project presents several challenges. Collecting high-quality medical images, such as CT and MRI scans, requires advanced imaging equipment and expertise, ensuring accurate geometry reconstruction. The process of converting these images into computational models involves sophisticated software tools like MIMICS and Ansys, necessitating significant computational resources and technical proficiency. Integrating real-time data from physical systems, such as force measurements from baropodometers, into the digital twins requires robust data integration mechanisms and continuous updates to maintain model accuracy. Additionally, developing and maintaining these complex models demand ongoing collaboration among multidisciplinary teams, licensing for specialized software, and ensuring interoperability between various systems and platforms. Addressing these challenges is crucial for the successful implementation and utility of digital twins in evaluating and improving fracture stabilization systems.

The “Evolve-Evalue” project integrates two advanced digital twin technologies to revolutionize medical simulation training. On one side, CAE Maestro Evolve offers an interactive virtual learning environment where medical students engage with virtual patients using various medical tools and equipment. This platform provides a continuous stream of pre-programmed Simulated Clinical Experiences (SCEs), enabling realistic and dynamic training scenarios. The digital twin of the patient allows for real-time manipulation of physiological values and responses based on students' interactions, fostering a highly immersive and practical learning experience. Complementing this is an evaluation tool that can be accessed remotely, allowing teachers to organize pre- and post-simulation exams. This tool features an extensive pool of questions with customizable difficulty and topic selection, providing detailed statistical insights into student learning and performance improvements, thus bridging the gap between theoretical knowledge and practical application.
Implementing digital twins in medical simulation training presents several challenges. Firstly, integrating complex simulation data from different sources requires sophisticated data management and interoperability solutions. Developing an extensive and accurate database of questions that can effectively evaluate simulations is another significant hurdle, as it must cover a wide range of medical scenarios and difficulty levels. Additionally, creating enriching and realistic virtual experiences demands advanced graphics, realistic physiological modelling, and responsive interaction capabilities. Ensuring these simulations accurately reflect the unique microclimate and environmental conditions of coastal areas adds further complexity. These challenges necessitate robust technical infrastructure, interdisciplinary collaboration, and continuous refinement to ensure the digital twin applications meet the high standards required for medical education.

The NONNA project employs digital twin technology to create comprehensive models of older adults' cognitive health by analysing their spontaneous language use. Participants' speech is recorded using MP3 devices during various activities and conversations, and these recordings are uploaded to a centralized database. Advanced algorithms and machine learning models process the audio data, converting it into text using natural language processing (NLP) techniques. This processed linguistic data forms the basis of the digital twins, which are continuously updated to reflect each participant's cognitive state. By integrating linguistic patterns and cognitive markers, these digital twins offer detailed, real-time insights into cognitive aging, enabling personalized monitoring and interventions.
Implementing digital twins in the NONNA project presents several challenges. Collecting high-quality linguistic data requires consistent and accurate recordings, which can be logistically complex and resource intensive. The processing and analysis of this data involve sophisticated NLP algorithms and machine learning models, necessitating significant computational power and technical expertise. Ensuring the accuracy and reliability of the digital twins requires meticulous validation and continuous refinement of the models. Additionally, integrating real-time updates and providing personalized interventions based on the digital twin data demands robust IT infrastructure and seamless interoperability between different systems and platforms. Addressing these challenges is crucial to realizing the full potential of digital twins in enhancing cognitive health monitoring and intervention.

The Walkable Cities project in Valencia aims to enhance physical activity levels among residents, particularly in neighbourhoods with low walkability, through the implementation of digital urban trails. Leveraging digital twin technology, the project simulates various aspects of the urban environment, including quantifying physical activity levels, mapping neighbourhood characteristics, and designing attractive urban routes aligned with WHO recommendations. By utilizing mobile applications such as Strava, residents are encouraged to increase their weekly number of steps, contributing to a more active lifestyle and reducing car use. However, challenges in user engagement and data collection pose potential hurdles,

particularly regarding long-term adoption of the application and accurate quantification of trail usage. Overcoming these challenges is crucial for ensuring the effectiveness of the digital twin approach in promoting physical activity and improving urban walkability in Valencia.
The implementation of digital twins in the Walkable Cities project presents several challenges that need to be addressed for successful outcomes. One significant challenge involves motivating residents, especially those with low walking motivation, to consistently use the mobile application to track their steps and engage with the urban trails. Ensuring widespread adoption and sustained usage of the application requires effective communication strategies and continuous user support. Additionally, accurately quantifying the use of the trails and monitoring population behaviour pose technical challenges, particularly regarding data collection methods and integration with the digital twin platform. Addressing these challenges requires innovative approaches and robust methodologies to enhance user engagement and ensure reliable data collection, ultimately maximizing the impact of the digital twin technology in promoting physical activity and improving urban health in Valencia.

The DART (Diabetes Augmented Reality Training) project aims to address the growing challenge of diabetes, particularly considering the potential exacerbating effects of the coronavirus pandemic. By leveraging innovative digital tools and training modules, DART seeks to motivate individuals with diabetes type I and II to improve their health outcomes through physical exercise and active participation in sports. The project introduces an innovative mobile application with augmented reality (AR) capabilities, providing personalized training programs and health monitoring features tailored to the needs of diabetic patients. Through the integration of digital twin technology, DART fosters cross-country collaboration and facilitates the evaluation of intervention effectiveness by analysing health indicators and patterns of physical activity habits. This digital twin aspect allows for cooperation across various contexts and languages, enabling the assessment of the impact of AR technology and online education on patients' health outcomes and physical activity behaviours.
In implementing the digital twin aspect of the DART project, several challenges are anticipated. Firstly, ensuring seamless integration of digital twin technology into the AR training platform requires meticulous attention to technical compatibility and data interoperability across different devices and systems. Secondly, maintaining the accuracy and reliability of real-time data collected from exercise training sessions poses a challenge, particularly in diverse healthcare settings with varying levels of technological infrastructure. Additionally, effectively utilizing insights derived from digital twin models to optimize training protocols and support health objectives necessitates ongoing refinement and validation of predictive algorithms and analytical methodologies. Lastly, ensuring privacy and security of patient data in the context of digital twin implementation requires robust data governance frameworks and adherence to regulatory standards, especially considering the sensitive nature of health information involved. Addressing these challenges will be crucial for maximizing the impact of digital twin technology in improving health outcomes for individuals with diabetes.

5. Selection of Experts and team formation

Each partner contributed expertise associated with the respective field area and/or project they provided, furnishing a comprehensive ensemble of expert profiles crucial for the elucidation of digital twin applications in coastal environments. The composition of each sub workgroup according to identified challenges is presented in following tables, providing a comprehensive representation of expertise across diverse domains:

Table 1. Agriculture sub-workgroup

Affiliation	Expertise Area	Role in Project
University Of Rostock	Abiotic stress tolerance and genome-based crop modelling	Team member
University Of Rostock	Agronomy	Project coordinator
University Of Rostock	Plant breeding	Team member
University Of Zadar	Plant protection and extension expert	Leader - Agronomy
University Of Zadar	Water management	Member
University Of Zadar	Agronomist – olive grooving expert	Member
"Inovativni Sustavi" – Private Company	IT support – AI expert	Leader - IT
University Of Zadar	Agronomist	Member
South East Technological University	BIM, Heritage Built Env.	Coordinator
South East Technological University	Sustainable Buildings	Member
South East Technological University	Landscape Research & Technology	Member
South East Technological University	Digital Construction	Member
Ludi, La Rochelle University	coordination of actions	Coordination
Ludi, La Rochelle University	development and maintenance of the UCLR tool (2024-2032)	Computer engineer
Ludi, La Rochelle University	Digital twins	Chaire Junior
Agricultural University of Athens	Agricultural buildings	Project coordinator for AUA
Wageningen University	Artificial Intelligence and Data Science	Leader of the Digital Twin Creation
Wageningen University	machine-learning	Employing Reinforcement

Table 2. Building and infrastructure sub-workgroup

Affiliation	Expertise Area	Role in Project
Frederick University	Sustainable Buildings	Coordinator
Passivhaus	Sustainable Buildings	Member
Energy Agency Cyprus	Environmental Assessment	Member
Cyprus University Of Technology	Sustainable Technologies	Member

University Of Rostock	Computer science in construction	Team member
University Of Rostock	Geoinformatics	Team member
Technical University of Civil Engineering Bucharest	Digital Twin of Building, Urban development, urban regeneration	Institutional Coordinator
Technical University of Civil Engineering Bucharest	Geodesy remote sensing, 3D modeling of the city	Institutional coordinator
Technical University of Civil Engineering Bucharest	Digital Twin of the building systems	Institutional coordinator
Politehnica Bucharest	Digital Twin, IoT	NetZeroCities coordinator
Politehnica Bucharest	Digital Twin of the Smart Grids	Member
Technical University of Civil Engineering Bucharest	Digital Twin of the systems	Member
Technical University of Civil Engineering Bucharest	Digital Twin of the buildings	Member
Technical University of Civil Engineering Bucharest	Digital Twin of the city	Member
TECHNICAL UNIVERSITY OF CIVIL ENGINEERING BUCHAREST, Pronzeb Cluster	Digital Twin of the city	Member
Technical University Of Civil Engineering Bucharest, Climatosfera	Digital Twin of the city	Member
South East Technological University	Smart Cities, Enterprise Development	PI
South East Technological University	Urbanisation and urban culture, Regional development policy	Member
South East Technological University	Urbanisation, Equality and Diversity, Smart Cities	Member
Klaipeda University	R&D of data acquisition, communication systems	Coordinator
Klaipeda University	Artificial Intelligence	Member
Klaipeda University	Advanced Control Systems	Member
Klaipeda University	Data Acquisition, LabVIEW programming	Member
Quanterall LTD	Software Development	Member

Table 3. Life science, health and medical applications sub-workgroup

Affiliation	Expertise Area	Role in Project
Catholic University of Valencia	Orthopaedics, surgery and Biomedicine	Coordinator
Catholic University of Valencia	Orthopaedics, surgery and Biomedicine	researcher
CEU Cardenal Herrera University	Engineering	researcher
CEU Cardenal Herrera University	Engineering	researcher

Affiliation	Expertise Area	Role in Project
Catholic University of Valencia	Orthopaedics, surgery and Biomedicine	researcher
Catholic University of Valencia	Orthopaedics, surgery and Biomedicine]	researcher
Catholic University of Valencia	Engineering	Coordinator
Catholic University of Valencia	Veterinary	Coordinator
Catholic University of Valencia	Veterinary	PhD Student
Catholic University of Valencia	Veterinary	PhD Student
Catholic University of Valencia	Anthropology	Coordinator
Catholic University of Valencia	Sports Science	Member
Catholic University of Valencia	Sports Science	Member
Catholic University of Valencia	Sports Science	Member
Catholic University of Valencia	Sports Science	Member
Universidad Católica De Valencia Hospital Arnau-Lliria	Intensive care medicine, Bioethics, Education and Simulation	Coordinator
Universidad Católica De Valencia. Advanced Simulation Center, Hospital Virtual	Simulation Tecnician	Member
Catholic University of Valencia	Physical Education & Sport Sciences	Coordinator
Catholic University of Valencia	Physical Education & Sport Sciences	Member
Catholic University of Valencia	Physical Education & Sport Sciences	Member
Catholic University of Valencia	Physical Education & Sport Sciences	Member
Catholic University of Valencia	Physical Education & Sport Sciences	Member
Catholic University of Valencia	Nursing	Member
Catholic University of Valencia	Nursing	Member
Catholic University of Valencia	Nutritionist	Member
Catholic University of Valencia	Medicine	Main researcher
Catholic University of Valencia	Cognitive neuroscience	coordinator
Catholic University of Valencia	Psychology	coordinator

Affiliation	Expertise Area	Role in Project
Catholic University of Valencia	Psychology	coordinator
Catholic University of Valencia	Medicine	coordinator
Catholic University of Valencia	Nutrition	coordinator
Catholic University of Valencia	Nutrition	coordinator
Catholic University of Valencia	General Health	coordinator
Catholic University of Valencia	Sport	coordinator
Catholic University of Valencia	Engineering	coordinator
Catholic University of Valencia	Project manager	Project manager
Catholic University of Valencia	Medicine	Main researcher
Catholic University of Valencia	Cognitive neuroscience	Coordinator
Catholic University of Valencia	Project manager	Project manager

