Priority research topics

D2.3 List of priority research topics that will guide research mobilities and PhD theses in Cotutelle

EU-CONEXUS ENABLES

Version 1.0

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1. Executive Summary

Deliverable D2.3 presents a comprehensive list of priority research topics that will guide research mobilities and PhD theses within the framework of Task 2.3, which is part of Work Package 2 (WP2) of the EU-CONEXUS ENABLES project. This deliverable aims to enhance knowledge transfer and collaboration between widening and non-widening partners, focusing specifically on the application of digital twin technology to address challenges faced by Smart Urban Coastal Cities (SmUCS).

The key objectives of Task 2.3 include identifying priority research topics that align with the project's goals and have the potential to significantly impact the development of digital twin solutions. This task involves collaboration among all project partners to ensure a multidisciplinary approach, facilitating discussions and decision-making processes to finalize the list of topics.

The process involved gathering input from various departments and units, detailing their research focus, core expertise, and available resources. The outcomes highlight a diverse range of research interests, including urban climate analysis, energy efficiency, and the application of digital twin technologies in coastal settings. The outcomes of this task include a well-defined list of priority research topics that will direct future research efforts and ensure that they are aligned with the overarching goals of the EU-CONEXUS ENABLES project.

Figure 1. Collaboration Map

2. Introduction

Identifying priority research topics is essential in the context of the EU-CONEXUS ENABLES project, particularly as it relates to Smart Urban Coastal Cities (SmUCS) and the application of Digital Twin technologies. Coastal cities face unique challenges, including climate change, urbanization, and environmental degradation. These challenges necessitate innovative research that can lead to sustainable solutions. By pinpointing priority research areas, the project aims to focus efforts on the most pressing issues, ensuring that resources are allocated effectively and that research outcomes have a meaningful impact on society.

The overarching goals of the EU-CONEXUS ENABLES project to emphasize the importance of collaboration and knowledge transfer among partner institutions. This project seeks to enhance the capacity of both widening and non-widening partners by fostering interdisciplinary research that addresses the specific needs of SmUCS. Digital Twin technologies play a crucial role in this endeavour, as they provide a framework for creating virtual representations of physical environments. This allows for real-time data analysis and simulation, which can inform decision-making processes and improve urban planning and management.

The purpose of this deliverable, specifically Deliverable D2.3, is to establish a comprehensive list of priority research topics that will guide research mobilities and PhD theses within the project. By identifying these topics, the project aims to align research efforts with its goals, ensuring that they contribute to the development of innovative solutions for SmUCS. The scope of this deliverable includes collaboration among all project partners to finalize the list of priority research topics, which will serve as a roadmap for future research initiatives and capacity-building activities.

3. Methodology

Data Collection and Stakeholder Input

The data collection process for identifying priority research topics involved a comprehensive approach that engaged various stakeholders, including academic partners, industry representatives, and research institutions. Input was gathered through structured workshops and collaborative meetings, where participants were encouraged to share their expertise and insights related to Sustainability of Urban Coastal Zones (SmUCS) and Digital Twins (DT). The document served as a foundational tool for collecting this information, providing a structured format for partners to articulate their current research areas, core expertise, available resources, and suggested research topics. The synthesis of this information was achieved by compiling responses from all partners, ensuring that diverse perspectives were integrated into the final list of priority topics.

Criteria for Selecting Priority Research Topics

The selection of priority research topics was guided by several key criteria to ensure alignment with the overarching project goals. These criteria included:

- **Alignment with Project Goals**: Topics were evaluated based on their relevance to the strategic objectives of the project, particularly in advancing knowledge and practices related to SmUCS and DT.
- **Relevance to SmUCS and Digital Twins**: The significance of each topic in addressing critical challenges and opportunities within the context of urban coastal sustainability and the application of digital twin technologies was assessed.
- **Feasibility**: Consideration was given to the practicality of pursuing each topic, including the availability of resources, expertise, and potential for collaboration among partners.

Collaboration and Decision-Making

Facilitating discussions and consensus-building among partners was a crucial aspect of the methodology. Regular meetings and workshops were organized to foster open dialogue and collaborative decision-making. During these sessions, partners engaged in discussions to evaluate the proposed topics against the established criteria. This collaborative approach ensured that all voices were heard and that the final list of priority topics reflected a collective agreement among stakeholders, thereby enhancing the commitment to the research agenda.

