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# Enabling far-reaching living labs through regional Digital Twins

HS5.7 - Multi-scale water-energy-food-environment (WEFE) nexus planning: from research to practice in managing socio-economic, climatic, and technological change

DEPARTMENT OF WATER RESOURCES & ENVIRONMENTAL ENGINEERING SCHOOL OF CIVIL ENGINEERING - NTUA



IRBAN WATER



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### **Abstract**

- The current and future landscape of our societies is predominantly governed by urgent and interconnected resilience challenges such as climate change adaptation, resource efficiency and sustainable WEFE nexus management. To overcome those challenges, the European Union (EU) has set the blueprints of transformational changes with the European Green Deal, that builds on **research and innovation** to meet the objectives. Despite advances in the field, the **uptake pace** of relevant innovations is often **hindered by** the **narrow** communication paths among research, public administration and citizens -who are the end
- This work utilizes the capabilities of **Digital Twins** (DT) to **connect hard and soft sensors** with environmental and infrastructure models at regional scale, to create a central hub for related data and knowledge to be turned into action, in a **co-creation process**. By building on existing data driven platform initiatives by the Ministry of Environment and Energy and the Decentralized Administration of Attica, we build the DT of the Region of Attica to provide: (i) access to relevant datasets (environmental, climatic, uses of resources etc.), (ii) access to relevant climate adaptation services (e.g. climate services, services to farmers, services to municipalities), (iii) links to local and regional Communities of Practice (CoP) and (iv) a repository for demonstrations of climate adaptation innovations within the region.
- This knowledge collaboration scheme forms a living lab constellation that allows rapid and far-reaching sharing, accumulation, transformation, and co-creation of knowledge among the administration parties and local case studies' stakeholders. Like ancient sailors who used constellations to navigate along route, our modern societies can use the living lab constellations of the regional DT to chart evidence-based pathways towards climate resilience and sustainable WEFE management. This dynamic and expandable ecosystem aims to speed up the introduction of climate adaptation innovations, connect knowledge and bring research closer to practice by allowing for a re-wiring of culture, where science and co-creation are perceived as necessary for successful policy making.

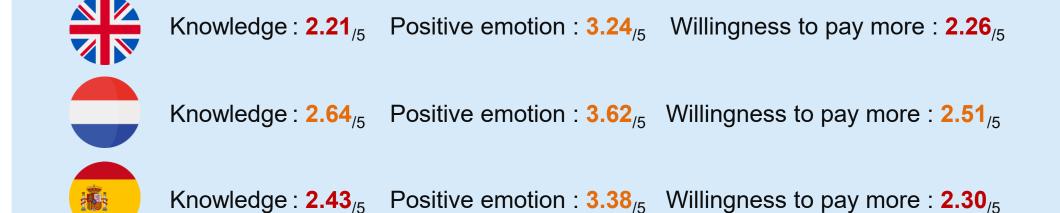
#### Introduction

Sustainable Water-Energy-Food and Environment system management is essential for the wellbeing of societies, economic growth and the resilience of ecosystems, at local and global level especially in the face of climatic challenges and population growth. Viable technology options towards meeting SDGs exist, yet their uptake and integration to sustainable adaptation pathways requires more intuitive knowledge sharing and co-creation synergies between research, private, and public stakeholders (TEC, 2021).

The European Environment Agency (2021) identifies that, the efficiency of regional policies and adaptation pathways may prove ineffective due to limited knowledge of administrative parties over available technologies and innovations, despite novel frameworks designed to assist regional stakeholders (re-)design resilient circular strategies (see e.g. Bouziotas et.al, 2023). EEA further notes that **financial barriers** may arise from the limited understanding of stakeholders over the potential economic and environmental benefits of such technologies, ultimately hindering the willingness to invest in relevant initiatives.

On top of the latter, **societal barriers** may also arise, at local level, due to limited knowledge by the citizens (end-users) which affects the positive response over relevant technologies, as surveys suggest (Smith et.al., 2021).