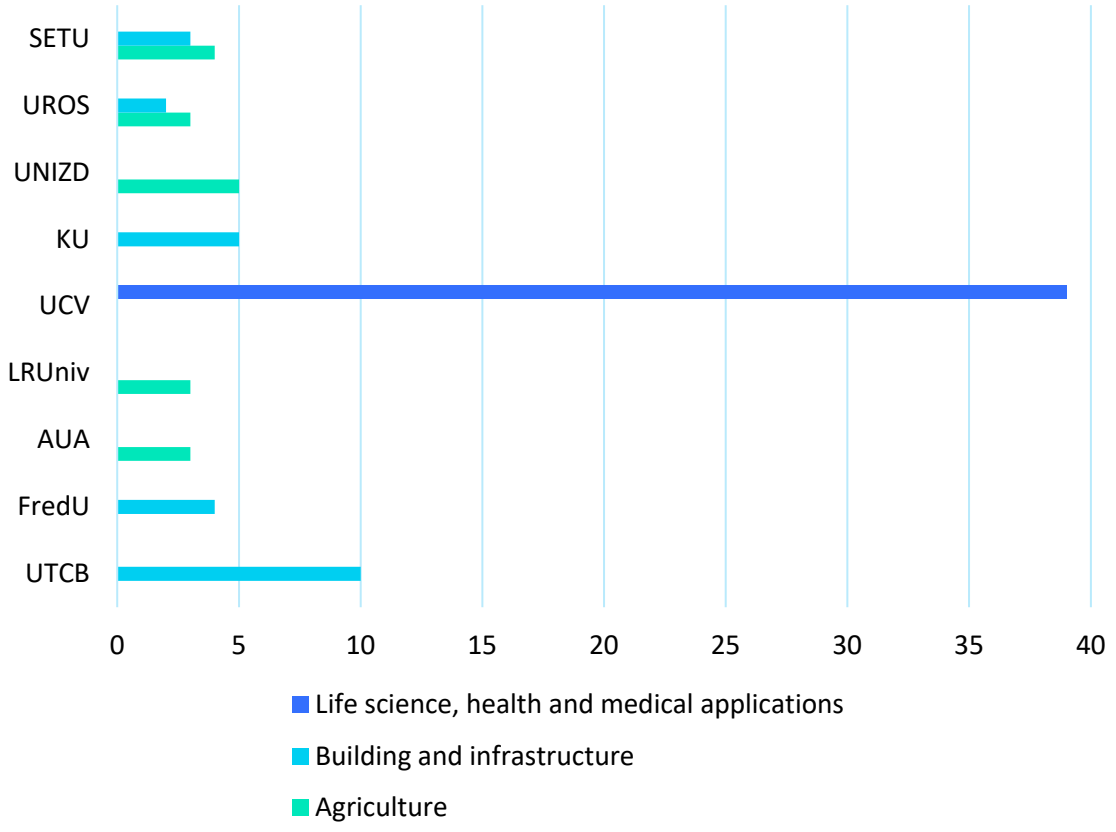

Figure 4: Number of experts assigned to identified challenges from each partner

6. Comprehensive Work Plan

This chapter outlines the work plan for the subgroups of experts with experience in Digital Twin projects, following the completion of the questionnaire found in the annex. The figure below recalls the identified challenges along with the specific areas that need to be addressed.

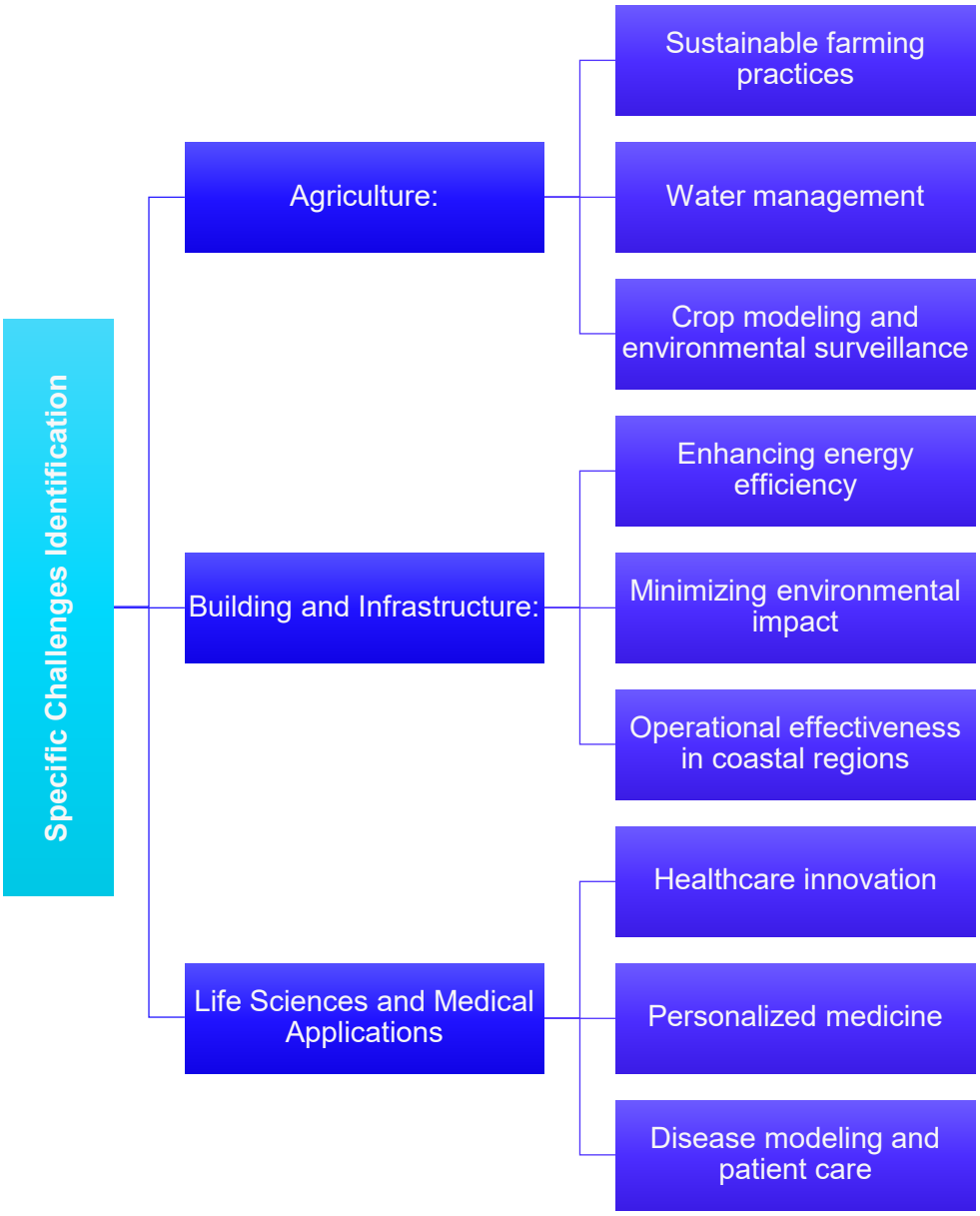

Figure 5: Specific challenges identified in the Alliance partners' projects

6.1. Work Plan for Sub-Workgroups

Activity 1: Identify and address specific challenges in coastal areas using Digital Twin technologies

- **Description:** Conduct a needs assessment to identify and address specific challenges in coastal areas using digital twin technologies, focusing on knowledge transfer.
- **Timeline:** M8

- **Output:** Specific challenges regard to coastal areas

Activity 2: Establish the challenge-based needs of SmUCS with digital twin solutions based on stakeholders' needs

- **Description:** Launch Task 2.2 by establishing the challenge-based needs of SmUCS, leveraging digital twin solutions tailored to stakeholders' requirements.
- **Timeline:** M9
- **Output:** Needs assessment report

Activity 3: Develop solutions integrating the latest digital twin technologies

- **Description:** Analyse the identified challenges to determine the most suitable digital twin solutions. Develop these solutions to effectively tackle the challenges.
- **Timeline:** M10-11
- **Output:** Digital twin solutions

Activity 4: Organize a workshop with experts to discuss and prioritize research topics for PhD theses in cotutelle and research mobilities

- **Description:** Launch Task 2.3 by organizing a workshop with experts to discuss and prioritize research topics for PhD theses in cotutelle and research mobilities.
- **Timeline:** M11-M12
- **Output:** Workshop summary report

Activity 5: Develop a list of priority research topics for PhD theses in cotutelle and research mobilities

- **Description:** Based on the outcomes of the workshop, develop a comprehensive list of priority research topics for PhD theses in cotutelle and research mobilities.
- **Timeline:** M13-M14
- **Output:** List of priority research topics

By following this detailed work plan, the subgroups of experts will systematically address the specific challenges identified in the SmUCS project, leveraging digital twin technologies to develop innovative and effective solutions through PhD theses in cotutelle and research mobilities.

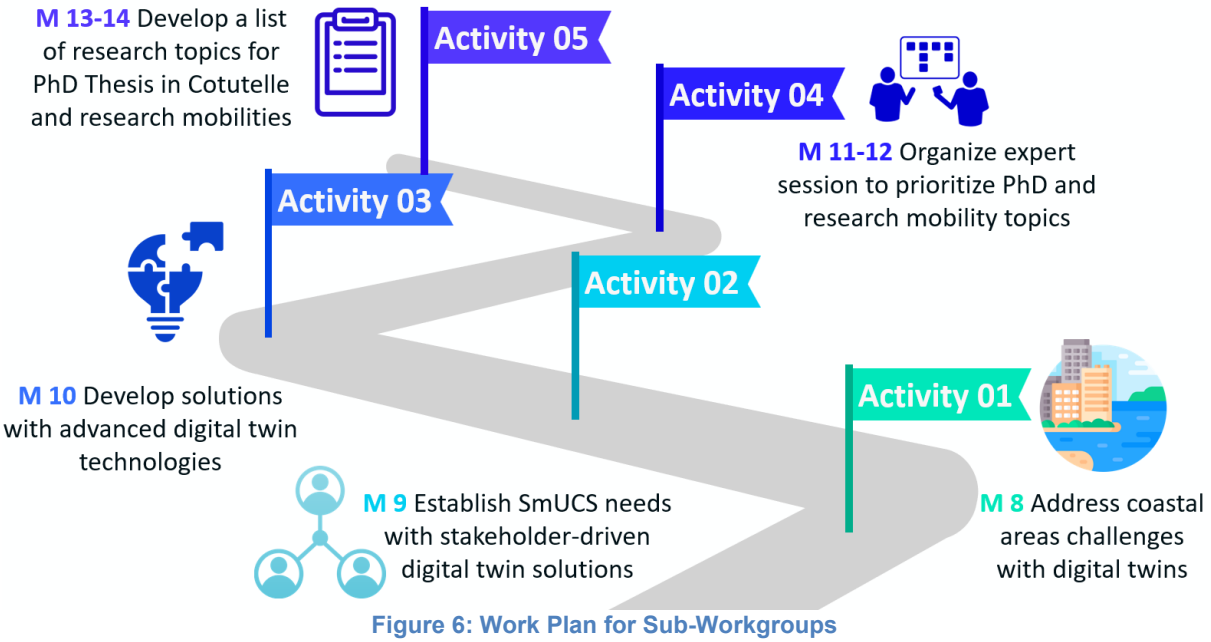

Figure 6: Work Plan for Sub-Workgroups

7. Conclusions

The clustering analysis underscores the intricate web of challenges and opportunities inherent in the application of digital twin technology across diverse domains within coastal environments. While examining the similarities across clusters reveals central themes such as data management complexities, interoperability concerns, and the need for robust infrastructure, it also illuminates unique challenges specific to each domain. However, it is important to note that many identified challenges are broad and could apply to various environments, not specifically coastal regions. Issues related to energy efficiency, structural integrity, and IT infrastructure lack a direct connection to coastal-specific conditions, highlighting the need for a more focused analysis.

In the Buildings and Infrastructure cluster, challenges revolve around integrating dynamic environmental data, ensuring data accuracy, and managing extensive datasets. This parallels challenges in Agriculture, where issues such as sustainable operations optimization and lifecycle phase integration present significant hurdles. Similarly, the Life Sciences cluster faces obstacles like data privacy and ethical concerns, demonstrating the importance of robust ethical guidelines and safeguards. However, these discussions often miss the unique challenges posed by coastal environments, such as high humidity, saltwater intrusion, and extreme weather events, which are critical for understanding the full scope of digital twin applications in these settings.

Differences also emerge among the clusters. For instance, in Buildings and Infrastructure, challenges include handling sensitive data governance and managing initial capital expenditure, whereas Agriculture projects emphasize IT infrastructure complexities and the need for skilled professionals. In contrast, Life Sciences projects grapple with motivating user engagement and adherence while navigating ethical considerations. Despite these variations, the overarching conclusion drawn from the analysis is the potential for digital twin technology to drive holistic and integrated solutions for coastal sustainability. However, the document could benefit from more specific use cases and examples of digital twin applications in coastal environments to provide a clearer link between the challenges and the project's objectives.

Despite the general discussion on digital twin technology applications, there is a lack of detailed exploration of how these technologies can be specifically adapted and optimized for coastal environments. Addressing this gap is crucial for making the technology more relevant and effective in coastal settings. Moving forward, concerted efforts to address the identified challenges can lead to tangible outcomes, including improved energy efficiency in buildings, optimized resource management in agriculture, and enhanced healthcare practices. Moreover, by fostering interdisciplinary collaboration and knowledge exchange, the potential for transformative impact in coastal sustainability becomes increasingly attainable.

Additionally, some projects may still be in their early stages, with challenges yet to be fully identified or articulated. These projects, while laying the foundation for future advancements, may encounter unforeseen obstacles as they progress. Therefore, it's essential to remain flexible and adaptive in addressing emerging challenges and refining strategies accordingly. By fostering a culture of continuous learning and adaptation, stakeholders can navigate the complexities of digital twin implementation more effectively, ultimately driving progress towards sustainable coastal development.