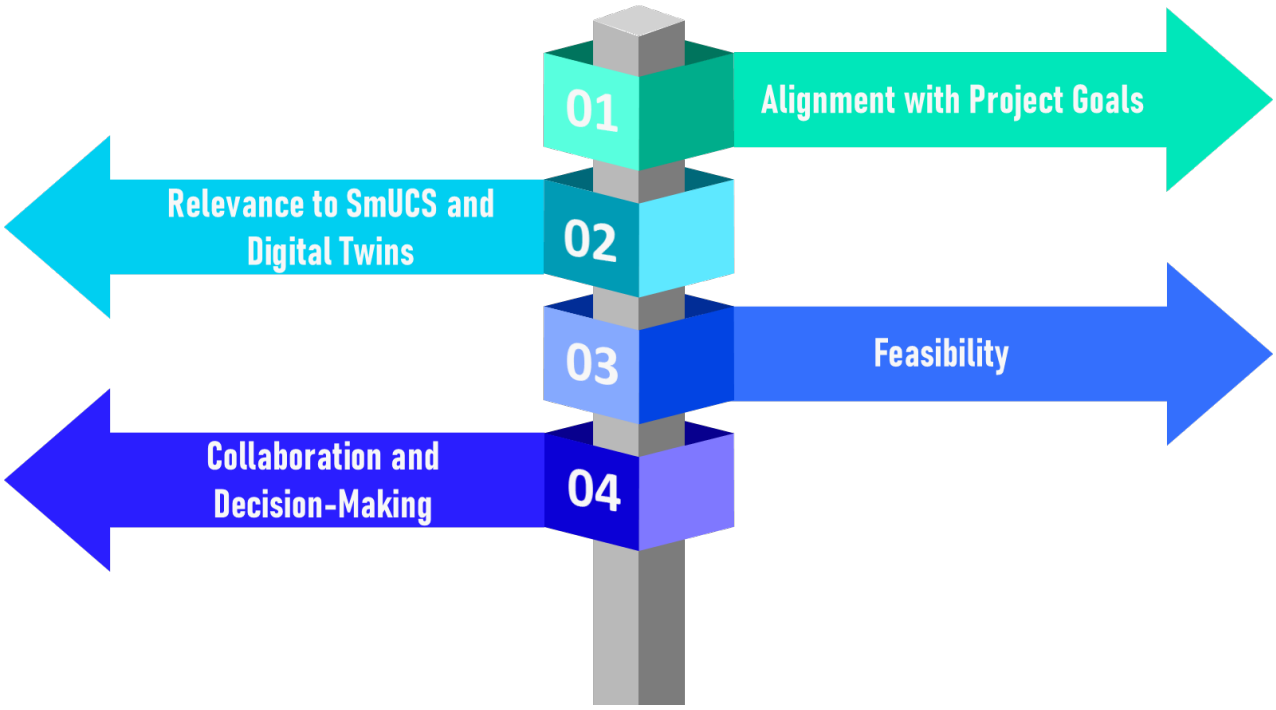

Figure 2. Workflow Diagram

4. Identified Priority Research Topics

4.1 Categorization of Topics

As part of the first task in Work Package 2 – **Framework for Knowledge Transfer**, three primary challenges were identified in relation to Smart Urban Coastal Sustainability (SmUCS) and Digital Twin (DT) applications. These challenges are:

- **A. Agriculture**
- **B. Building and Infrastructure**
- **C. Life Science and Medical Applications**

The distribution of suggested research topics across these challenges is illustrated in **Figure 3**. The data highlights the interdisciplinary nature of the proposed research, showcasing how different sectors contribute to addressing SmUCS challenges through DT solutions.

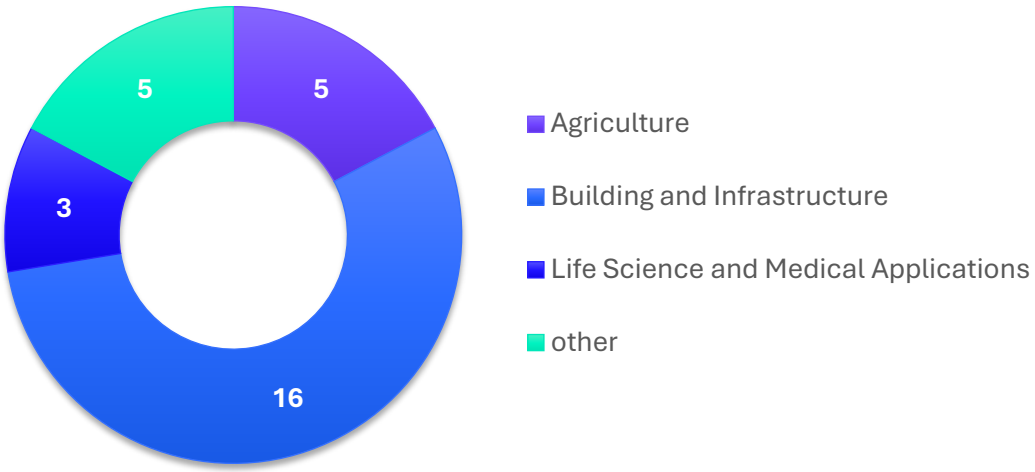

Figure 3. Classification of research topics by challenges identified in Task 2.1 through multidisciplinary groups

Agriculture (5 Topics, 17%)

Topics in agriculture focus on leveraging Digital Twins for sustainable farming, water management, and environmental monitoring. These address key SmUCS challenges such as resource optimization and climate resilience.

Building and Infrastructure (16 Topics, 55%)

Many research topics fall under this category, reflecting the importance of DT in urban planning, energy optimization, and sustainable construction. This dominance aligns with the critical role of infrastructure in coastal urban sustainability.

Life Science and Medical Applications (3 Topics, 10%)

This category explores the application of DT in healthcare, such as patient monitoring and public health modelling, contributing to improved societal well-being in SmUCS contexts.

Other (5 Topics, 17%)

Miscellaneous topics that do not fall strictly under the three main categories but still provide significant insights into cross-cutting issues, such as climate monitoring, ecosystem management, or interdisciplinary applications of DT.

Aligned with the SmUCS framework that shapes the EU-CONEXUS research community, six Joint Research Challenges have been defined using a bottom-up approach to foster collaboration among EU-CONEXUS researchers:

- **Smart Coastal Infrastructure for Disaster Mitigation**
- **Sustainable Coastal Waste Management**
- **Sustainable Disease Management**
- **Ensuring Healthy Food and Soil**
- **Protecting Oceans, Seas and Waters**
- **Adaption and Mitigation of Global Climate Change in Coastal Environments**

Figure 4 presents the distribution of suggested research topics across these six challenges, showcasing the breadth and diversity of research focus areas within the EU-CONEXUS community.

