
GWF
GEOSPATIAL WORLD FORUM
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Geospatial World Forum 2024
Digital Twins for Climate Resilience

16 May 2024

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UNIVERSITY OF TWENTE.

- Combining technical and social sciences to make a difference in society
- Most entrepreneurial university
- Cross-disciplinary way of working
- Internationally oriented

HIGH TECH
HUMAN TOUCH

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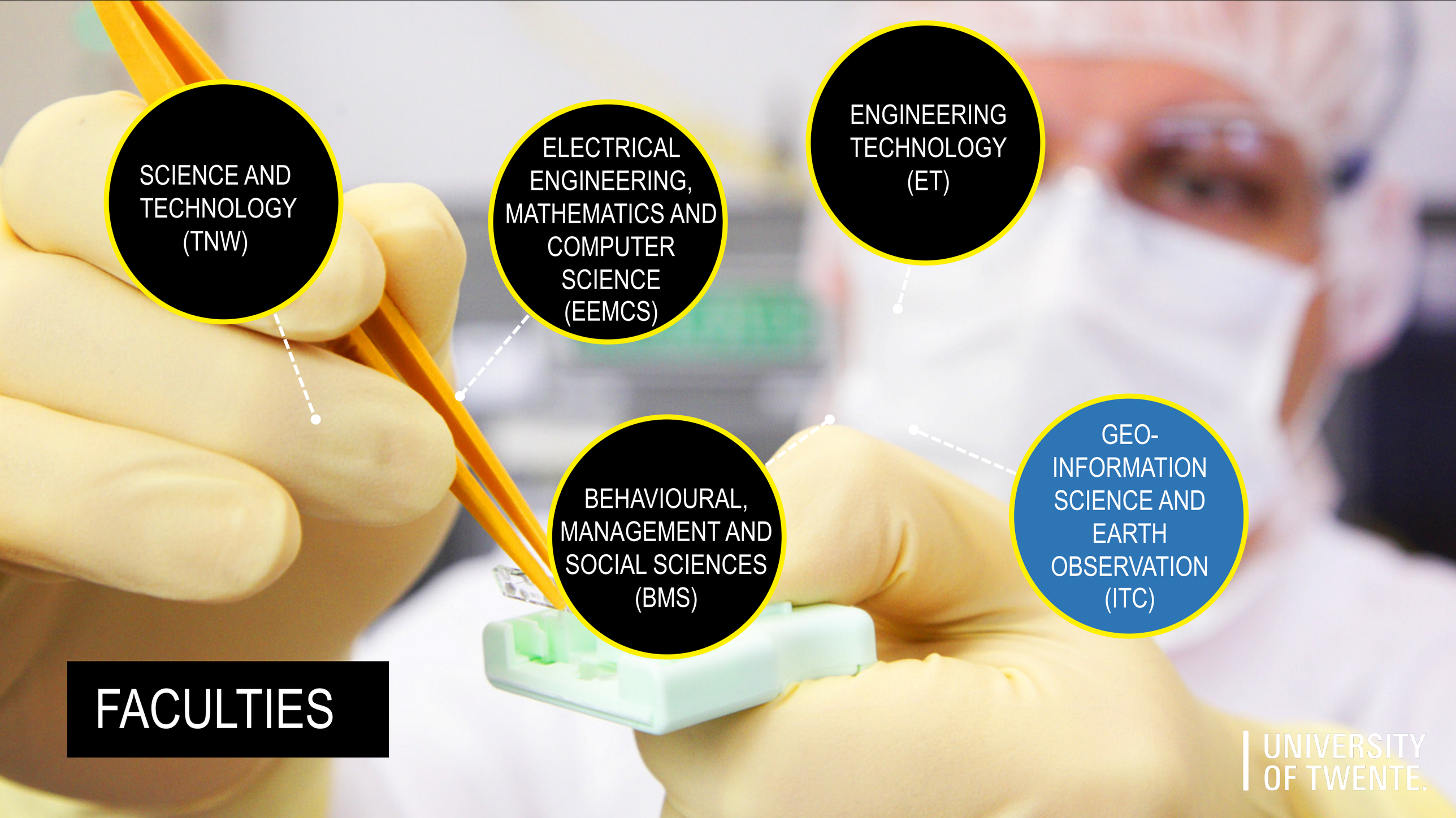