By following the detailed work plan, the next tasks will systematically address specific coastal challenges using digital twin technologies. Next steps will establish challenge-based needs from stakeholders' perspectives and develop tailored digital twin solutions. A workshop will be

organized to prioritize research topics for PhD theses and research mobilities, culminating in a comprehensive list of priority topics. This collaborative approach ensures innovative and effective solutions through interdisciplinary PhD research.

In summary, the clustering analysis underscores the necessity of adopting a comprehensive strategy when implementing digital twin applications in coastal settings, recognizing both shared challenges and unique attributes across various fields. Establishing specialized groups within each cluster, focused on addressing specific issues, will be pivotal in navigating complexities effectively. Furthermore, re-evaluating the identification of challenges with a stronger emphasis on the coastal context, refining the scope of challenges, and providing detailed case studies and examples that highlight successful digital twin applications in coastal regions will be essential. By fostering collaboration, strategic planning, and innovative solutions within these groups, we can advance towards the realization of sustainable and resilient coastal communities driven by the transformative capabilities of digital twin technology.

1. List of tables

2. List of figures

3. References

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4. Annexes

Questionnaire template

Digital Twin Applications in Coastal Environments – Related field

Field	Description
Specific Application	[Name or type of the digital twin application]
Description of Digital Twin Role	[How the digital twin is used within the coastal context]
Connection to Coastal Context	[Explain the relevance to coastal areas]
Benefits and Challenges	[Potential benefits and anticipated challenges]

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	[Title of the project]
Brief Description	[A short summary of the project]
Digital twin aspect	[Aspect within the project related to digital twins]

Experts Panel

Expert Name	Affiliation	Expertise Area	Role in Project	Contact Information
[Name 1]	[Affiliation]	[Area of Expertise]	[Role]	[Contact]
[Name 2]	[Affiliation]	[Area of Expertise]	[Role]	[Contact]
...	...	...	...	...

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
[Current Tech]	[Tools Needed]	[Databases Used]	[Support and Logistics]

Questionnaires from all partners

4.1. Questionnaire completed by FredU

Digital Twin Applications in Coastal Environments – Related field

Field	Description
Specific Application	Digital Twin for Coastal Building Sustainability Analysis
Description of Digital Twin Role	This digital twin application models energy usage, environmental impact, and operational efficiency of buildings in coastal zones to improve sustainability practices and reduce carbon footprints.
Connection to Coastal Context	The application considers the unique microclimate and environmental conditions of coastal areas, such as high humidity and varying temperature gradients, to optimize building performance and energy consumption.
Benefits and Challenges	Benefits include enhanced energy efficiency through optimization of heating, ventilation, and air conditioning (HVAC) systems, and informed decision-making for eco-friendly material use and waste reduction. Challenges encompass the intricacy of integrating dynamic coastal environmental data into the model, ensuring data accuracy, and the requirement for sophisticated algorithms to handle large datasets.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	SmartLivingEPC (HORIZON-CL5-2021-D4-01-01, GA 101069639)
Brief Description	The SmartLivingEPC project revolutionizes the energy performance certification by embracing digitization and integrating digital twins for buildings and their technical systems. This initiative extends the Building Information Modeling (BIM) framework to include detailed simulations of buildings' operational behaviors and technical systems, facilitating a comprehensive assessment of energy efficiency and sustainability. By incorporating a new rating scale, SmartLivingEPC evaluates life cycle performance, building smartness, and the real-world performance of building technical systems through technical audits. The project also broadens its scope to address water usage, noise pollution, and acoustics, ensuring compatibility with digital logbooks and renovation passports for seamless data integration into digital platforms. Focused on both individual buildings and complexes, SmartLivingEPC aims to pioneer energy certification at the neighborhood level, employing an integrated, participatory approach. This collaborative effort, spanning 36 months with 16 partners from 12 European countries, sets the stage for new standards in smart energy performance certificates, emphasizing the digital twin's role in monitoring and improving the operational performance of buildings.
Digital twin aspect	Within SmartLivingEPC, the digital twin concept is pivotal, extending to both the structural and the technical systems of buildings. These digital twins offer a dynamic, enriched digital representation that mirrors the real-life energy consumption, sustainability metrics, and operational efficiency of buildings and their systems. By integrating real-time data from monitoring the operational performance of buildings, these digital twins enable a precise assessment of energy efficiency and sustainability impacts over the building's life cycle. This technological approach not only enhances the accuracy of energy performance certificates but also supports continuous improvement in building operations through detailed insights into the performance of heating, ventilation, air conditioning (HVAC), lighting, and

	other critical technical systems. This forward-thinking methodology underlines SmartLivingEPC's commitment to advancing the digitization of the built environment, fostering smarter, more sustainable buildings and communities.

Experts Panel

Affiliation	Expertise Area	Role in Project
Frederick University	Sustainable Buildings	Coordinator
PassivHaus	Sustainable Buildings	Member
Energy Agency Cyprus	Environmental Assessment	Member
Cyprus University of Technology	Sustainable Technologies	Member

Resources and Infrastructure

Field	Description
Available Technologies	The suite of available technologies includes Building Information Modeling (BIM) software for comprehensive architectural and engineering design, digital twin platforms for real-time building performance simulation, IoT devices for granular data collection, and smart sensors capable of capturing a wide range of environmental and operational parameters.
Required Tools	Essential tools encompass sophisticated data analytics and visualization software to make sense of complex datasets, machine learning algorithms for predictive analytics and optimization of energy consumption, integration platforms to facilitate seamless communication between BIM, digital twins, IoT data streams, and smart sensors, as well as big data management solutions to handle the volume, velocity, and variety of data generated.
Data Sources	Key databases utilized are enriched by proprietary BIM libraries, extensive sustainability and energy performance benchmarks, comprehensive repositories of IoT and smart sensor data capturing real-time building operations, alongside big data sets that include local environmental conditions, occupancy patterns, and energy grid analytics.
Logistics Needs	Logistics demands include a robust and scalable cloud computing infrastructure to support extensive data storage and processing capabilities, advanced professional training programs to upskill staff in utilizing digital and smart technologies for sustainability assessments, and a comprehensive network of technical support for the installation, maintenance, and upgrading of IoT devices, smart sensors, and related monitoring systems.

4.2. Questionnaire completed by UTCB

Digital Twin Applications in Coastal Environments – Digital Twin of the building and of its systems

Field	Description
Specific Application	Digital Twin of the Building
Description of Digital Twin Role	Real-time data collection and processing allow for continuous monitoring of building conditions, including structural integrity and environmental impacts (e.g., humidity, saltwater intrusion). They simulate various scenarios, such as storm surges or high winds, to assess how a building might respond to specific coastal hazards. The twins optimize building performance for energy efficiency and environmental impact, considering the unique challenges posed by the coastal climate.
Connection to Coastal Context	Coastal buildings are subject to dynamic weather conditions and climate phenomena, such as hurricanes and flooding. Proximity to saltwater increases the risk of structural degradation, necessitating vigilant monitoring and maintenance strategies. Buildings in coastal areas often interact closely with sensitive marine ecosystems, requiring careful management to minimize environmental footprints.
Benefits and Challenges	Digital twins help in designing and retrofitting buildings to withstand coastal-specific challenges, enhancing overall resilience to extreme weather events. Real-time monitoring and predictive analytics can forecast maintenance needs and structural risks, improving safety for occupants. Optimization of energy and resource use contributes to more sustainable building operations, crucial in ecologically sensitive coastal zones. Managing and interpreting the vast amounts of data from multiple sources and sensors can be technically challenging and require advanced analytical capabilities. Initial setup and ongoing maintenance of digital twin technology involve significant investment, which might be prohibitive for some stakeholders. Integrating digital twins with existing building management systems and protocols can be complex, requiring significant customization and technical support.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	"National Competence Centre and solutions for the development of Climate Neutral and Smart Cities" (NetZeRoCities)
Brief Description	Smart City describes the goal of a new integrated urban development that combines current technical and social innovations. A Smart City is built on connecting people and things (*data sharing for accelerating innovation*). Smart Cities support monitoring emission reductions in mobility, providing smart energy grids, improving energy efficiency in buildings, monitoring air pollution, water, and waste management, leading to increased awareness on climate change. Cities of the future will integrate solutions for environmental protection

	and climate change, integrating social inclusiveness, diversity, and the participation of all stakeholders to communities' lives. From a business perspective, in parallel to these societal phenomena, local economies need to adapt and validate innovative technologies and methods to make processes, such as the production or logistics of goods, as climate neutral as possible. The private as well as the public sector must deal with these and other challenges to create attractive places to live. Digitalisation can help to address many of these challenges. Our Competence Centre promotes system innovation across the value chain of city investment, targeting multiple sectors such as governance, transport, energy, construction, and recycling, with support from powerful digital technologies. Cities requires a shift in regulations, approaches and instruments combined with the willingness to go beyond existing schemes and habits. It requires an attitude change towards practical implementation that includes concerns of people and stakeholders working together: citizens, local governments, central and regional governments, and European institutions. Following the vision of creating a safe, liveable, and lovable living space, urban neighbourhoods offer a good opportunity to implement and validate new ideas and innovative concepts. This is why our CC focuses on both static (i.e., city infrastructure) and dynamic (i.e. people, businesses) components of the city.
Digital twin aspect	A key component of a NetZero Smart City is the Digital Twin (DT), defined as a digital replica of living and non-living entities that enable any interaction happening in the real world to be transmitted in the digital world and vice-versa. Hence, the DT is an ever-evolving platform that stores historical and current data of the real-life twins and helps monitoring, creating new models and trends, and even creating what-if simulation scenarios from which one can extract insights that can affect the real physical twin. The main technologies that are part of the DT are: Internet of Everything (IoE) – a concept that uses sensors and actuators to extract insights from the physical world; Big Data – a technology that connects massive amounts of data using IoE but also other sources like Social Networks; Artificial Intelligence – algorithms used to extract insights about the real-life twin, its future behaviour or how different aspects are influencing it; Communication – technologies that power the data flow from the real-world Twin to the Digital one (such as 5G technology); Cybersecurity – the data has to be secured and privacy has to be implemented in building the DT; Synchronous interactions – allowing the twins to interact and to influence each other, improving the quality of life of the real twin and allowing the DT to evolve based on the measurements and interactions of the real twin. All these components will be implemented in the NetZero Smart Campus DT platform, making it the all-in-one Box solution to be transferred to NetZero Smart Cities.

	The platform data will be open to all stakeholders to use and to develop applications and services that will benefit the NetZero Smart Cities. One of the major issues with DT platforms for smart cities is the heterogeneous data, the fact that different twins don't communicate between each other. For example, measuring the CO2 concentration in a given area and the traffic pattern, a DT platform should suggest a commuter an alternative way to travel that will decrease the level of CO2 in that area. To overcome this issue, we aim to introduce the idea of Convergent Digital Twins. A Convergent DT will interconnect data and services from all Smart Cities dimensions, which would be a horizontal application between all the Specific RDI Projects in this proposal. Furthermore, the Convergent DT will also interconnect multiple cities, which is a vertical application, going from more advanced smart cities to less advanced ones. Hence, multiple smart cities will be interconnected by such a DT, which will make it easier for public authorities to identify causes of related problems from other DTs in the same situation. There will be models created that will interact with each other both for Smart Cities as well as models for each physical object or industry type DT. The communication technology used will be 5G, as the Ultra-low Latency and High Reliability use case is optimal for a Smart City DT, together with the possibility to have low-energy consumption 5G cells that will reduce the overall communication carbon footprint. Thus, the main objective of this RDI project is to create a NetZero Smart Campus living lab environment by the end of the project. We will accomplish this goal by using the UPB Campus as a living lab for piloting NetZero solutions and by creating a Digital Twin platform that will collect data from all the IoT sensors, using the 5G infrastructure, analyse them and present relevant results to the citizens or developers or decision-making authorities. Accomplishing this goal will result in creating smart policies for reducing carbon footprint and empowering citizens and businesses to be NetZero at an individual/company level.