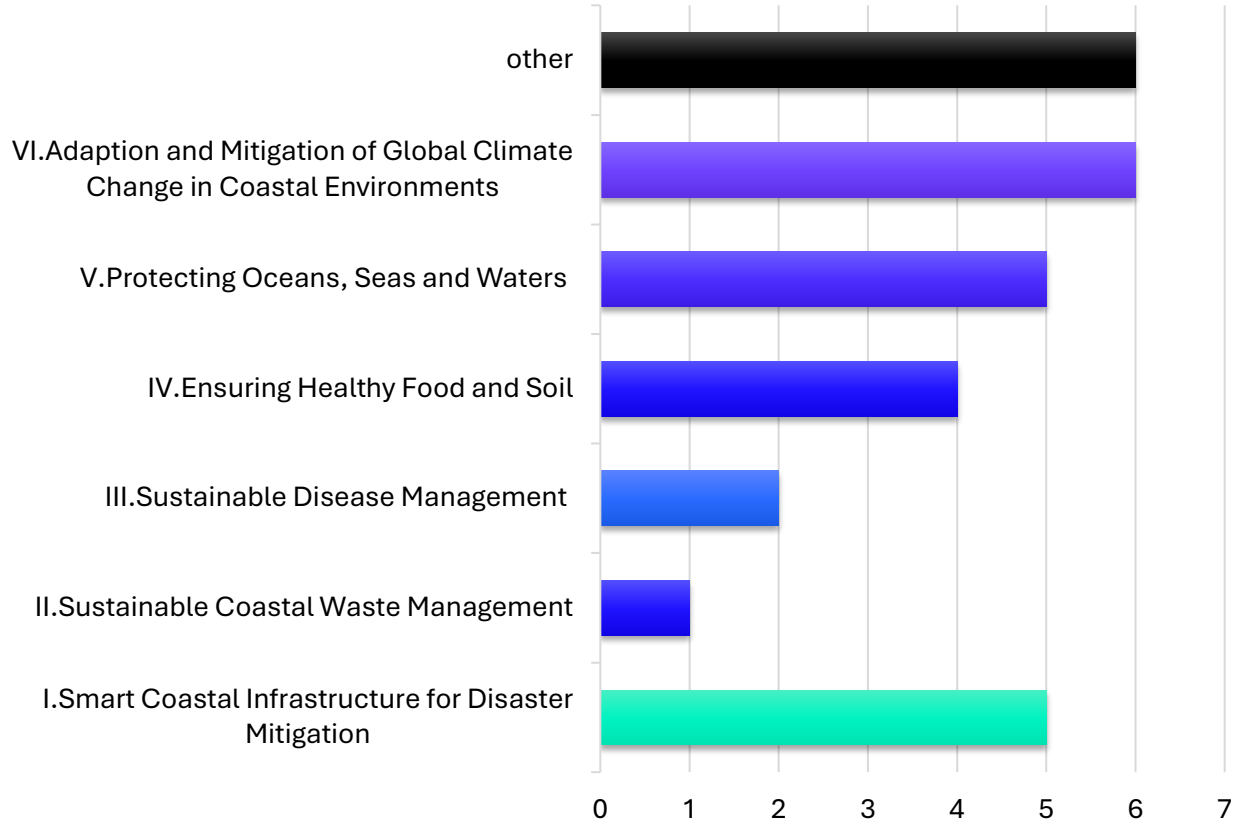

Figure 4. Classification of research topics by EU-CONEXUS Joint Research Challenges

4.2 Detailed Description of Each Priority Topic

This chapter provides an in-depth overview of the priority research topics identified during Task 2.3. Each topic is analysed based on its background, relevance, expected impact, and alignment with the overarching goals of the EU-CONEXUS ENABLES project. These topics serve as a roadmap for future research mobilities and collaborative efforts within the framework of Smart Urban Coastal Sustainability (SmUCS) and Digital Twin technologies.

Geospatial Data Acquisition, Integration, and Modelling for Coastal Built Environments in Digital Twin

- **Background and Relevance**

  Coastal built environments face unique challenges, including climate change, urbanization, and environmental degradation. The integration of accurate geospatial data is essential to creating effective Digital Twin (DT) solutions. This research focuses on applying advanced geospatial data acquisition methods and developing modelling tools to support sustainable urban and coastal planning.

- **Expected Impact**

  Improved spatial planning, disaster response capabilities, and environmental management through precise geospatial modelling tailored to coastal regions.

- **Link to Project Goals**

  Supports SmUCS by leveraging advanced geospatial tools and DT technologies to create sustainable urban solutions.

- **Challenges**

  Building and Infrastructure; Protecting Oceans, Seas and Waters

Optimization of the Workflow for Geospatial Data Integration in Coastal Digital Twin Models

- **Background and Relevance**

  Effective Digital Twin models require seamless integration of geospatial data from diverse sources, including satellite imagery, UAV data, and open geospatial platforms. This topic focuses on designing optimized workflows to address the complexities of integrating varied data formats for comprehensive modelling of coastal regions.

- **Expected Impact**

  Enhanced accuracy and efficiency in the development of coastal Digital Twins, fostering better decision-making for urban planning and resilience.

- **Link to Project Goals**

Aligns with project objectives by enabling data-intensive DT solutions for addressing SmUCS challenges.

- **Challenges**

  Building and Infrastructure; Protecting Oceans, Seas and Waters

Integrating GeoAI Tools for Modelling the Coastal Built Environment

- **Background and Relevance**

  GeoAI tools combine geospatial data with artificial intelligence, creating powerful capabilities for analysing and modelling coastal environments. This research explores integrating GeoAI into GIS workflows to better understand and predict changes in coastal areas.

- **Expected Impact**

  Advanced modelling capabilities for coastal urban environments, leading to improved sustainability and resilience strategies.

- **Link to Project Goals**

  Contributes to the integration of AI technologies in SmUCS-related DT applications.

- **Challenges**

  Building and Infrastructure; Protecting Oceans, Seas and Waters

Development of Digital Twin Frameworks for Climate-Resilient Cities

- **Background and Relevance**

  Urban areas are increasingly vulnerable to climate change impacts such as rising sea levels and extreme weather events. This research focuses on developing robust Digital Twin frameworks to enhance cities' resilience and adaptive capacity.

- **Expected Impact**

  Greater urban resilience through predictive modelling and scenario analysis enabled by Digital Twin technologies.

- **Link to Project Goals**

  Addresses SmUCS by applying DT solutions to create adaptive and climate-resilient urban systems.

- **Challenges**

  Building and Infrastructure; Smart Coastal Infrastructure for Disaster Mitigation

Energy Optimization in Cities Using Digital Twins

- **Background and Relevance**

  Urban energy systems are critical to achieving sustainability goals. This research investigates the application of Digital Twins for optimizing energy use, integrating renewable energy, and improving energy performance in urban areas.

- **Expected Impact**

  Increased energy efficiency, reduced greenhouse gas emissions, and improved sustainability of coastal buildings. The integration of renewable energy systems will also enhance energy resilience and reliability in these environments.

- **Link to Project Goals**

  Advances the project's focus on sustainability and energy efficiency within SmUCS frameworks.