FACULTIES

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DIGITAL TWIN GEOHUB

DR. M.N. KOEVA (MILA)
Associate Professor, DTG Coordinator

DR.IR. S.J. OUDE ELBERINK (SANDER)
Associate Professor

PROF.DR.IR. C. PERSELLO (CLAUDIO)
Adjunct Professor

DR.IR. L.L. OLDE SCHOLTENHUIS (LÉON)
Associate Professor

DR.IR. F. VAHDATIKHAKI (FARID)
Assistant Professor

DR.IR. W.J. TIMMERMANS (WIM)
Researcher

DR. P. NOURIAN MARCH (PIROUZ)
Assistant Professor

Digital Twin Geohub

University of Twente

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DIGITAL TWINS

WHAT?

2D/3D city model

+

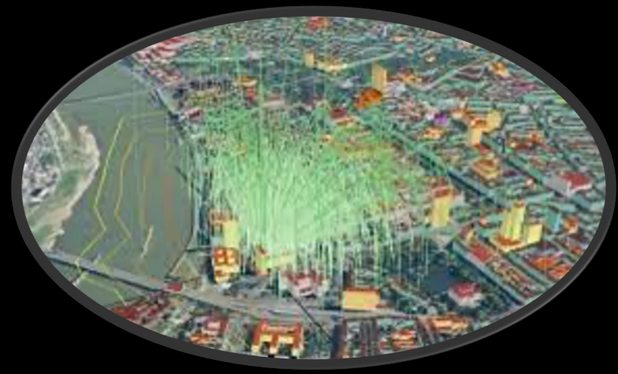
Real-time data

Continuous data update

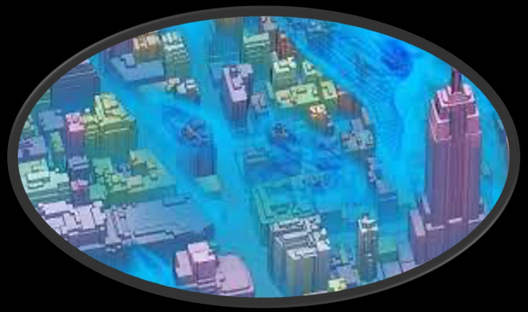
User requirements

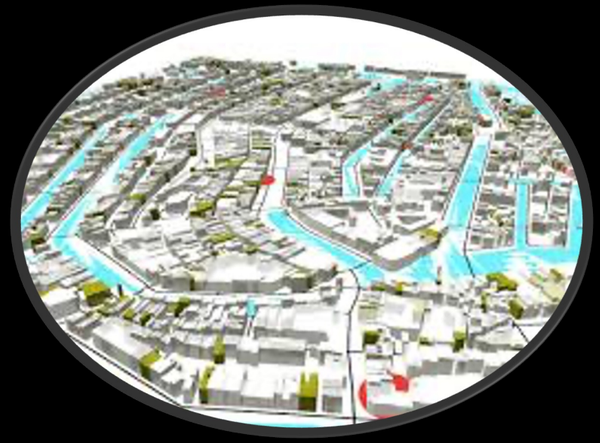
Open data

=



What if scenarios?





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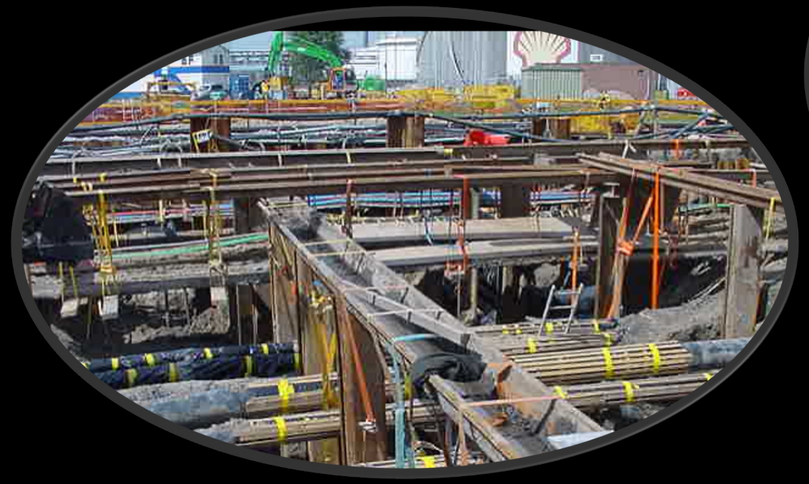
DIGITAL TWINS

WHY?