Field	**Description**
Project Title	WeGenerate: Co-creating people-centric sustainable neighbourhoods through urban regeneration
Brief Description	The Project 'WeGenerate' as signified by its name, seeks to infuse the elements of people and co-creation in the urban regeneration processes. It fully embraces the paradigm shift from building for the people to building with the people. We – cities, citizens, communities, businesses, researchers, and practitioners – take ownership of the urban regeneration processes and co-create together sustainable, people-centric, accessible, and beautiful neighbourhoods. This project is based on the stories of four neighbourhoods and their communities located in different parts of Europe. Although they are at different stages of development and are

	facing different urban challenges, but they share the same vision of positive change. WeGenerate will help them to reinvent themselves and in the process find new values and opportunities. WeGenerate sets out a journey to find the right ingredients and recipes for sustainable and inclusive urban regeneration that can create long-lasting positive impacts within the neighbourhoods and beyond. The process will be highly participatory with close collaboration with the city administrations as well as the citizens, local communities, and businesses. Advanced digital applications (such as Digital Twins, Metaverse and extended reality) will be implemented and experimented to support decision-making and stimulate citizen engagement. Expertise in Social Science and Humanities is called upon to foster social innovation and participatory actions across the project. In addition to technological and social interventions, the art and cultural dimensions will be drawn on in the co-creation processes. Four sustainable and people-centric neighbourhoods will be realised by the end of the project, the legacy will be upheld through replication by five Fellow Cities and others, who are inspired by the WeGeneration stories.
Digital twin aspect	Cities around the world are exploring possibilities with emerging technologies such as Digital Twins, extended reality and eventually the Metaverse. The number of cities in the Metaverse is increasing rapidly, and many European cities, including Tampere, are yet to innovate in this sphere. In this Demo, a Digital Twin of the city centre will be developed and building on it, a Metaverse will be created. This real-time digital representation of the city centre will enable, for instance, data-driven analysis of possible walking, cycling and public transport options and routes to support the development of sustainable mobility chains as well as the design of interactive and intuitive Co-create with citizens through participatory planning processes including innovative governance model, decision-making procedures and digital applications. Incorporating citizens in the central city planning by providing them showcases with the Digital Twin. Social equality and cognitive change will be stimulated through constant awareness local workshops. The developed Digital Twin has a key role for the transferability and scalability of project results. The Digital Twin must be technically solid, stable and of good quality to be achieve the Demo objectives. The key Digital Twin experts will be involved in the early study of the Demo to integrate all the essential details to roll-out the final robust digital tools. A risk management analysis will be initiated by NTNU, management leader and main technical partners for Digital Twin integration. The Digital Twin application is intended to support decision-making. There might be resistance from city practitioners to use new methods and tools. Increase of the competence and confidence of city practitioners by knowledge exchange, experience sharing and capacity

	building so that they are informed about the benefits of new approaches and are more adapted to change.

Field	Description
Project Title	ReGreeneration: The next generation of green, resilient and socially inclusive smart cities
Brief Description	ReGreeneration is a Horizon project dedicated to shaping the future of green and inclusive smart cities. It involves four leading cities across Europe, Bucharest, Paris, Alverca, and Barcelona pioneering the implementation of nature-based solutions in diverse urban environments. These projects will then be replicated in other European cities: Roma, Ghent, Ljubljana, Segrate, and Lappeenranta. The project's primary objectives encompass demonstrating the positive impact of nature-based solutions on mitigating urban climate change while improving urban living conditions. It also seeks to actively engage citizens, raise awareness, and promote long-term social compromise. Moreover, the initiative aims to empower municipalities to work towards climate neutrality and develop smart digital city models that enhance visualization of current and future city-states (including climate change, social aspects, air quality, and pollution). ReGreeneration is a public-private consortium including 9 European cities that will design & experiment together for 4 years Nature Based Solutions to regenerate deprived neighbourhoods for climate resilience, GES reduction and local ecosystem dynamization through participative methods. A set of mixed skills, covering architecture, landscape design, geospatial analysis and digital twins, project value modelling, urbanism, nature & public space facilities, sociology, economics will be deployed in different projects in Paris (FR), Barcelona (ES), Alverca (PT), Bucharest (RO), followed by replicators located in Roma (IT), Gent (BE), Ljubljana (SL), Segrate (IT), Lappeeranta (FI). Projects are complementary and will contribute to create a replicable knowledge on a large set of cities' challenges: - How to regenerate quality of life, health and attractiveness in marginalized areas (Bucharest, Paris) - How to capture carbon, create freshness Islands, preserve biodiversity, make a better usage of water, develop low carbon mobility & continuity, prepare resilience to stressed weather events (Alverca, Barcelona, Paris) - How to educate and make local actors (inhabitants, municipality agents, local businesses, political authorities) participate to design & maintain the green areas created ? (the nine cities) - How to analyze the diversity of local contexts to choose the right best practices to replicate in a european territory, and define the required investment & governance model ? (Roma, Gent, Ljubljana, Segrate, Lappeeranta) The knowledge to successfully create for meeting these

	challenges will focus on some key concepts: 1) Creation of an in-depth territory analysis unifying multiple planning domains and able to simulate evolution scenarios; 2) Extensive use of 15 Min methodology and pedestrian/green mobility focus to support life quality and impacts analysis; 3) Permanent integration of local climate resilience challenges at each key milestones of the project.
Digital twin aspect	An urban digital twin can help cities make more informed decisions when it comes to implementing solar energy by helping identify areas that receive sufficient sunlight and are free from shading. By analyzing factors such as the angle and orientation of the panels, shading from nearby buildings or trees and weather patterns, city officials can estimate how much energy the panels will generate over time. Once solar panels have been installed, the urban digital twin can monitor their performance in real time. By analyzing data from sensors installed on the panels, officials can quickly identify any issues that may arise and take action to address them, like adding battery packs for street lighting.

Experts Panel

Affiliation	Expertise Area	Role in Project
UTCB	Digital Twin of Building, Urban development, urban regeneration	Institutional Coordinator
UTCB	Geodesy remote sensing, 3D modeling, geospatial analysis	Institutional coordinator
UTCB	Digital Twin of the building systems	Institutional coordinator
Politehnica Bucharest	Digital Twin, IoT	NetZeroCities coordinator
Politehnica Bucharest	Digital Twin of the Smart Grids	
UTCB	Digital Twin of the systems	
UTCB	Digital Twin of the buildings	Member
UTCB	Digital Twin of the city	Member
UTCB, PROnZEB cluster	Digital Twin of the city	Member
UTCB, Climatosfera	Digital Twin of the city	Member

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
[Current Tech]	[Tools Needed]	[Databases Used]	[Support and Logistics]
Real-time Data Collection Systems	Sensors and IoT devices for data collection Laser Scanners Sattelite Imagery (access to high resolution data)	Structural health monitoring databases, weather data, coastal environmental impact data	Installation and maintenance teams for sensors, data collection infrastructure
Simulation Software	High-performance	Historical data archives, real-time	Technical support for software management,

	computing (HPC) systems, simulation software (e.g., Autodesk, Ansys, CityEngine, AGOL, ArcGIS Urban)	environmental data, urban planning databases	regular updates, and system upgrades
Visualization and Analysis Tools	Data visualization software (e.g., Tableau, Power BI), Geographic Information Systems (GIS)	GIS databases, real-time monitoring data, urban development records	Continuous training for staff on data interpretation and decision-making processes
Predictive Analytics Platforms	Machine learning platforms, AI algorithms GIS software (e.g. ArcGIS Pro, QGIS)	Historical climate data, building performance data, sensor data streams	Skilled data scientists and analysts, AI training and development infrastructure
Communication Technologies	5G networks, cloud data management platforms	Internet of Things (IoT) device data, social networks, public databases	Robust network infrastructure, ongoing network management, cybersecurity measures
Cybersecurity Systems	Advanced cybersecurity solutions	Access logs, transaction logs, user interaction data	Cybersecurity teams, continuous monitoring and threat detection systems
Integration Platforms	Middleware, API management tools	Cross-platform data (e.g., from IoT, social media, city management systems)	Integration specialists, continuous system testing and updates

4.3. Questionnaire completed by UROS

Digital Twin Applications in Coastal Environments – UROS

Field	Description
Specific Application	• Methods of digital twins for the automatic design of sustainable buildings • Modelling (genetic, plant development, abiotic stress) • Remote sensing • Digital Twins for agricultural and environmental applications (including water stress, floods and droughts)
Description of Digital Twin Role	The digital twin approaches contribute to sustainable practices in different disciplines.
Connection to Coastal Context	The application considers environmental conditions of coastal areas, including coastal protection, coastal environment for plant and crop models
Benefits and Challenges	Artificial intelligence (AI) methods for a sustainable construction industry of the future, Optimize sustainable operations, connecting element of the digital twins across the life cycle phases

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
LDAS-MV – LandsurfaceDataAssimilationSystem Mecklenburg-Vorpommern	Improved modeling of agricultural yield and the water cycle for the area of Mecklenburg Western Pomerania by using data assimilation techniques within a digital twin environment. In particular, the Sentinel satellite fleet provides daily updates of surface states, which are assimilated into a land surface model using a Kalman filter family based approach. The digital twin allows us to obtain near future forecasts of agricultural yield by using NWFP and different management scenarios. In such an ensemble based approach, uncertainties int the yield predictions are reduced by each new satellite observation.
Brief Description	Improved modeling of agricultural yield and the water cycle for the area of Mecklenburg Western Pomerania by using data assimilation techniques within a digital twin environment.
Digital twin aspect	Fusion of land surface models, satellite remote sensing data and near sesonal weather predictions to obtain and predict sub-daily surface conditions

Field	Description
NATURE-DEMO	Improved modeling of NATURE-DEMO will validate its general methodology for prioritising Nature-based Solutions and digital twin platforms for protecting infrastructure against climate treats. UROS is responsible for the development of digital twins of the infrastructure using graph neural network models. The project focusses on application in alpine areas, but, methodical approaches are transferable to costal environments.

Brief Description	Development of digital twins of build infrastructure and its natural environment.
Digital twin aspect	Using graph neural network models for automating the development of digital twin models.

Experts Panel

Affiliation	Expertise Area	Role in Project
UROS	Computer science in construction	Team member
UROS	Abiotic stress tolerance and genome-based crop modeling	Team member
UROS	Geoinformatics	Team member
UROS	Agronomy	Lead UROS

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
Combined high-precision 3D measurement system	[Tools Needed]	[Databases Used]	[Support and Logistics]
		Sentinel-1 &-2 datacube over north-east Germany	
Autonomous Monitoring Systems			
Cluster computing system			
Repository of radiative transfer models			

4.4. Questionnaire completed by UNIZD

Digital Twin Applications in Coastal Environments – Related field

Field	Description
Specific Application	Digital Twin for Coastal Sustainably Agriculture
Description of Digital Twin Role	This digital twin supports the food producer in faster and simpler decision-making. It supports the extension process for environment friendly food production through the saving of water as an important natural resource and the timely recognition of harmful organisms for the purpose of targeted protection of plants with as little use of harmful chemicals as possible in the Mediterranean.
Connection to Coastal Context	The application considers the unique climate and environmental conditions of Mediterranean coastal areas, such as high aridity and drought, but to optimize watering performance and chemical consumption.
Benefits and Challenges	The benefits are the simplification of the interface to the manufacturer as support when making important decisions. And the challenges are setting up, processing, transferring and manipulating a large set of data that requires the knowledge of a top IT specialist.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	SAN - Smart Agriculture Network
Brief Description	The "SAN - Smart Agriculture Network" project represents a complete solution that will enable the creation of a system for smart food production based on the IoT (Internet of Things) concept and artificial intelligence with the aim of making timely, precise and correct decisions in the food production process in area of irrigation and plant protection. Research and development project activities were carried out in two phases: industrial research and experimental development.
Digital twin aspect	The project concept is aimed primarily at creating a smart network in olive growing and viticulture, with an emphasis on crops with high added value. The SAN system is designed to monitor all important information in real time, related to temperature (air, soil), humidity (air, soil), intensity of light and photosynthesis, leaf humidity, availability of nutritional elements, soil chemical composition, amounts of electricity used. energy and water, condition of water tanks, speed and direction of wind, monitoring the appearance and height of the population of harmful organisms (fungal diseases and pests of animal origin). With the aim of making recommendations and/or undertaking corrective activities and automation of processes with the aim of creating more optimal agrotechnical conditions in the development stages of a particular culture. The broader concept is the reduction of human work, the emission of greenhouse gases and agrochemicals in the production of water as an important resource for the Mediterranean.

Experts Panel

Affiliation	Expertise Area	Role in Project
University of Zadar	Plant protection and extension expert	Leader - Agronomy
University of Zadar	Water management	Member
University of Zadar	Agronomist – olive grooving expert	Member
"Inovativni sustavi" – private company	IT support – AI expert	Leader - IT

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
Artificial intelligence models for the detection of harmful organisms	Hardware and software support for model development needs	Images of harmful organisms Climatological datasets	System of organization of image and data collection and annotation, and model development. Education system for users, advanced courses for professionals and farmers.
SAN server side	Hardware, software and telecommunications support	Data from sensor elements and external sources	Colocation/cloud server, software code development
Cameras, sensors.	Hardware and software elements that make up the functionality of cameras and water management (eg lenses, sensors, batteries, antennas, housings, SBC, etc.)	Data from the server side and images taken by the cameras and sensors	Development of hardware and software elements of cameras.