- **Challenges**

  Building and Infrastructure; Adaption and Mitigation of Global Climate Change in Coastal Environments

Environmental Quality in Urban Spaces: The Pedestrian Comfort Perspective

- **Background and Relevance**

  Urban spaces significantly influence pedestrian comfort, encompassing factors such as thermal comfort, air quality, and noise levels. As cities grow denser, ensuring environmental quality in these spaces becomes critical for promoting health, well-being, and urban liability. This research focuses on assessing and improving pedestrian comfort using Digital Twin (DT) technologies to model urban environments dynamically.

- **Expected Impact**

  Improved pedestrian comfort and health outcomes through data-driven urban design strategies. Enhanced environmental quality will foster more liveable and sustainable urban spaces, contributing to societal well-being.

- **Link to Project Goals**

  Directly aligns with SmUCS objectives by applying DT technologies to enhance the quality of life in urban coastal zones, addressing environmental and societal challenges.

- **Challenges**

  Building and Infrastructure; Other

Smart Energy Solutions in Coastal Built Environments via Digital Twins

- **Background and Relevance**

  Coastal built environments face unique challenges such as harsh climatic conditions, rising energy demands, and the integration of renewable energy systems. This research explores the application of Digital Twin (DT) technologies to develop smart energy solutions tailored to these settings. It focuses on optimizing energy performance, incorporating renewable energy sources, and mitigating climate impacts on energy infrastructure.

- **Expected Impact**

  Exploring DT applications to optimize energy systems in coastal buildings, integrating renewable energy sources and improving energy performance in harsh climatic conditions.

- **Link to Project Goals**

  Contributes to SmUCS objectives by leveraging DT solutions to address energy-related challenges in coastal urban areas, advancing the project's sustainability and innovation goals.

- **Challenges**

  Building and Infrastructure; Adaption and Mitigation of Global Climate Change in Coastal Environments

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Lifecycle Assessment Integration in Coastal Digital Twin Models

- **Background and Relevance**

  Lifecycle Assessment (LCA) is a key methodology for evaluating the sustainability of infrastructure projects. This research integrates LCA methodologies into coastal Digital Twin models to enhance their capacity for assessing environmental impacts.

- **Expected Impact**

  Incorporating LCA methodologies into DT platforms for coastal infrastructures to assess and improve sustainability throughout their lifecycle.

- **Link to Project Goals**

  Supports sustainable infrastructure development aligned with SmUCS objectives.

- **Challenges**

  Building and Infrastructure; Adaption and Mitigation of Global Climate Change in Coastal Environments

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Enhancing crop resilience and productivity by utilizing algae biomass as a source of novel biostimulant compounds

- **Background and Relevance**

  A holistic approach to investigate the enhancement of crop resilience and productivity using eco-friendly, algae-derived biostimulants. Crop monitoring and multi-omics analysis will be employed to generate big data, providing a deeper understanding of the effects on crops. The aim is to develop a platform that reveals the relationship between the type and concentration of biostimulants and the crops' responses, leveraging digital twin technology to optimize crop management and predict outcomes under different treatments.

- **Expected Impact**
  - Improved crop yields and resilience to environmental stress.
  - Development of sustainable agricultural practices.
  - Big-data insights to refine crop management strategies.

- **Link to Project Goals**

  Supports SmUCS objectives by leveraging Digital Twin technology and eco-friendly innovations to advance sustainable agriculture and resource management.

- **Challenges**

  Agriculture; Ensuring Healthy Food and Soil

AI in Protected Areas Management

- **Background and Relevance**

  Artificial Intelligence (AI) can revolutionize the management of protected areas by enabling real-time monitoring, predictive analytics, and efficient resource allocation. This research focuses on applying AI tools to enhance biodiversity conservation and address environmental challenges.

- **Expected Impact**

  Enhanced decision-making for sustainable management of protected areas. Improved ecosystem monitoring and conservation strategies.

- **Link to Project Goals**

  Supports SmUCS objectives by leveraging AI technologies to protect and sustain biodiversity in coastal and urban ecosystems.

- **Challenges**

  Other; Protecting Oceans, Seas and Waters

Social Media and Apps Use by Hikers

- **Background and Relevance**

  Social media platforms and mobile apps play a growing role in shaping hikers' experiences and environmental behaviours. This research explores their use in navigation, community building, and promoting sustainable practices in outdoor activities.

- **Expected Impact**

  Improved understanding of digital tools' influence on outdoor recreation. Enhanced promotion of environmental awareness and sustainability among hikers. Support for digital innovation in nature-based tourism.

- **Link to Project Goals**

  Aligns with SmUCS objectives by integrating digital technologies to encourage sustainable practices in coastal and urban recreational areas.

- **Challenges**

  Other; Other

Walkability Promotion in Urban Contexts for Public Health

- **Background and Relevance**

  Walkability in urban areas is a key factor in improving public health by encouraging physical activity and reducing environmental stressors. This research focuses on strategies to enhance walkable urban designs and their impact on community well-being.

- **Expected Impact**

  Increased physical activity and improved public health outcomes. Reduced urban congestion and environmental pollution.

- **Link to Project Goals**

  Supports SmUCS objectives by promoting sustainable urban planning and public health improvements through walkable infrastructure designs.

- **Challenges**

  Life Science and Medical Applications; Other

Development of a Responsible Digital Twin for Territorial Resilience: Towards an Open Source Platform with Reduced Environmental Impact

- **Background and Relevance**

  With increasing emphasis on digital responsibility, this research aims to develop open-source Digital Twin platforms that minimize environmental impact while enhancing territorial resilience to climate change and other challenges.

- **Expected Impact**

  Broader adoption of sustainable DT solutions, improved territorial management, and reduced ecological footprint of digital infrastructures.

- **Link to Project Goals**

  Contributes to the creation of a sustainable, data-driven ecosystem as envisioned in the SmUCS framework.