#### Survey on societal acceptability for circular solutions (water re-use)



### Regional Digital Twins to support evidence-driven regional adaptation pathways: The case of Attica DT

### The Attica region, Greece

- Includes the Athens capital • Area: 3.800 km<sup>2</sup>
  - Population: 3,7 million
  - (9,6 million inhabitants & tourists annually)
  - Typical Mediterranean region

- Conflicting demands agriculture-environment Tourism intensifies competing demands
- Groundwater over-use salinity yields
- High temperatures / reduced rainfall Increased energy consumption for cooling Reduced air quality
- Prone to flash floods

### The Attica DT



Goal: Regional integration solution for sharing, accumulation, transformation, & co-creation of knowledge among the administration parties, technology providers and the local case studies' stakeholders – focused on regional

Region-wide climatic indexes Copernicus and local datasets (hard and soft-sensors).

**Online services** 

DT integrated Flood assessment

Assessment of flood events in the region

Spatial visualisation of impacts and flood

characteristics (velocity, water level etc.)

**Supporting Reforestation and Biodiversity** 

Feedback and knowledge exchange from successful

• Biodiversity monitoring of different landscapes

• "Learning from experience" factors to develop

optimal reforestation strategies

Deep Learning driven (CNN)

HEC-RAS powered modelling backend

Tapped into the DT regional database

• Real-time or scenario-based

restoration efforts



**Data accumulation and transformation** 

Past: Identify trends, patterns, behaviours • Integrative regional data

**Future:** Make projections and explore mitigation and adaptation pathways

and knowledge hub to **Present:** Identify climate vulnerable hotspots boost green business models, enable knowledge sharing and CoPs, and reach further into local and regional social web.

#### • Decision support background for the identification, prioritisation and characterisation of enabling/driving conditions for technology implementation.

### Conclusions

- Attica DT, and relevant regional DTs, can help future-proof our societies through evidence-based co-design of mitigation and adaptation pathways that utilise viable innovative solutions and prioritizing the climatevulnerable hotspots at regional and local level.
- Regional DTs enable far-reaching knowledge exchange, especially towards policy makers, and can boost the uptake of novel technologies that emerge from European, national or private R&D – creating a more robust green business environment that lives past the end of initiatives.
- Citizen's engagement can eliminate societal barriers, shift policy and lead to faster paces of adoption

#### References

TEC. (2021), Innovative approaches to accelerating and scaling up climate technology implementation for mitigation and adaptation, Bonn, Germany: Technology Executive Committee, UN, TEC/2020/20/7 (2021). "Circular economy in Europe: insights from the policy implementation assessment European Environment

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Bouziotas D., Stofberg S., Frijns J., Nikolopoulos D. & Makropoulos C. (2023) Assessing the resilience of circularity in water management: a modeling framework to redesign and stress-test regional systems under uncertainty, Urban Water Journal, DOI: 10.1080/1573062X.2023.219003

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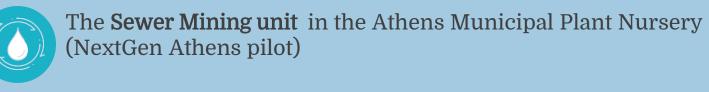
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### **Hub for far-reaching demonstration of innovations**

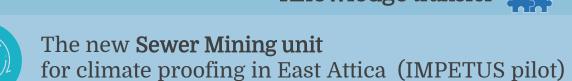




#### 25 m<sup>3</sup>/day at the point of demand Nutrient and energy recovery solutions

- From disconnected information silo to an online real-world demonstrator
- Descriptive and visual information for easy understanding of the technologies and operations (increase knowledge transfer at various levels)
- Real-world data and performance plots provide insights and evidence for benefits • EYDAP (Athens' water company) quality analysis measurements (evidence to overcome
- societal acceptance barriers) FIWARE "Smart Water" specification and hardware-independent data connection to
- Attica DT can host any similar real-world pilot.

# Knowledge transfer



Urban greening and climate proof against droughts Municipal ecosystem services

- Park irrigation reduction of heat island effects at local level
- Knowledge transfer from AMPN Sewer Mining New technologies to reduce the energy footprint
- Attica DT data to support stakeholders and provide increased insights over regional status and indexes
- Synergies between research private public administration in a co-creation scheme • Support feedback loop between local and regional Communities of Practice (CoP)



## **Controlled Environmental Agriculture (CEA)**

Increase resilience & sustainability of Attica's agricultural sector and adjacent natural habitats

- IMPETUS proof of concept demonstrators with Attica DT support
- Optimise water and fertilizer efficiency, reduce energy consumption, retain or enhance quality crop parameters
- · Communication tools, new business models and supporting software services to empower local CEA farms (support local CoP and clustering)