Digital Twin Applications in Coastal Environments – Related field

Field	Description
Specific Application	Digital Twin for Coastal Sustainably Agriculture
Description of Digital Twin Role	This digital twin supports the food producer in faster and simpler decision-making. It supports the extension process for environment friendly food production through the saving of water as an important natural resource and the timely recognition of harmful organisms for the purpose of targeted protection of plants with as little use of harmful chemicals as possible in the Mediterranean.
Connection to Coastal Context	The application considers the unique climate and environmental conditions of Mediterranean coastal areas, such as high aridity

	and drought, but to optimize watering performance and chemical consumption.
Benefits and Challenges	The benefits are the simplification of the interface to the manufacturer as support when making important decisions. And the challenges are setting up, processing, transferring and manipulating a large set of data that requires the knowledge of a top IT specialist.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	PESCAR - Pesticide Control and Reduction
Brief Description	In the last few decades, in the area covered by the project, an increased use of pesticides has been observed, and their excessive and uncontrolled use of pesticides causes serious pollution of the environment, nature, food and human health, therefore it is necessary to use pesticides in a strictly controlled manner and to minimize them. The PESCAR project aims to protect the environment and encourage sustainable use of natural resources. Apart from the fact that the project will create prerequisites for the controlled use of pesticides, the knowledge and experience gained through the implementation of the project will be used to strengthen existing institutional capacities. The newly acquired practical knowledge will be the basis for providing a completely new service aimed at farmers: giving recommendations to agricultural producers. One of the output results of the project was the establishment of a sustainable internet site: https://www.agroprognoza.eu/ whose goal is to provide producers with timely recommendations for the sustainable use of pesticides based on agrometeorological data. The described project covers a significantly larger area and is functional even after 4 years from the completion of the project.
Digital twin aspect	The project concept is aimed primarily at creating a decision support to agricultural production in Zadar county, with an emphasis on crops with high added value. The PESCAR is designed to monitor all important information in real time, related to meteorological data temperature (air, soil), humidity (air, soil), intensity of light and photosynthesis, leaf humidity, etc. Then, monitoring of the appearance and height of the population of harmful organisms (fungal diseases and pests of animal origin). With the aim of making recommendations and/or undertaking corrective activities and automation of processes with the aim of creating more optimal agrotechnical conditions in the development stages of a particular culture. The broader concept is the reduction of human work, and establish real time and sefe recommendation support center for decision making processes important for the Mediterranean in clime change threatens.

Experts Panel

Affiliation	Expertise Area	Role in Project
University of Zadar	Plant protection and extension expert	Leader - Agronomy
University of Zadar	Agronomist	Member

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
A network of agrometeorological stations connected as a whole through the agroprognoza.eu system.	Stations and IoT support tools	Meteorological data	Management of the network of agrometeorological stations, management of the website agroprognoza.eu Education system for users, advanced courses for professionals and farmers. Expert for recommendation obtaining.
Sensors.	Hardware and software elements that make up the functionality of agrometeorological stations functioning (stand, measuring devices, batteries, antennas, etc.)	Data from the server side and images taken by the sensors. Stored to server	Development of hardware and software elements of meteorological sensors.

4.5. Questionnaire completed by SETU

Digital Twin Applications in Coastal Environments – Related field

Field	Description
Specific Application	Digital Twin Cities - Establishing a framework to Leverage Digital twins as a tool for de-carbonising the built environment.
Description of Digital Twin Role	A detailed Digital Twin is vital to the successful sustainable development of a city's built environment and infrastructure, specifically the accurate and verifiable monitoring of greenhouse gases reduction, river health and the transition to renewable energy usage. Digital Twin City (DTC) will reshape the city governance structures and rules and inject a continuous momentum for the development and transformation of cities. Many of the important cities around the world have launched plans to build digital twin cities. The rapid development of digital twin technologies has also made it possible to construct digital twin cities.
Connection to Coastal Context	The Digital Twin is based on Waterford City which is situated at the mouth of the River Suir in south east Ireland. Waterford is naturally considered a maritime city with centuries of commerce and development determined by its coastal location.
Benefits and Challenges	The benefit of the initiative is that it will create a digital twin through the lens of energy and sustainability in order to align the processes and philosophies of contemporary digital technologies with the necessary requirement to achieve our zero carbon climatic goals by developing a dynamic framework for an urban Digital Twin. A challenge will be capturing the tangible and intangible historical and cultural elements of this City with Viking origins.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	Cúpla Trá: Combining digital twin technology with landscape biography for environmental analysis of a coastal region (EPA: 2023-NE-1229)
Brief Description	The Cúpla Trá (meaning Twin Beach in Irish) three year project aims to enable an assessment of the natural environment of the region of a coastal region based in County Waterford, in south east Ireland, by employing digital twin technology, whilst being managed and structured around a landscape biography methodological framework. It aims to develop and implement a digital twin platform of the region which will map the current and natural environment of the area, including human and non-human behavioural patterns and use. It will incorporate and integrate existing relevant environmental datasets, along with socio-economic data from inter alia national and local governing bodies, community grassroots organisations and publicly-funded organisations in order to build a comprehensive and holistic model and database of the region. This will allow for a predictive analysis of differing levels of influence and impact

	from these various inter-dependent factors, the balance of human and ecological, which will be the able to feed into future policy to ensure responsible and appreciated usage to protect and restore the local coastal environment.
Digital twin aspect	This is a novel use of the digital twin technology in this type of environment, in building an eco-centric model, rather than with a focus of a built environment, thereby seeking to develop the capabilities of the current technology. It will be combined with an immersive, interactive "mission room" which will be publicly available for stakeholder awareness and participation. The digital twin will be able to capture the dynamic nature of the region and its ecosystem.

Experts Panel

Affiliation	Expertise Area	Role in Project
SETU	BIM, Heritage Built Env.	Coordinator
SETU	Sustainable Buildings	Member
SETU	Landscape Research & Technology	Member
SETU	Digital Construction	Member

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
[Current Tech]	[Tools Needed]	[Databases Used]	[Support and Logistics]

Digital Twin Applications in Coastal Environments – Related field

Field	Description
Specific Application	smartSE
Description of Digital Twin Role	smartSE will be a be 2000m^2, three floor, state-of-the-art smart city experimental facility located in the heart of Waterford City. The facility will look out onto the historic quays of the city. smartSE will transform the city into a living lab, providing innovation actors with an opportunity to leverage high-quality reliable data, access infrastructure and create and test new ideas and solutions that help achieve the strategic objectives of the city and accelerate growth in smart specialisation areas of the region. smartSE places an emphasis on data, innovative solutions and cocreation across the quadruple helix to enable digitalisation and public service, evidence based policymaking, and regional planning. smartSE will offer up-to-date smart technology to demonstrate the need for and benefits of data to local innovation ecosystem and provide the right infrastructure and services for accelerating development and commercialisation of smart city solutions The pillars of activity for *smart*SE include the Innovation Imaginarium, a design-led program to foster startup creation; • the Smart City Experimental Sandbox for testing concepts using regional data; Data Analytic Services

	offering advanced technology and analytical platforms; • Capability Development resources for various users; and • Value creation through a Data Platform to facilitate data trading and sharing, supporting new enterprises and local partnerships.
Connection to Coastal Context	The *smart*SE Initiative will be a cornerstone project in the South-East region of Ireland, a region bounded on two sides by coastline, and will be based in the coastal city of Waterford. The project will aim to transform this coastal region into a data-driven, agile, and innovative hub. A key focus for all actors in the years to 2030 especially, framed by Ireland's commitments under its Climate Action Plan, themselves calibrated according to European targets, will be sustainability. *smart*SE will be a key instrument in enabling local government, other public sector actors, private enterprise, communities and citizens, through data, to understand the city's sustainability related actions and will empower them to act appropriately towards addressing the city's and region's sustainability goals. The smartSE Lab will enhance cross-sectoral collaboration, steering the region away from isolated initiatives towards comprehensive smart development, thereby setting a pathway for an attractive business climate for enterprise generation. The critical need for coherent multi-sectoral action to meet climate change mitigation targets is well established; *smart*SE will be a focal point in the coastal city of Waterford for many actors to come together towards a common goal. The lab will also work to change public perceptions of data, promoting transparency and citizen empowerment. As such the laboratory will be an important instrument for citizen engagement especially with sustainability issues and for community empowerment to foster local action.
Benefits and Challenges	This project offers benefits to citizens, to local government, and to enterprise, as well as to the university. • For citizens, it offers access to the city's data and encourages citizen engagement with city decision-making and citizen empowerment; • For local government, it offers independent, clear data to support decision-making across a range of areas in city management, especially in relation to sustainability challenges; • For enterprise, the facility offers experimental laboratories and access to credible data where new processes, products, and business ideas can be tested and further developed; • For the university, the facility offers a state-of-the-art Smart City laboratory to facilitate research and

	innovation activity in areas of priority for the city and region. Challenges include: • The governance and management of the facility, especially in relation to sensitive data; • The volume of available data; • Initial capital expenditure; • Mobilizing enterprise to engage with the facility.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	[Title of the project]
Brief Description	[A short summary of the project]
Digital twin aspect	[Aspect within the project related to digital twins]

Experts Panel

Affiliation	Expertise Area	Role in Project
SETU	Smart Cities, Enterprise Development	PI
SETU	Urbanisation and urban culture, Regional development policy	Member
SETU	Urbanisation, Equality and Diversity, Smart Cities	Member

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
[Current Tech]	[Tools Needed]	[Databases Used]	[Support and Logistics]

4.6. Questionnaire completed by LRUniv

La Rochelle University (Anaïs Schmitt)

Field	Description
Specific Application	Urban and Coatal Lab La Rochelle (UCLR)
Description of Digital Twin Role	Establishment of a platform dedicated to pooling, exploiting and valorizing data, models and digital tools from the various research laboratories of La Rochelle University. In the short term, the project focuses on developing the platform, collecting and formatting data and models. This area aims to establish a common data management policy within the establishment. In the longer term, the project aims to develop scientific tools to analyze, simulate and promote research results by including digital twins. By contributing to the objectives of La Rochelle University in terms of research, innovation and development, the UCLR project wants to promote a multidisciplinary approach to propose innovative solutions to meet the challenges of sustainable management of coastal territories.
Connection to Coastal Context	The platform aims to collect all the data produced by the laboratories, with a particular focus on data from the La Rochelle region. The mutualization, the simulation and prediction tools which will be made available will aim to assist in decision-making for the sustainable management of the Charente coastline.
Benefits and Challenges	This sharing space is produced with particular attention to interoperability, adopting the principles of open science such as data sharing, transparency, collaboration and reuse of research results. The UCLR project aims to become an accessible and open tool, benefiting both researchers and territorial managers. This open-source development tool will be transposable to other sites.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	UCLR
Brief Description	The Urban & Coastal Lab La Rochelle (UCLR) project represents an ambitious initiative focused on scientific knowledge to improve the understanding and management of a coastal territory subject to strong anthropogenic influence. This project aims to set up a platform of data, models and digital tools from the various research laboratories of La Rochelle University. In the short term, the project focuses on developing the platform, collecting and formatting data and models. This first axis constitutes the development of a common data management policy within the establishment. The first data will be pooled around different case studies to demonstrate the usefulness of an overall vision and to highlight the opportunity for the creation of new multidisciplinary research projects. This sharing space is produced with particular attention to interoperability. By adopting the principles of open science

	such as data sharing, transparency, collaboration and reuse of research results, the UCLR project aims to become an accessible and open tool, benefiting both researchers and managers. of the territory. This project is part of a national perspective through initiatives such as recherche.data.gouv and territorial initiatives through collaboration with the establishment of the TERREZE platform of the LRTZC project. In the longer term, the project aims to develop scientific tools to analyze, simulate and integrate data and models, to collaborate with other actors and to promote research results. By contributing to the objectives of La Rochelle University in terms of research, innovation and development, the UCLR project wants to promote a multidisciplinary approach to urban and coastal management and propose innovative solutions to meet the challenges of sustainable management of coastal territories.
Digital twin aspect	Currently, the focus is on the development of the tool. However, proposing a systemic approach based on the crossing of digital twins associated with data sciences for the holistic modeling of coastal zones subject to human action, and decision support approaches associated with human resources are in progress. deployment with the recruitment of a Junior Chair (start of 2025 for 3/4 years). Job title: JUNIOR CHAIR: “DIGITAL TWINS OF AN ANTROPICAL COAST” –

Experts Panel

Affiliation	Expertise Area	Role in Project
LUDI, La Rochelle University	coordination of actions	Coordination
LUDI, La Rochelle University	development and maintenance of the UCLR tool (2024-2032)	Computer engineer
LUDI, La Rochelle University	Digital twins	Chaire Junior

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
The UCLR project is developing an open-source web platform based on interoperability standards. The first service will include a catalog to share, preserve, cite, explore research data, models and digital tools. The second service is based on TERREZE data platform upgraded with analytics services on-demand to process and	Collect data and access to data is crucial for delivering a robust and high-performance service whether in terms of data locality and data format. In scientific research and data analysis, the ability to reproduce	The data sources come from multidisciplinary use cases that produced structured and unstructured data. The data are stored in heterogeneous databases (flat files, SQL and NoSQL databases) without a	The platform will rely on scalable infrastructures and will be able to be used for distributed and heterogeneous infrastructure (from commodity server (IT management) to HPC clusters (DOREMI mésocentre)).

interpret of coastal data for various scientific, research, and application purposes.	results is critical. The history of processes on datasets and provenance of data enable researchers to recreate experiments and analyses, fostering transparency and peer review.	centralized information system.	