- **Challenges**

  Building and Infrastructure; Smart Coastal Infrastructure for Disaster Mitigation

Research into the Use of Semantic Web Approaches for Data Integration and Exploitation in Digital Twin Applications

- **Background and Relevance**

  The Semantic Web provides a framework for integrating and exploiting data with spatial and temporal dimensions, enabling improved interoperability and decision-making. This research explores Semantic Web approaches for data curation, integration, and decision support in Digital Twin (DT) applications. In the building and infrastructure sector, the increasing adoption of Building Information Modelling (BIM) highlights the need for seamless data management and advanced analytical tools. By leveraging Semantic Web technologies, this research aims to enhance the capacity of DT systems to manage complex, multidimensional datasets.

- **Expected Impact**

  Improved interoperability between heterogeneous data sources in DT applications.

- **Link to Project Goals**

  This research aligns with SmUCS objectives by leveraging innovative Semantic Web and BIM approaches to enhance the effectiveness and scalability of DT solutions. It supports the project's aim to create sustainable urban and coastal systems through advanced data-driven methodologies.

- **Challenges**

  Building and Infrastructure; Smart Coastal Infrastructure for Disaster Mitigation

Creation of a Generic Coastal System Model

- **Background and Relevance**

  Coastal systems are highly dynamic and influenced by a range of environmental and anthropogenic factors. This research aims to develop a generic model that integrates physical, ecological, and socioeconomic data, enabling holistic management of coastal zones.

- **Expected Impact**

  Improved coastal zone management through predictive modelling and enhanced decision-making tools.

- **Link to Project Goals**

  Supports SmUCS by advancing interdisciplinary approaches to coastal management using DT technologies.

- **Challenges**

  Other; Sustainable Coastal Waste Management

Coupling Digital Twins and Multi-Agent Systems for Coastal Behaviour Modelling

- **Background and Relevance**

  The coupling of Digital Twins with multi-agent systems offers a novel approach to modelling human behaviour and its environmental impact, particularly in coastal regions. This research focuses on simulating interactions between coastal populations, infrastructure, and ecosystems to inform policymaking.

- **Expected Impact**

  Better understanding of coastal dynamics and stakeholder behaviour, leading to informed policy interventions and enhanced public awareness.

- **Link to Project Goals**

  Aligns with SmUCS goals by integrating socio-ecological systems modelling into DT applications for coastal resilience.

- **Challenges**

  Building and Infrastructure; Smart Coastal Infrastructure for Disaster Mitigation

Relationship Between Physical Activity and Sport on Global Physical or Cognitive Health Across Different Ages and Contexts

- **Background and Relevance**

  Physical activity and sport have profound effects on both physical and cognitive health. This research explores the relationship between sport participation and its impact on

various aspects of health, such as motor skills, cardiovascular fitness, mental acuity, and emotional well-being. The study focuses on different age groups and contexts, addressing variations in benefits and challenges. By integrating Digital Twin (DT) technology, this research aims to create personalized and dynamic models to better understand and predict the outcomes of physical activity across diverse populations.

- **Expected Impact**

  Development of evidence-based strategies to enhance health outcomes through tailored physical activity programs.

- **Link to Project Goals**

  Aligns with SmUCS objectives by extending DT applications to healthcare and well-being, fostering interdisciplinary research, and promoting societal benefits. This research supports the project's broader aim of addressing challenges in urban and coastal zones by improving quality of life through innovative solutions.

- **Challenges**

  Life Science and Medical Applications; Adaption and Mitigation of Global Climate Change in Coastal Environments

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Optimization of Operating Strategies for Industrial Control Systems Using AI-Driven Digital Twin Models

- **Background and Relevance**

  This research topic focus on developing advanced algorithms to optimize operating strategies in industrial control processes by leveraging digital twins (DTs). The objective is to explore how AI, machine learning, and optimization techniques can be integrated with DT models to improve process efficiency, reduce energy consumption, and increase system reliability. Key areas of investigation include:

  - Creating real-time optimization frameworks using digital twins for predictive maintenance, fault detection, and control strategy adjustments.
  - Development of hybrid models combining physical simulations with data-driven AI algorithms to improve the accuracy of industrial process control.
  - Optimization algorithms for multi-objective problems, balancing cost, efficiency, sustainability, and performance in industrial settings.
  - Testing and validating the models in real-world industrial systems, particularly in manufacturing, energy production, or chemical processes.

- **Expected Impact**

  Increased operational efficiency, reduced energy consumption, and improved reliability of industrial systems.

- **Link to Project Goals**

  Advances the integration of AI and DT technologies in industrial applications, supporting SmUCS's innovation objectives.

- **Challenges**

  Building and Infrastructure; Other

Enhancing Energy Efficiency in Industrial Systems through Digital Twin Integration

- **Background and Relevance**

  This research aims to address the challenges of fragmented energy consumption data by developing a digital twin-based framework for integrating and analysing data across various industrial systems. Key areas of investigation include:

  - Designing a digital twin architecture that aggregates data from heterogeneous sources (e.g., equipment performance, environmental sensors, maintenance systems) and standardizes it for real-time analysis.
  - Utilizing machine learning and predictive analytics within the digital twin to identify inefficiencies, forecast equipment performance, and enable proactive energy management.
  - Investigating how this digital twin-based solution can optimize energy strategies, improve operational efficiency, and reduce costs through dynamic adjustments based on real-time data.
  - Exploring applications in industries such as manufacturing, energy, and smart buildings, where energy efficiency is critical.

- **Expected Impact**

  Optimized energy strategies, reduced costs, and increased sustainability in industrial and building systems.

- **Link to Project Goals**

  Supports the SmUCS goal of fostering energy-efficient, sustainable practices through DT innovations.

- **Challenges**

  Building and Infrastructure; Other

Vision-Based Indoor Tracking Systems Integrated with Digital Twins

- **Background and Relevance**

This research would focus on developing a vision-based indoor positioning system (IPS) for hospitals, integrated with digital twin technology to track and analyse patient movement and activity. Key areas of investigation include:

- Designing a vision-based IPS using cameras and computer vision techniques to monitor patient and asset locations in real-time within hospital environments.
- Integrating this system with a digital twin of the hospital to create a dynamic virtual model reflecting the real-time physical state, enabling better decision-making and resource management.
- Incorporating heatmaps into the system to visualize patient movement and activity patterns, helping identify high-traffic areas, potential inefficiencies, and opportunities for improving patient flow.
- Using predictive analytics within the digital twin to enhance patient safety, optimize staff allocation, and streamline hospital operations.