To answer major societal question to solve wicked problems
with strong geospatial relationships:

- Climate change
- Urbanization
- Disaster management
- Land rights, equality
- 3D valuation/taxation
- Improved living conditions
- Pandemics



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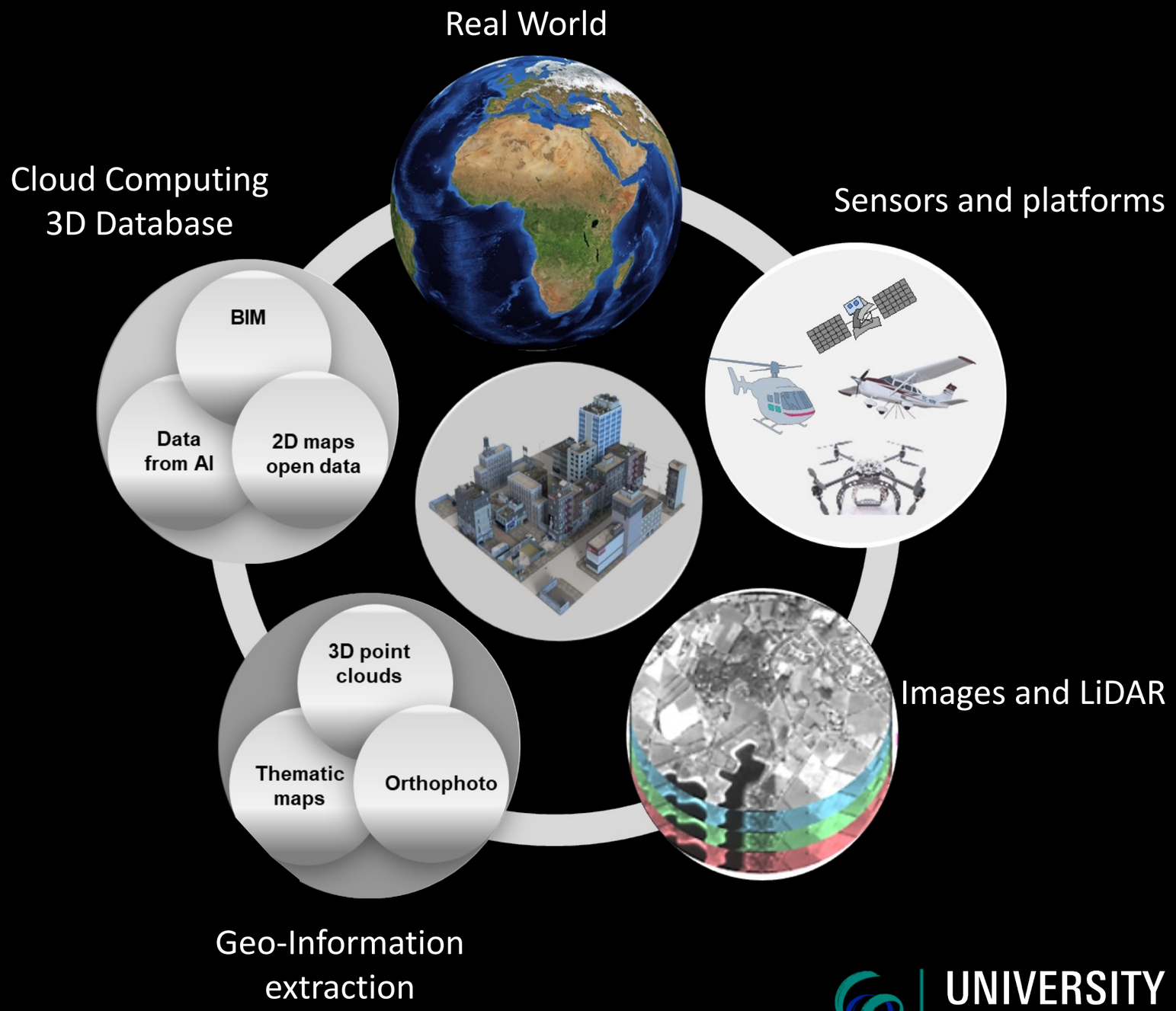
DIGITAL TWINS FOR CLIMATE RESILIENCE

HOW?