4.7. Questionnaire completed by UCV

Digital Twin Applications in Coastal Environments – Veterinary

Field	Description
Specific Application	Computational biomechanics
Description of Digital Twin Role	The aim of this project is to evaluate the mechanical behaviour of various systems and materials used to stabilise long bone fractures. To this end, non-invasive computational systems are used to reproduce the conditions endured by organisms in vivo.
Connection to Coastal Context	[Explain the relevance to coastal areas]
Benefits and Challenges	Another of the novelties of the project is the generation of translational veterinary/human models to evaluate the use of new implants and materials, as well as to evaluate different configurations of current and future fracture stabilisation systems.

Digital Twin Applications in Coastal Environments – Veterinary

Field	Description
Project Title	“In silico” analysis of Biomechanics models for long bones fractures orthogonal stabilization systems
Brief Description	[A short summary of the project]
Digital twin aspect	[Aspect within the project related to digital twins]

Experts Panel

Affiliation	Expertise Area	Role in Project
UCV	[Orthopaedics, surgery and Biomedicine]	[coordinator]
UCV	[Orthopaedics, surgery and Biomedicine]	researcher
UCH CEU	Engineering	researcher
UCH CEU	Engineering	researcher
UCV	[Orthopaedics, surgery and Biomedicine]	researcher
UCV	[Orthopaedics, surgery and Biomedicine]	researcher

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
[Current Tech]	[Tools Needed]	[Databases Used]	[Support and Logistics]

Digital Twin Applications in Coastal Environments – Veterinary

Field	Description
Specific Application	Utilizing digital modeling via computational fluid dynamics (CFD) to analyze the respiratory and vascular systems in canine, feline, equine, and experimental animals. This approach aims to replicate and comprehend various aspects of these systems while calculating physical variables that are otherwise inaccessible in vivo.
Description of Digital Twin Role	The application of digital twins in biomedical engineering, particularly in biomechanics, harnesses the principles of physics and mechanics to address challenges and explore phenomena within the biomedical domain. Through digital twins, animal organs can be replicated using virtual or digital

	models, capturing their functionalities, properties, and behaviors. This approach yields valuable insights without the need for experimental animal use. Moreover, digital twins enable the replication of medical devices and their interactions with the animal body, facilitating evaluations without the necessity of clinical trials.
Connection to Coastal Context	[Explain the relevance to coastal areas]
Benefits and Challenges	Our focus lies in applying digital twin technology within veterinary medicine to enhance both animal and human health. By employing digital twins, we aim to gain deeper insights into various pathologies, particularly those affecting the respiratory and vascular systems. The advantages of this approach include minimizing the need for animal testing, reducing costs associated with experimental setups, decreasing waste generation, thereby benefiting the environment, and ultimately advancing both animal and human medical practices.

Digital Twin Applications in Coastal Environments – Veterinary

Field	Description
Project Title	Analysis of respiratory and vascular pathologies in domestic and experimental species using advanced imaging techniques and computational fluid dynamics.
Brief Description	This project aims to utilize computational fluid dynamics (CFD) in clinical applications concerning the respiratory and vascular systems of various animal species, including canine, feline, equine, and experimental animals. It involves a non-invasive technique capable of simulating in silico phenomena related to respiratory mechanics, cardiovascular biomechanics, medical device interactions, and pathology treatments, among other aspects. Currently, our research involves evaluating upper airway resistance, flows, and pressures in cats by comparing those intubated with an endotracheal tube to those with a supraglottic device (V-Gel) under general anesthesia. Additionally, we are investigating and contrasting the transport and deposition of aerosol particles (such as salbutamol and fluticasone) in healthy cats and dogs with lower airway pathology, all under general anesthesia. Furthermore, our project includes studying the correlation between velocities and pressures obtained via echocardiography and computational fluid dynamics in both healthy and pathological subjects. We are also actively engaged in the development of a novel biodegradable, 3D-printable, and customizable airway stent. This endeavor encompasses innovative digital design, computational simulations, 3D printing utilizing new absorbable materials, and experimental animal models. The primary objective is to investigate the interaction between biodegradable stents and biological tissue for potential clinical applications.

Digital twin aspect	The digital twin is crucial for this project that revolve around replicating animals with utmost fidelity, encompassing their properties, characteristics, and behaviors through computerized virtual models. These models can function independently or be integrated with other virtual systems, facilitating the design and analysis of interactions, such as the interaction of medical devices with biological tissue. Our specific focus lies in utilizing virtual animal models generated via numerical algorithms and three-dimensional geometries derived from medical images to deepen our understanding of animal pathologies and enhance their treatments, ultimately advancing animal healthcare. While the application of biomedical engineering in human medicine has a long history of success, its direct applicability to veterinary medicine is equally promising. Computational modeling based on patient-specific images, including computed tomography and magnetic resonance imaging, allows for the extraction of physical variables and mutual interactions between living tissue and medical devices that are otherwise inaccessible in vivo, both in animals and humans. By utilizing these technologies, we aim to bridge the gap between human and veterinary medicine, leveraging cutting-edge computational approaches to drive advancements in both fields.

Experts Panel

Affiliation	Expertise Area	Role in Project
[Universidad Pública de Navarra]	[Engineering]	Coordinator
[Universidad Católica de Valencia]	[Veterinary]	Coordinator
[Universidad Católica de Valencia]	[Veterinary]	PhD Student
[Universidad Católica de Valencia]	[Veterinary]	PhD Student

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
The available equipment and resources include a Computational Tomography at our Veterinary Teaching Hospital UCV (Universidad Católica de Valencia) from were CT images can be obtained in DICOM (Digital Imaging and Communications in Medicine) format; a visualization software though the imaging viewer (Horos viewer v.4.0.0 RC5, 64-bit,	All the software needed, as Horos viewer (v.4.0.0 RC5, 64-bit, HorosTM, Brooklyn, NY, USA), the image-based geometry reconstruction software (MIMICS, Materialise Software, Leuven, Belgium), the	All Computational and Magnetic Resonance images are obtained from clinical or experimental cases at the Veterinary Teaching Hospital UCV.	4 persons of 2 different institutions compose the expert panel. It is necessary cover travel expenses for programmed visits, meeting and brainstorming between the cities hosting the 2 institutions (Valencia and Pamplona).

HorosTM, Brooklyn, NY, USA). To process the medical images and generate the image-based geometry the reconstruction software MIMICS (Materialise Software, Leuven, Belgium) is available. Then, to generate the digital models and to obtain the required physical variables, a finite elements-based software is available (Ansys 2020 R2, Ansys Inc., Canonsburg, PA, USA). Finally, the virtual geometries are generated using the computer aided design software Rhinoceros (v.7, Robert McNeel and Associates, Seattle, WA, USA).	virtual modeling software (Ansys 2020 R2, Ansys Inc., Canonsburg, PA, USA, and the CAD software Rhinoceros (v.7, Robert McNeel and Associates, Seattle, WA, USA)) require annual licensing and maintenance.		

Digital Twin Applications in Coastal Environments – Related field: Marine biology

Field	Description
Specific Application	Circalitoral benthic community exploration and restoration
Description of Digital Twin Role	[Ed maps of the seabed, cataloguing the marine community and the impacts for future restoration. This thesis is linked to ThinkinAzul project and a new project “Scientific study and assessment for habitat restoration by removal of marine litter in Ifach marine Area (Alicante, Spain)”]
Connection to Coastal Context	[Use of R.O.V., side scan sonar, bathymetry and SCUBA diving to explore the circalittoral seabed (range -30 to -60 m depth to evaluate the conservation status, the sources of impact and the capability for restoration and habitat improvement.]
Benefits and Challenges	[Improvement if the environmental quality of the coast and Natura 2000 habitats]

Digital Twin Applications in Coastal Environments – Marine Biology

Field	Description
Project Title	ThinkinAzul project and a new project “Scientific study and assessment for habitat restoration by removal of marine litter in Ifach marine Area (Alicante, Spain)”]
Brief Description	[A short summary of the project]
Digital twin aspect	[Aspect within the project related to digital twins]

Experts Panel

Affiliation	Expertise Area	Role in Project
[UCV (IMEDMAR-UCV)]	[Marine Biology]	[Principal researcher]
[UCV (IMEDMAR-UCV)]]	[Marine Biology]	[Principal researcher]

Digital Twin Applications in Coastal Environments – Related field
Walkable cities: the case of Valencia

Field	Description
Specific Application	Walkable cities: the case of Valencia
Description of Digital Twin Role	This project aims to promote physical activity (PA) at the population level in neighborhoods with low walkability levels in the city of Valencia, Spain. This increase in PA is intended to be achieved through the implementation of digital urban trails. The purpose is to encourage the population to increase their weekly number of steps, in order to prevent non-communicable diseases, reduce car use as well as air pollution that affects coastal health, and promote a more sustainable health system.
Connection to Coastal Context	This project, which increases physical activity in neighborhoods with low walkability levels, presents an important connection with the health of the city's coast, which extends through several interrelated aspects. By actively promoting a more active and healthy lifestyle among residents, we not only address the challenge of improving public health and reduce diseases related to physical inactivity, but also generate beneficial indirect impacts on the coastal environment. Promoting physical activity leads to a decrease in motor vehicle use, which in turn reduces air pollution, a critical factor affecting air quality throughout the region, including coastal areas. This reduction in air pollution has positive effects on water quality and marine biodiversity by minimizing the entry of air pollutants into the aquatic environment. Furthermore, by encouraging people's connection with nature through outdoor physical activity, greater environmental awareness and more responsible care of coastal ecosystems is promoted, which contributes to their long-term preservation. In summary, the project not only seeks to improve the health and well-being of residents, but also aims to protect and conserve the natural coastal environment, thus creating a positive and sustainable impact on the health of Valencia's coast.
Benefits and Challenges	The benefits are numerous. In the short term there is the increase in physical activity (PA) at the population level at a really low environmental and economic cost, since this is being carried out through digital trails, that is, its layout will be followed by an APP, avoiding the economic and environmental cost of building up a physical path. Also in the short term, increases in PA will lead to an improvement in the psychological and physiological well-being of citizens. In the medium term, this increase in PA will lead to a lower onset of non-communicable diseases or a better evolution of those that have already started, which would reduce the economic impact that these diseases have on the public health system. Apart from the health advantages, there are others at an economic and environmental level. On the economic side, increasing PA within a neighborhood means more physical

	exposure to local businesses, which could increase the purchase of products within the neighborhood, favoring the microeconomy. On the environmental side, this purchase of local products also reduces the maritime transport of goods and the use of ports, which greatly pollutes the coasts. Furthermore, getting the population used to walking could cause daily walking trips to increase and car transportation to decrease in the medium term, which would reduce atmospheric pollution and water pollution. Of course, WCP will face different challenges. For example, how to motivate a population with low walking motivation to increase their weekly steps, or how to monitor the population to confirm this increase in PA. However, there is a plan to mitigate these obstacles, such as awareness talks in the social venues of each neighborhood, the creation and use of an APP to remind and encourage people to take their daily steps, and different local collaborations.

Digital Twin Applications in Coastal Environments Walkable cities – Anthropology and sport

Field	Description
Project Title	CityWalk - Towards energy responsible places: establishing walkable cities in the Danube Region
Brief Description	The CityWalk project is helping 10 cities in the Danube region to reduce emissions, noise and street congestion through a range of measures that promote more sustainable forms of mobility. The emphasis is on improving conditions for pedestrians to make cities more liveable, safer and healthier places.
Digital twin aspect	Both projects (Walkable Cities and CityWalk) share common points related to the walkability of cities, reducing pollution and improving people's health: 1. Focus on urban walkability: Both the project in Valencia and the CityWalk project in the Danube region are focused on improving walkability in urban environments. Both point out that promoting walking as a means of transportation has strong, significant benefits for public health and community well-being, both in the short and long term. 2. Implementation of digital urban trails: Both are using digital technology to encourage physical activity and walkability in cities. While in Valencia digital urban trails are implemented through an APP, the CityWalk project develops a "walking toolkit" that includes online resources to share good practices and solve common problems. 3. Pollution reduction: Both projects recognize the crucial role that promoting walking plays in reducing pollution. In Valencia, it is expected that increasing physical activity and reducing car use will contribute to reducing air pollution, while the CityWalk project goes one step further, seeking to change the design of streets to prioritize pedestrians. on the car, which has a positive impact on air quality at a higher economic cost. 4. Health benefits: Both projects highlight the health benefits associated with promoting walking. In Valencia, the increase in physical activity is expected to lead to an improvement in the

	psychological and physiological well-being of citizens, as well as a lower occurrence of non-communicable diseases. In summary, both the project in Valencia and the CityWalk project share the vision of promoting urban walkability as a way to improve people's health and reduce environmental pollution in cities. Both projects also recognize the value of using innovative technology and tools to achieve these goals.