- **Expected Impact**

  Improved patient safety, optimized resource allocation, and enhanced decision-making in healthcare facilities.

- **Link to Project Goals**

  Expands the application of DT solutions to healthcare, showcasing the versatility and societal impact of the SmUCS framework.

- **Challenges**

  Life Science and Medical Applications; Sustainable Disease Management

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Forecasting the Influence of Weather Parameters on Harmful Organisms Using Digital Twin Technology

- **Background and Relevance**

  In modern modelling research, big data is often used as a basis for launching actions to predict the number of species, modelling their population distribution and damage as harmful organisms, be it animals, plant diseases or weeds. As a result, it is often difficult to get a clear picture because the repetitive processes of analysis are demanding for the single processes used in practice today. By implementing artificial intelligence and DT, by better designing models of the functioning of these technologies by experts who know them better, it is possible to predict scenarios many times faster if they can happen in the near or even better in far future. There is room for development, initial knowledge is descriptive through scientific works, there is only an open need to form functional and successful interdisciplinary teams.

- **Expected Impact**

Enhanced agricultural resilience and productivity through better pest and disease management.

- **Link to Project Goals**

  Aligns with SmUCS objectives by addressing agricultural sustainability and leveraging DT solutions to manage environmental challenges.

- **Challenges**

  Agriculture; Sustainable Disease Management

Optimizing Water Use for Mediterranean Crops Using Digital Twin Technology

- **Background and Relevance**

  In modern water modelling research, big data is often used as a basis for launching actions to predict need for water management in given edaphic conditions. The optimal addition of water is closely related to many parameters of the environment, but also to the phenotypic and genotypic characteristics of the plant, therefore it is necessary to combine many of them into complex models. As a result, it is often difficult to get a clear picture because the repetitive processes of analysis are demanding for the single processes used in practice today. By implementing artificial intelligence and DT, by better designing models of the functioning of these technologies by experts who know them better, it is possible to predict scenarios many times faster if they can happen in the near or even better in far future. There is room for development, initial knowledge is descriptive through scientific works, there is only an open need to form functional and successful interdisciplinary teams.

- **Expected Impact**

  Improved water resource management in agriculture. Enhanced crop yield and quality in water-scarce regions.

- **Link to Project Goals**

  Contributes to SmUCS by addressing water management challenges and leveraging DT solutions for environmental sustainability.

- **Challenges**

  Agriculture; Ensuring Healthy Food and Soil

AI Algorithms for Digital Twins in Energy Efficiency and Refurbishment

- **Background and Relevance**

Digital Twin technology combined with artificial intelligence offers new possibilities for analysing and optimizing energy efficiency in buildings. This research focuses on developing AI algorithms to evaluate energy data and derive strategies for sustainable building refurbishments.

- **Expected Impact**

  Reduced energy consumption and carbon emissions in urban areas. Enhanced building performance through optimized refurbishment strategies.

- **Link to Project Goals**

  Advances SmUCS goals by integrating AI and DT technologies to promote energy-efficient practices in urban systems.

- **Challenges**

  Other; Adaption and Mitigation of Global Climate Change in Coastal Environments

Design of Sustainable Buildings with AI

- **Background and Relevance**

  Artificial Intelligence (AI) offers transformative potential in the architectural design process by enabling the creation of sustainable building designs. This research focuses on integrating AI-driven algorithms to meet sustainability standards, optimizing energy efficiency, resource use, and environmental impact during the design phase.

- **Expected Impact**

  Improved energy efficiency and reduced carbon footprints of buildings. Accelerated design processes with innovative AI solutions.

- **Link to Project Goals**

  Aligns with SmUCS objectives by applying AI and Digital Twin technologies to promote sustainable building design, contributing to resilient and efficient urban development.

- **Challenges**

  Building and Infrastructure; Other

Digital Twins for Construction Robots in Building Navigation and Exploration

- **Background and Relevance**

  Construction robots are becoming critical tools for modernizing and automating building processes. This research explores the use of DT technology to enable robots to

navigate existing building models or autonomously explore construction sites. It seeks to improve accuracy, safety, and efficiency in construction operations.

- **Expected Impact**

  Accelerated construction processes through automation.

- **Link to Project Goals**

  Supports SmUCS by promoting digital innovation in construction, a key component of sustainable urban development.

- **Challenges**

  Building and Infrastructure; Adaption and Mitigation of Global Climate Change in Coastal Environments

Assessing Coastal Flood Protection Systems Using Space-Borne Interferometric Radar

- **Background and Relevance**

  Coastal flood protection systems are vital for safeguarding communities against sea-level rise and storm surges. This research employs remote sensing techniques, such as space-borne interferometric radar, to monitor the stability of these systems and identify potential vulnerabilities.

- **Expected Impact**

  Improved safety and reliability of coastal flood protection systems. Cost-effective, large-scale monitoring solutions.

- **Link to Project Goals**

  Contributes to SmUCS by addressing climate resilience and applying DT solutions to critical infrastructure.

- **Challenges**

  Building and Infrastructure; Smart Coastal Infrastructure for Disaster Mitigation

Effects of Climate Change on Coastal Wetlands and Peatlands

- **Background and Relevance**

  Peatlands are key ecosystems for mitigation of climate change as they store carbon in a natural way. However, coastal peat- or wetlands are endangered ecosystems to a sea level rise on the one hand side. On the other side they are endangered due to drainage activities thus leading to a subsidence of the peat- or wetland itself increasing the effects of a sea level rise. In this project idea, a holistic approach to investigate the state

of coastal wet- and peatlands over Europe will be foreseen including remote sensing-based approaches to monitoring the state of the coastal wet- and peatlands.

- **Expected Impact**

  Protection and restoration of critical ecosystems. Enhanced understanding of carbon dynamics in wetlands.

- **Link to Project Goals**

  Supports SmUCS by addressing environmental challenges in coastal zones through DT-enabled ecosystem monitoring.