- Simulation of real systems
- Climate adaptation and mitigation
- Predictive analysis and decision support
- Optimization of resources
- Interactive and collaborative tools



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PEOPLE LAND AND URBAN SYSTEMS (PLUS)

- How Digital Twins can help?
- How photogrammetry and RS can help?
- How geospatial innovations can help?
- How AI or VR can help?

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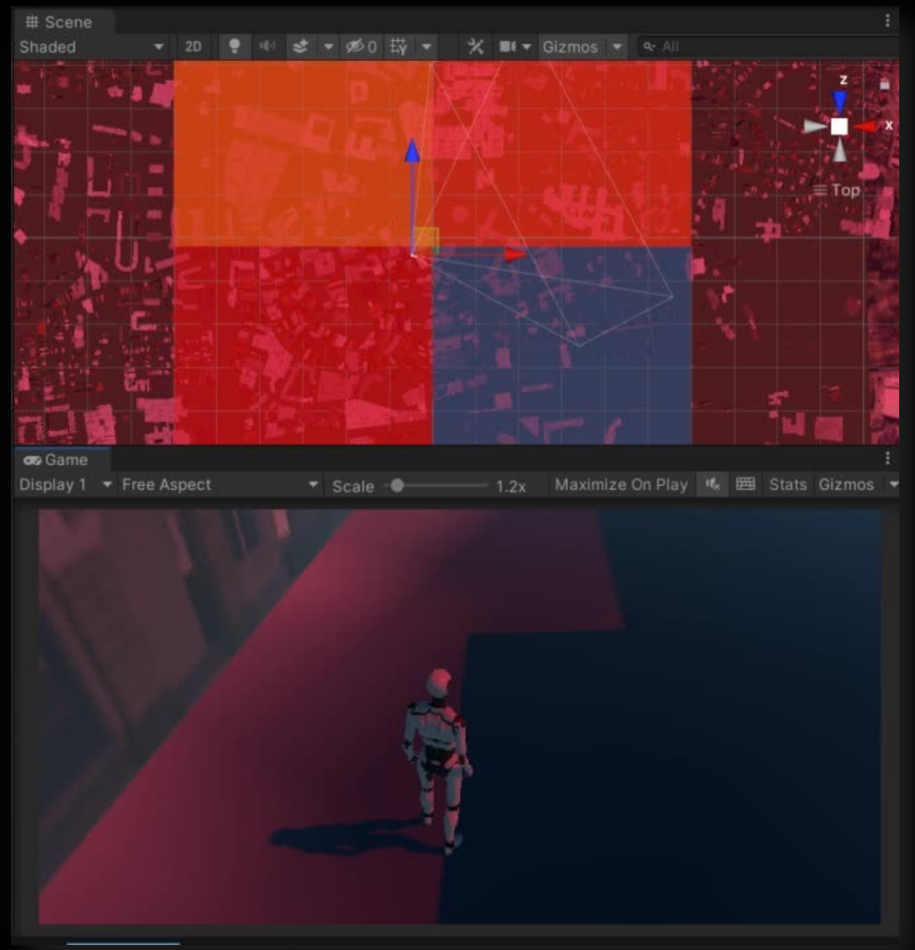
DIGITAL TWIN – ENSCHEDE