Experts Panel

Affiliation	Expertise Area	Role in Project
Catholic University of Valencia	Anthropology	Coordinator
Catholic University of Valencia	Sports Science	Member
Catholic University of Valencia	Sports Science	Member
Catholic University of Valencia	Sports Science	Member
Catholic University of Valencia	Sports Science	Member

Resources and Infrastructure

Field	Description
Available Technologies	The technology to use is varied and accessible. On the one hand, an application of statistical analysis would be necessary to quantify the physical activity of the residents (see the Logistics section). On the other hand, an APP would be needed to create the route and have citizens follow the route through it.
Required Tools	The necessary tools, beyond those specified in the Available Technologies section, would be the IPAQ-S questionnaire to quantify the physical activity of citizens.
Data Sources	This work is based on the improvement of specific neighborhoods. In this way, the first step is to identify which neighborhoods are walking the least. This must be done by analyzing the built environment and quantifying the physical activity of its citizens. And once the neighborhoods that walk less have been identified, the project can be carried out.
Logistics Needs	The logistics level revolves around different axes. Regarding the creation of the routes, they should consider the weekly physical activity recommendations of the World Health Organization. That is, the routes must encourage people to meet or exceed these recommendations. On the other hand, there must be a study of the terrain so that the route layout connects both the green areas of the neighborhood and certain local businesses. Scientific evidence shows both that exposure to urban green areas increases the feeling of well-being and that physical proximity to shops can increase purchases in them. Likewise, the route must be accessible to both young people and those with reduced mobility due to age or illness. As for the application to use to create the routes and for citizens to follow, it must be known which application is the one most accepted by citizens (in the case of Spain, we identified two applications: Strava and Wikiloc). Regarding the dissemination of the routes and awareness days, the leisure centers and cultural centers of the neighborhood must be identified to hold these days there.

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
[Current Tech]	[Tools Needed]	[Databases Used]	[Support and Logistics]

Field	Description
Available Technologies	The suite of available technologies includes Building Information Modeling (BIM) software for comprehensive architectural and engineering design, digital twin platforms for real-time building performance simulation, IoT devices for granular data collection, and smart sensors capable of capturing a wide range of environmental and operational parameters.
Required Tools	Essential tools encompass sophisticated data analytics and visualization software to make sense of complex datasets, machine learning algorithms for predictive analytics and optimization of energy consumption, integration platforms to facilitate seamless communication between BIM, digital twins, IoT data streams, and smart sensors, as well as big data management solutions to handle the volume, velocity, and variety of data generated.
Data Sources	Key databases utilized are enriched by proprietary BIM libraries, extensive sustainability and energy performance benchmarks, comprehensive repositories of IoT and smart sensor data capturing real-time building operations, alongside big data sets that include local environmental conditions, occupancy patterns, and energy grid analytics.
Logistics Needs	Logistics demands include a robust and scalable cloud computing infrastructure to support extensive data storage and processing capabilities, advanced professional training programs to upskill staff in utilizing digital and smart technologies for sustainability assessments, and a comprehensive network of technical support for the installation, maintenance, and upgrading of IoT devices, smart sensors, and related monitoring systems.

Digital Twin Applications in Coastal Environments – Medical simulation training

Field	Description
Specific Application	Digital twin for medical simulation training and evaluating tools.
Description of Digital Twin Role	This project will unify two different digital twins, on one hand CAE Maestro Evolve is an interactive virtual learning platform with unlimited possibilities for medical training and content development with virtual patients, virtual medical equipment, various teaching tools and continuous stream of pre-programmed Simulated Clinical Experiences (SCEs). On the other hand, teaching will be evaluated through a digital application where each teacher can organize pre- and post-simulation exams, the number and difficulty of the questions can be chosen from an extensive pool of questions. The difference between the pre and post exams will give us an evaluation of whether the main objectives are met and where we can improve.
Connection to Coastal Context	The application considers the unique microclimate and environmental conditions of coastal areas to optimize simulation and training performance. As well as the different pathophysiologies of coastal areas will be included in the simulation clinical cases.
Benefits and Challenges	Benefits include improved education for medical students. The possibility of developing the clinical eye and decision-

	making abilities in stressful situations. In addition to being able to equalize and promote homogeneity in medical training at the European level. Challenges encompass the complexity of integrating simulation data, creating and optimizing a sufficiently extensive and accurate database of questions to evaluate simulations; and create enriching virtual experiences for students.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	UCV Evolve-Evalue
Brief Description	This project will unify two different digital twins, on one hand CAE Maestro Evolve is an interactive virtual learning platform with unlimited possibilities for medical training and content development with virtual patients, virtual medical equipment, various teaching tools and continuous stream of pre-programmed Simulated Clinical Experiences (SCEs). On the other hand, teaching will be evaluated through a digital application where each teacher can organize pre- and post-simulation exams, the number and difficulty of the questions can be chosen from an extensive pool of questions. The difference between the pre and post exams will give us an evaluation of whether the main objectives are met and where we can improve.
Digital twin aspect	This digital twin shows a simulated patient, to which the teacher can assign all types of pathologies, physiological values and responses can be altered according to the students' interactions. Students can enter the simulation room and interact with the patient according to their own suspicions, knowledge and skills. On the other hand, the evaluation tool can be accessed remotely from any device connected to the network. The teacher selects the topic, number and complexity of the questions and an exam is created. The questions change in order and the answers also between each student. The exam is repeated before and after the simulation. The app shows statistics about learning.

Experts Panel

Affiliation	Expertise Area	Role in Project
Universidad Católica de Valencia Hospital Arnau-Lliria	Intensive care medicine Bioethics Education and Simulation	Coordinator
Universidad Católica de Valencia. Advanced simulation center, Hospital Virtual	Simulation Tecnician	Member

Resources and Infrastructure

Field	Description
Available Technologies	The available technologies include CAE Maestro Evolve software in demonstration mode, which allows us limited use of the resource. And the application developed for our university UCV Evalua, which currently has a pool of about 500 questions, whose use has already been tested.
Required Tools	Expanded access to the CEA maestro evolve tool will be needed and the UCV evalua question pool will be expanded, as well as perhaps expanded or improved exam access and editing.
Data Sources	The main data sources will be the exams taken by the students before and after the simulation.
Logistics Needs	Logistical demands include a robust and scalable cloud computing infrastructure to support extensive data storage and processing capabilities, advanced professional training programs to enhance staff skills in the use of digital and smart technologies (UCV evaluates and CAE Maestro evolve specifically) and technical support for the development, maintenance, and updating of the UCV evalua application.

Digital Twin Applications in Coastal Environments – Sport & Health Sciences: Exercise Training based on Augmented Reality with Diabetic Populations

Field	Description
Specific Application	Digital Twin for Exercise Training based on Augmented Reality with Diabetic Populations
Description of Digital Twin Role	This digital twin application helps to improve the resources for medical doctors, nurses, physical activity teachers, coaches and families related to physical activity and diabetes, using digital technology (innovative mobile augmented reality technology) for achieving the health goals giving a digital dimension.
Connection to Coastal Context	This project aims to promote inclusion in sport, promote health-enhancing physical activity for people with diabetes type I and II, encourage healthy lifestyle and raise awareness of the added value of sport and physical activity in coastal cities, using environment and outdoor activities (geofencing app) to develop these goals.
Benefits and Challenges	During the the project life´s time we will involve a significant number of volunteers and diabetic athletes from the participating sport organizations and diabetes association. The volunteers will participate to the videos that will be incorporated in our mobile apps aiming to encourage diabetic people to physical activity. Our project's outputs can be used to diabetic patients of both type I and II. As a consequence the project deliverables have the potential to be tested by a large number of young athletes/teachers/coaches belonging to our target groups originating from other European countries too. Additionally, there is a high potential to develop recommendations for sport policy makers related to health enhancing physical activity for disadvantaged groups. The digital outputs of our project will be open licensed and therefore accessible through Google Play, Apple store and WWW. This project will face different challenges: how to increase the motivation of Diabetic population to use the App and follow the monitoring program (pre- during and post intervention) to evaluate the effects of the intervention. However, the design of the APP and connection with other free plattforms (e.g., Strava, Polarflow, Health,…) will help us to evaluate the increase of PA. Moreover, the Partner institutions have associations, collaborators and links with a significant number of other European sports and diabetes associations and plan to disseminate the Project's outputs to local, national and European level. A dissemination and communication plan will be developed in order to give publicity to the project’s results and reach sports associations, schools, universities, diabetic associations all over Europe.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	DART- Diabetes- Augmented Reality Training- http://dartproject.eu/index.html
Brief Description	There is growing evidence to suggest that coronavirus might cause diabetes in some people or make the condition worse for others. Since, the numbers of those who will suffer from diabetes will grow in future years, it is important to find innovative ways that will motivate children and adults suffering from Diabetes type I or II to improve their health condition through physical exercises and active participation in sport life. DART project aims to promote synergies between sport and health, promote inclusion in sport, promote health-enhancing physical activity for people with diabetes type I and II, encourage healthy lifestyle and raise awareness of the added value of sport and physical activity. DART objectives will be achieved through the design and implementation of innovative digital tools and training e-modules. Specifically, DART project will develop and implement: a) an innovative, fun and eco-friendly Mobile app in 7 language versions using an Augmented reality Personal trainer teaching diabetic patients specialized physical exercises that will help reduce blood pressure, lower the levels of fats in the blood, keep the heart healthy, improve blood sugar levels and prevent excess weight gain. Also, the app will include geofence technology for outdoor activities, a customized calendar for inserting medicines, doctors' appointments etc. and an insulin dose reminder; b) 30 interactive e-modules based on Moodle targeting Physical Education teachers including series of Podcasts; c) Awareness raising Events (Multiplier and live streaming) targeting a wider audience of Diabetic patients (type I and II) and their families from all countries involved and above. DART consortium is consisted of 7 institutions experienced in all related fields (education, sport, medicine, technology) from 6 countries. DART outputs' will be tested to a large number of patients and physical education teachers. Results and recommendations will be included in special reports.
Digital twin aspect	This digital twin let to work in cooperation in different countries (the tool will be designed in 7 different languages) and context (education, training, medicine, family,…), to check the effectiveness of intervention using AR tech and online education on patients´s health indicators and patterns of PA habits. On the other hand, the evaluation data can be accessed remotely from any device connected to the network.

Experts Panel

Affiliation	Expertise Area	Role in Project
Catholic University of Valencia	Physical Education & Sport Sciences	Coordinator
Catholic University of Valencia	Physical Education & Sport Sciences	Member
Catholic University of Valencia	Physical Education & Sport Sciences	Member

Catholic University of Valencia	Physical Education & Sport Sciences	Member
Catholic University of Valencia	Physical Education & Sport Sciences	Member
Catholic University of Valencia	Nursing	Member
Catholic University of Valencia	Nursing	Member
Catholic University of Valencia	Nutritionist	Member

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
The suite of available technologies includes software and human resources in charged of development of App tool. For health and physical testing we count on laboratories, instruments and human resources with expertise in analyzing data related with health and fitness testing.	-	-	-

Digital Twin Applications in Coastal Environments – Healthy lifestyles

Field	Description
Specific Application	Health
Description of Digital Twin Role	Exploring why healthy lifestyles contribute to enhancing resilience and brain health: Understanding the relationship between healthy lifestyles and cognitive well-being is paramount in promoting overall resilience and brain health. Research suggests that adopting healthy habits such as regular physical activity, balanced nutrition, sufficient sleep, stress management, and cognitive stimulation can significantly impact brain function and resilience.
Connection to Coastal Context	Smart and healthy cities
Benefits and Challenges	Benefits: Healthy lifestyles promote brain health by supporting cognitive functions such as memory, attention, and executive function, leading to improved mental acuity and overall cognitive performance. Resilience Against Age-Related Decline: Adopting healthy habits such as regular physical activity, balanced nutrition, and stress management can mitigate the effects of aging on the brain, enhancing resilience and reducing the risk of cognitive decline and neurodegenerative diseases such as Alzheimer's. Challenges: Motivation and Adherence.

Digital Twin Applications in Coastal Environments – Brain Health – medical research

Field	Description
Project Title	Brain Health and Resilience Valencia Challenge
Brief Description	

	A collaborative research and innovation proposal is underway to establish in Valencia an internationally recognized hub for the study of resilience and brain health. The challenge involves creating a people-centered ecosystem of excellence, co-created and co-developed by participants. Coordinated from UCV (Catholic University of Valencia) and open to participation from universities within the Community, nationwide, and from other countries. This hub aims to bring together businesses, technological and innovation centers, as well as healthcare institutions. See: https://saludcerebral.ucv.es/ Moreover, neuromodulation is a pivotal component of this initiative, leveraging advanced techniques such as Transcranial Magnetic Stimulation (TMS). By integrating neuromodulation into our research framework, we aim to explore the direct modulation of brain activity to enhance resilience and promote brain health.
Digital twin aspect	To come across cultural issues (e.g., blue areas) to carry out cross-cultural comparisons.