- **Challenges**

  Other; Protecting Oceans, Seas and Waters

Smart Deficit Irrigation Strategies for Sustainable Crop Production

- **Background and Relevance**

  With the effects of climate change, irrigation is becoming increasingly important in Central European crop production. Most state-of-the-art irrigation scheduling models rely on remote sensing data and include algorithms for estimating the climatic water balance. However, it is well known that the economic optimum for crop irrigation often lies below the agronomic optimum. Our goal is to develop smart deficit irrigation models that minimize energy and water inputs, promoting resource-efficient crop production.

- **Expected Impact**

  Reduced water and energy use in agriculture. Enhanced crop yield and sustainability. Increased resilience of agricultural systems to climate variability.

- **Link to Project Goals**

  Aligns with SmUCS goals by promoting resource-efficient practices in agriculture using DT and advanced modelling.

- **Challenges**

  Agriculture; Ensuring Healthy Food and Soil

Towards Genotype-Specific Precision Farming: A Digital Twin for Wheat

- **Background and Relevance**

  High nitrogen surpluses in agricultural production continue to cause eutrophication of water bodies. Precision farming can help reduce these surpluses to some extent. However, current models do not account for genotype- or variety-specific differences in

nitrogen use efficiency. Our goal is to develop a digital twin of wheat that allows us to provide variety-specific fertilization recommendations. Methodologically, this will involve genomic prediction, classical plant growth models, and AI-based models.

- **Expected Impact**

  Reduced nitrogen runoff and associated environmental damage.

- **Link to Project Goals**

  Aligns with SmUCS objectives by leveraging DT technology to address environmental and agricultural sustainability challenges, promoting innovative solutions for coastal and urban ecosystems.

- **Challenges**

  Agriculture; Ensuring Healthy Food and Soil

4.3 Research Topics proposed in EU-CONEXUS Doctoral School Catalogue

Within the framework of the EU-CONEXUS Doctoral School and Joint Research Institutes (JRIs), a range of primary research topics has been proposed. These topics align with the goals of the ENABLES project and emphasize the integration of Digital Twin technologies and digital solutions in addressing Smart Urban Coastal Sustainability (SmUCS) challenges.

The catalogue was reviewed, and relevant topics were selected based on their alignment with Digital Twin and digital technology applications. The distribution of these topics across the JRIs is illustrated in **Figure 5**. The numbers associated with each topic indicate their position in the catalogue.

- GIS, GNSS and Remote Sensing; Real Estate Management; Geospatial Modelling Technologies CAD, GIS and BIM - This topic involves digital technologies that are essential for smart urban planning and sustainability. (Number: 24 - CEI)
- GIS, GNSS and Remote Sensing; Geospatial Modelling Technologies CAD, GIS and BIM - Similar to the previous topic, this also pertains to the use of digital technologies in urban coastal sustainability. (Number: 25 - CEI)
- The influence of artificial intelligence on socio-technical aspects of maritime education and training - This topic addresses the integration of digital technologies, particularly AI, in the context of maritime education, which can contribute to sustainable practices. (Number: 50 - SCHSI)
- Multilingualism in the Context of Urban Coastal Sustainability - This topic relates to the social aspects of sustainability in urban coastal areas, potentially involving digital communication technologies. (Number: 69 - SCHSI)

- Digitization of the management process using artificial intelligence (Number 126 - SCHSI)
- Possibilities of using artificial intelligence in management research (Number 127 - SCHSI)
- Organisational resilience for sustainable development (Number 128 - SCHSI)
- Resilience leadership development to empower a creation of sustainability and a commercial value (Number 129 - SCHSI)
- Social Innovation Ecosystem to Boost Resilience and Sustainability (Number 130 - SCHSI)
- Business framework for sustainable society (Number 131 - SCHSI)
- Economic modelling of maritime clustering processes and trends in the EU-CONEXUS network countries (Number 136 - SCHSI)
- Economic assessment of industry digitization and level of productivity in the urban coastal areas (Number 137 - SCHSI)
- Fostering digital entrepreneurship for regional development (Number 147 - SCHSI)
- The development of a green and sustainable seaport ecosystem by reducing the environmental impact of port operations and supply chain technologies (Number 155 - CEI)
- The decarbonisation of long-distance shipping using a high efficiency marine power system fuelled with ammonia (Number 156 - CEI)
- Ammonia fuelled propulsion and waste heat driven power generation technologies for decarbonising long-distance shipping (Number 157 - CEI)
- Fog Computing based model for Intelligent Transport Systems (Number 189 - CEI)
- Wireless communication networking models for 5G/6G for Agri. Tech (Number 191 - CEI)
- Deep learning-based Edge Analytics for IoT Applications (Number 202 - CEI)
- IoT platform for Wireless Sensor Network applications in Smart Dairy Processing (Number 203 - CEI)
- Utilisation of environmental impact assessment methodology for interchanging natural habitats: A case study of coastal mangroves along the Southern Hilo Coast, Hawaii Island (Number 259 - LSBI)
- Addressing Cybersecurity challenges in Industrial Control and Automation Environments in the era of Industry 4.0 (Number 342 - CEI)
- Use of AI and Biomechanics analysis to create a Hurling training program in Ireland (Number 341 - CEI)
- Calibration of Digital Twins for Buildings using Machine Learning (Number 367 - CEI)

- Development of methodology of mapping seaweed in the intertidal zone of the coastline of Ireland using the combination of hyperspectral, satellite and multispectral imagery (Number 368 - CEI)
- An investigation of dynamic temperature monitoring and control in modular data centers - initially using Infrared Thermography (IRT) and a novel machine-learning framework to improve efficiency (Number: 420 - CEI)
- Microfluidic analysis of chemical oxygen demand (Number: 442 - ESBI)
- Using reconstructed soil microbiomes for improving soil bioremediation (Number 452 - ESBI) - This topic relates to sustainability in urban coastal areas through soil health and remediation, which can be enhanced by digital technologies for monitoring and management.
- Development of thermoset bioplastics with alternative, sustainable starches (Number 454 - ESBI) - This research could contribute to sustainability efforts in urban coastal environments by promoting the use of sustainable materials, potentially supported by digital technologies for design and production processes.

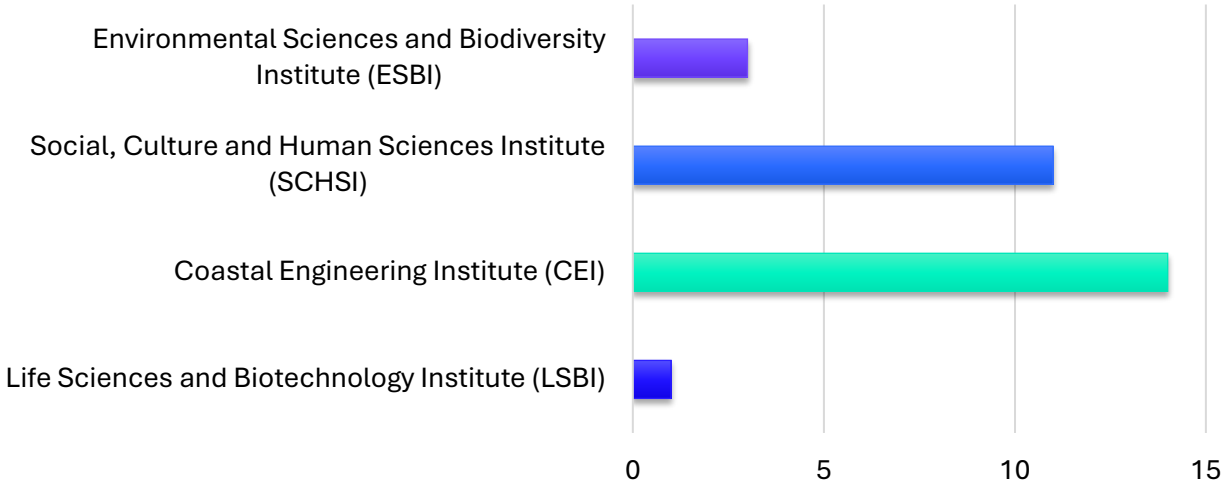

Figure 5. Research Topics proposed in EU-CONEXUS Doctoral School Catalogue

5. Research topics tailored to Stakeholder's Needs

Based on the stakeholders' answers provided in the document, the following priority research topics for a PhD thesis in cotutelle can be identified:

- **Development and Implementation of Digital Twin Technologies**: Focus on integrating geospatial data to enhance Smart Urban Coastal Sustainability (SmUCS) and optimize energy efficiency in construction projects.
- **BIM Classification System for the Romanian AEC Market**: Investigate the creation and adoption of a classification system tailored to the Romanian architecture, engineering, and construction (AEC) sector to facilitate collaboration and data

integration.

- **Impact of BIM Tools on Digital Twin Implementation**: Assess the consequences of the lack of appropriate BIM tools on the implementation of Digital Twin concepts in Romanian AEC projects.
- **Collaborative Methodologies for Digital Twin in Construction**: Explore collaboration models among multidisciplinary teams to optimize construction processes and building management, with a focus on energy efficiency.
- **Sustainability Assessment Software Development**: Develop software for assessing the sustainability level of buildings, including the integration of greenhouses and research on plant-based ventilation options.
- **Semantic Web Approaches for Spatial and Temporal Data**: Investigate the use of semantic web technologies for the integration and exploitation of spatial and temporal data in the context of buildings and infrastructure.
- **Digital Twin for Crop Production Systems**: Research the development, evaluation, and demonstration of a digital twin specifically for crop production systems.
- **Indoor Tracking and Positioning Systems**: Investigate the development and implementation of accurate indoor tracking and positioning systems using various technologies, such as radio frequency and vision.

These topics reflect the interests and needs expressed by the stakeholders and align with current trends in research and technology within the fields of architecture, engineering, and construction.

6. Conclusion

The deliverable D2.3 has successfully identified and articulated a comprehensive list of priority research topics that are pivotal for guiding research mobilities and PhD theses within the EU-CONEXUS ENABLES project. This initiative is particularly significant in the context of Smart Urban Coastal Cities (SmUCS), where the integration of Digital Twin technologies can address pressing challenges such as climate change, urbanization, and environmental degradation.

The key findings of this deliverable highlight the necessity of a multidisciplinary approach to research, as evidenced by the diverse range of topics categorized under Agriculture, Building and Infrastructure, and Life Science and Medical Applications. Each category reflects the unique challenges faced by coastal urban environments and underscores the importance of collaboration among project partners to foster innovative solutions. The detailed descriptions of each priority topic provide a clear roadmap for future research initiatives.

Moving forward, the next steps for implementing these research priorities involve establishing collaborative frameworks among the various stakeholders, including academic institutions, industry representatives, and research organizations. This collaboration will be essential for ensuring that the identified topics are not only pursued but also effectively integrated into ongoing and future research projects. Additionally, the development of joint research challenges, as outlined in the document, will facilitate knowledge transfer and capacity building among both widening and non-widening partners.

To enhance the effectiveness of research mobilities and PhD theses, it is recommended that the EU-CONEXUS community leverage the **Research & Innovation Information System** (RIIS). This portal serves as a vital resource, listing research staff, units, infrastructures, and services across EU-CONEXUS. By utilizing RIIS, researchers, academics, and students can facilitate communication and identify synergies and opportunities for collaboration. This system will not only streamline the process of connecting with potential partners but also enhance the visibility of ongoing research efforts, thereby fostering a more integrated research environment.

In conclusion, the research topics identified in this deliverable are not merely academic pursuits; they represent a strategic alignment with the overarching goals of the EU-CONEXUS ENABLES project. By focusing on these priority areas and utilizing the RIIS, the project aims to enhance the sustainability and resilience of urban coastal environments, ultimately contributing to the well-being of communities and the preservation of natural resources. The commitment to leveraging Digital Twin technologies within these research initiatives will play a crucial role in shaping the future of urban planning and management in coastal regions.

List of figures

Acknowledgement of AI Assistance

This deliverable was developed with the assistance of AI-based tools, in compliance with the principles outlined in the EU Artificial Intelligence Act.