Experts Panel

Affiliation	Expertise Area	Role in Project
UCV	Medicine	Main researcher
UCV	Cognitive neuroscience	coordinator
UCV	Psychology	coordinator
UCV	Psychology	coordinator
UCV	Medicine	coordinator
UCV	Nutrition	coordinator
UCV	Nutrition	coordinator
UCV	General Health	coordinator
UCV	Sport	coordinator
UCV	Engineering	coordinator
UCV	Project manager	Project manager

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
[Current Tech]	[Tools Needed]	[Databases Used]	[Support and Logistics]

Digital Twin Applications in Coastal Environments – Health

Field	Description
Specific Application	Health
Description of Digital Twin Role	The aim of this project is to examine spontaneous language components through Natural Language Processing. Gather a diverse range of linguistic data from older adults, including conversations, written texts, and other forms of language production. Moreover support on IT solutions for this field would be of interest.
Connection to Coastal Context	Smart cities

Benefits and Challenges	Benefits: i) Personalized Interventions: Insights into an individual's cognitive functioning, enabling tailored interventions and support strategies to address specific cognitive strengths and weaknesses; ii) Remote Monitoring: Digital twins can facilitate remote monitoring of cognitive health by analysing language data collected through digital communication platforms or wearable devices, offering a non-intrusive and convenient way to track cognitive changes over time. Challenges: Data Privacy and Ethical Concerns. Collecting and analysing sensitive linguistic data raise concerns about privacy, informed consent, and data security, necessitating robust ethical guidelines and safeguards to protect participants' confidentiality and rights.

Digital Twin Applications in Coastal Environments – Health- Cognitive abilities in older adults

Field	Description
Project Title	NONNA (a**N**alysing c**O**gnition through **N**atural la**N**guage in older **A**dults)
Brief Description	NONNA is a research project exploring how spontaneous language use can reveal insights into cognitive abilities in older adults. By analyzing natural language patterns, the project aims to understand cognitive processes related to aging, ultimately leading to better detection and intervention strategies for cognitive decline.
Digital twin aspect	Diverse range of linguistic data and IT support

Experts Panel

Affiliation	Expertise Area	Role in Project
UCV	Medicine	Main researcher
UCV	Cognitive neuroscience	Coordinator
UCV	Project manager	Project manager

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
[Current Tech]	[Tools Needed]	[Databases Used]	[Support and Logistics]

4.8. Questionnaire completed by KU

Klaipeda University

Field	Description
Specific Application	Digital Twin for Thermochemical Heat Upgrade System
Description of Digital Twin Role	The digital twin will serve as a comprehensive simulation model of the entire system solution, encompassing components such as heat exchangers, tanks, and pumps. By integrating the selected components, thermodynamic parameters for optimal performance, and specific design choices, the digital twin will enable accurate representation and analysis of the system. This simulation will facilitate the evaluation of various application scenarios, ensuring that the system operates at maximum efficiency and effectiveness.
Connection to Coastal Context	In a coastal context, the system can incorporate sustainable energy sources such as wind and wave energy, leveraging the natural resources available in coastal regions. This integration not only enhances the system's sustainability but also optimizes energy usage by harnessing renewable coastal energy sources. The digital twin becomes a vital tool for optimizing thermochemical heat upgrade systems in coastal environments, aligning technological performance with environmental sustainability.
Benefits and Challenges	The digital twin offers enhanced efficiency and sustainability by optimizing the thermochemical heat upgrade system and integrating renewable coastal energy sources like wind and wave energy. It ensures environmental compliance, resilience to coastal challenges such as sea level rise and extreme weather, and optimal use of coastal resources, leading to cost savings and economic benefits for local communities. However, challenges include the complexity of simulations, data quality issues, integration of renewable sources, uncertainty in long-term environmental impacts, regulatory hurdles, maintenance needs, high initial costs, and the requirement for specialized technical expertise. Despite these challenges, the digital twin remains a vital tool for maximizing system performance and sustainability in coastal contexts.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	TechUPGRADE (HORIZON-CL5-2022-D4-01, GA 101103966)
Brief Description	Waste heat recovery is a crucial industrial method that aligns with ecological goals, aiming to improve energy and cost efficiency while reducing waste. Due to its significance, various innovators are actively seeking ways to optimize, enhance and increase the efficiency and output of this technology, to meet ecological and energy efficiency standards. One of these innovative projects is the EU-funded TechUPGRADE, which aims to demonstrate and validate an innovative thermochemically operating technology capable of reaching much higher temperature levels, all while maintaining a superior level of safety, cost-effectiveness and energy efficiency compared to competing technologies. Furthermore, the technology's adaptability allows easy integration into systems that use renewable energy, while offering enhanced durability and reduced energy costs.
Digital twin aspect	Digital twins are the crucial role of the operation management of the system, particularly in measuring thermophysical properties and developing a robust control system. It highlights the need for high time resolution monitoring and autonomous operation, requiring minimal human intervention. Control

	principles, incorporating system behavior knowledge, must react quickly to uncertainties, aided by technologies like artificial intelligence, data mining, deep learning, and predictive control. These advanced techniques optimize energy consumption and ensure the quality of controlled parameters, such as deviations from set points and convergence speed. The integration of these control strategies into the digital twin software is essential for ensuring the system's reliability and optimization.

Experts Panel

Affiliation	Expertise Area	Role in Project
Klaipeda University	R&D of data acquisition, communication systems	Coordinator
Klaipeda University	Artificial Intelligence	Member
Klaipeda University	Advanced Control Systems	Member
Klaipeda University	Data Acquisition, LabVIEW programming	Member
Quanterall LTD	Software Development	Member

Resources and Infrastructure

Field	Description
Available Technologies	The suite of available technologies includes simulation modeling software for comprehensive engineering design, digital twin platforms for real-time building performance simulation, IoT devices for data collection, and smart sensors capable of capturing a wide range of environmental and operational parameters. The Informatics and Statistics Department boasts several state-of-the-art laboratories: Computer Simulation Modeling and Data Analysis, Software Systems Engineering, Professor A. A. Bielskis Applied Robotics, Artificial Intelligence Systems and Embedded Systems Programming, Software and Information Systems Engineering, Virtual Instruments and Computer Networks, Advanced Control Systems, Artificial Intelligence and Autonomous Systems, Computer Vision and Optics, Analog and Digital Electronics, and Computer Systems Engineering. These facilities are equipped with advanced equipment to support cutting-edge research and development in their respective fields.
Required Tools	Essential tools include sophisticated data analytics and visualization software for interpreting complex datasets, machine learning algorithms for predictive analytics and optimizing energy consumption, and integration platforms that enable seamless communication between digital twins, IoT data streams, computer vision cameras. Additionally, big data management solutions are crucial for handling the volume, velocity, and variety of generated data. The integration of high-performance computing (HPC) and advanced edge computing technologies is also vital, ensuring rapid data processing and real-time analytics. These technologies collectively enhance the efficiency and effectiveness of managing and optimizing building performance and energy systems.
Data Sources	Data sources include real-time sensor data on temperature, humidity, air quality, and energy usage; IoT device data from smart thermostats, weather data; utility data from energy providers; operational data from building management and SCADA systems; occupancy data from sensors and security systems; maintenance records from CMMS; financial data on energy and operational costs; external databases with industry benchmarks and standards; health and safety data on air quality and emergency systems. Integrating and analyzing these data sources provides comprehensive insights for optimizing building performance,

	enhancing energy efficiency, and improving occupant comfort and safety.
Logistics Needs	Logistics requirements encompass a robust and scalable cloud computing infrastructure to support extensive data storage and processing capabilities. Additionally, advanced professional training programs are essential to upskill staff in utilizing digital and smart technologies for sustainability assessments. A comprehensive network of technical support is also necessary for the installation, maintenance, and upgrading of IoT devices, smart sensors, and related monitoring systems.

4.9. Questionnaire completed by AUA

Digital Twin Applications in Coastal Environments – Related field

Field	Description
Specific Application	Digital Twins for Crop Monitoring
Description of Digital Twin Role	Digital twins can leverage data-driven approaches to manage agricultural activities near coastal areas. These areas often have unique environmental conditions and challenges, such as saltwater intrusion, coastal erosion, and specific microclimates. Digital twins can simulate these conditions and optimize agricultural practices to ensure sustainable and resilient crop production. They help in monitoring soil health, water quality, and crop growth while minimizing environmental impacts, thus supporting coastal agricultural sustainability and aligning with broader environmental goals.
Connection to Coastal Context	They integrate real-time data from sensors, satellite imaging, and weather stations to monitor crop health continuously. Using AI and machine learning, digital twins predict crop growth stages, potential diseases, and pest outbreaks, allowing for proactive management. They simulate various field conditions to assess their impact on crop development, helping optimize irrigation, fertilization, and pesticide application. Digital twins detect anomalies like pest infestations or nutrient deficiencies early, enabling quick corrective actions. They support informed decision-making by providing insights and recommendations based on data analysis and simulations, continuously refining their models for improved accuracy and reliability.
Benefits and Challenges	Digital twins offer significant benefits in managing agricultural activities, particularly in coastal areas with unique challenges like saltwater intrusion and coastal erosion. They optimize farming practices, monitor soil health, water quality, and crop growth, and minimize environmental impacts, promoting sustainable and resilient crop production. However, challenges include integrating diverse data sources, ensuring technical accuracy, scalability across different regions, and overcoming adoption barriers among farmers unfamiliar with advanced technologies.

Digital Twin Applications in Coastal Environments – Related projects

Field	Description
Project Title	Smart Droplets HE Project
Brief Description	The Smart Droplets project aims to reduce pesticide and fertilizer use in agriculture through advanced technologies. By integrating AI, data, and robotic systems, Smart Droplets enhances crop monitoring, optimizes resource usage, and ensures precise chemical application. The project focuses on creating digital twins for real-time field simulations and deploying autonomous spraying systems. These innovations support the EU Green Deal goals by promoting sustainable farming practices, reducing environmental impact, and improving agricultural efficiency.

Digital twin aspect	Digital twins in the Smart Droplets project enhance agricultural practices by predicting crop growth and diseases, optimizing chemical spraying, and detecting anomalies for quick action. They simulate scenarios for better resource use, integrate with autonomous systems for efficient field operations, and assess environmental impacts like emissions and water usage. Additionally, they predict yields, aiding in harvest planning. These applications support sustainable farming and EU Green Deal targets.

Experts Panel

Affiliation	Expertise Area	Role in Project
Professor Department of Natural Resources Development and Agricultural Engineering belongs to the School of Environment and Agricultural Engineering	Agricultural buildings	Project coordinator for AUA
Wageningen University	Ioannis N. Athanasiadis is a Professor of Artificial Intelligence and Data Science at Wageningen University and Research. He investigates the enabling role of artificial intelligence for understanding nature, and big data science applications that relate to environment, agriculture, food and the quality of life. His expertise lies with machine learning, big data, and knowledge engineering.	Leader of the Digital Twin Creation
Wageningen University	Researcher on the development and integration of machine-learning methods for data-driven decision making in agriculture, from yield prediction to fertilizer optimization.	Employing Reinforcement Learning to find data driven policies for reducing the use of nitrogen and pesticides while maintaining or increasing crop yields.

Resources and Infrastructure

Available Technologies	Required Tools	Data Sources	Logistics Needs
AI and Machine Vision: Utilizing AI models based on advanced architectures like CNNs and Transformers, combined with machine vision systems for anomaly detection and	AI and Machine Vision Systems: Advanced AI models like Convolutional Neural Networks (CNNs) and Transformers,	Weather Data Soil and Water Monitoring Crop Growth Data Pesticide Application Data Geospatial Data	Big Data Management Platforms: managing and processing large heterogeneous data streams efficiently. Digital Twin Framework: Integrates

crop monitoring. These AI models are optimized for deployment on edge devices for real-time processing . Process-Based Models: Incorporating agronomic models to simulate biological mechanisms and predict vegetation growth, nutrient uptake, and pest outbreaks. This helps in providing precise recommendations for farm management operations . Data Management Platforms: Using big data solutions like Apache Kafka and Apache Spark to manage and process large heterogeneous data streams. This platform ensures high performance and scalability for maintaining digital twins and training AI models . Digital Twin Framework: Creating dynamic virtual representations of physical farms that integrate multiple data streams for a comprehensive view of temporal and spatial farm phenomena. This framework supports the development and maintenance of digital twins for various crops and field systems .	optimized for real-time processing on edge devices, are used for anomaly detection and crop monitoring. Process-Based Agronomic Models: These models simulate biological mechanisms to predict crop growth, nutrient uptake, and pest outbreaks, providing precise farm management recommendations. Big Data Management Platforms: Tools like Apache Kafka, Apache Spark, RabbitMQ, AWS Kinesis, and Azure Stream are used for high-performance data processing and management of heterogeneous data streams. Digital Twin Framework: This framework integrates multiple data streams for a comprehensive virtual representation of farm phenomena, enabling real-time simulations and predictions. Interoperability Standards: Ensuring data exchange and	(GNSS) Historical Data Farm Management Systems (FMIS)	multiple data streams for comprehensive virtual representations of farm phenomena, enabling real-time simulations and predictions. Interoperability Standards: Protocols, data formats (XML, JSON), and agricultural ontologies ensuring data exchange and semantic interoperability .

	semantic interoperability using protocols (RESTful APIs, MQTT) and data formats (XML, JSON), supported by agricultural ontologies like SAREF4Agri and AgrO .		