URBAN HEAT ISLAND



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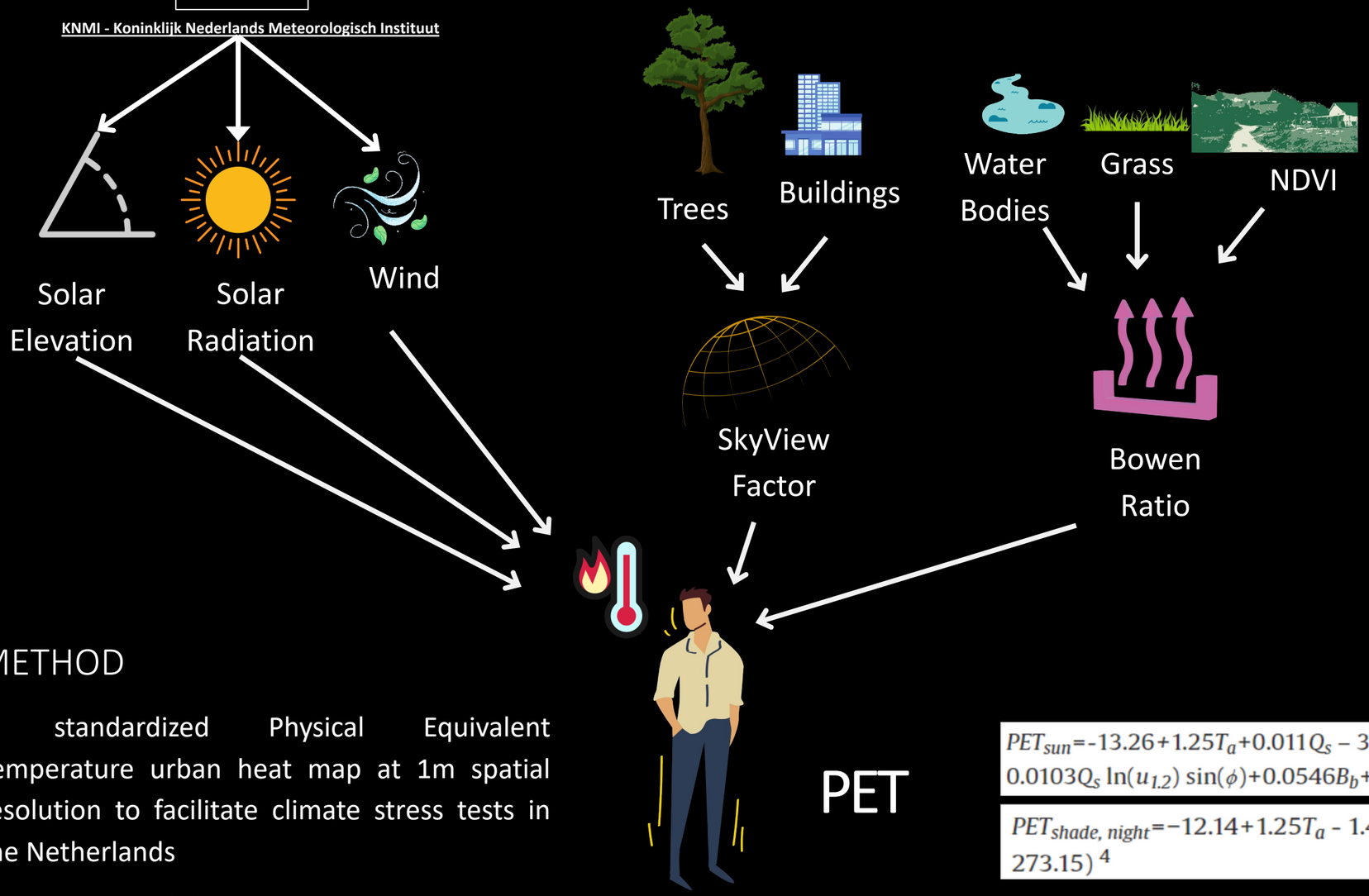
DIGITAL TWIN – ENSCHEDE

URBAN HEAT ISLAND

KNMI - Koninklijk Nederlands Meteorologisch Instituut



- Body Temperature = Ext. T° + Int.T° + Sweat + clothing
- Male 35yo, 1.75, 75kg, cloths =0.9, Walking at 4km/h

PET	Physiological Stress Grade	
18°C	Slight Cold Stress	
	No Thermal Stress	
23°C	Slight Heat Stress	
29°C	Moderate Heat Stress	Existing Grades
35°C	Strong Heat Stress	
41°C	Extreme Heat Stress (LV1)	
46°C	Extreme Heat Stress (LV2)	
51°C	Extreme Heat Stress (LV3)	New Required Grades
>56°C	Extreme Heat Stress (LV4)	

METHOD

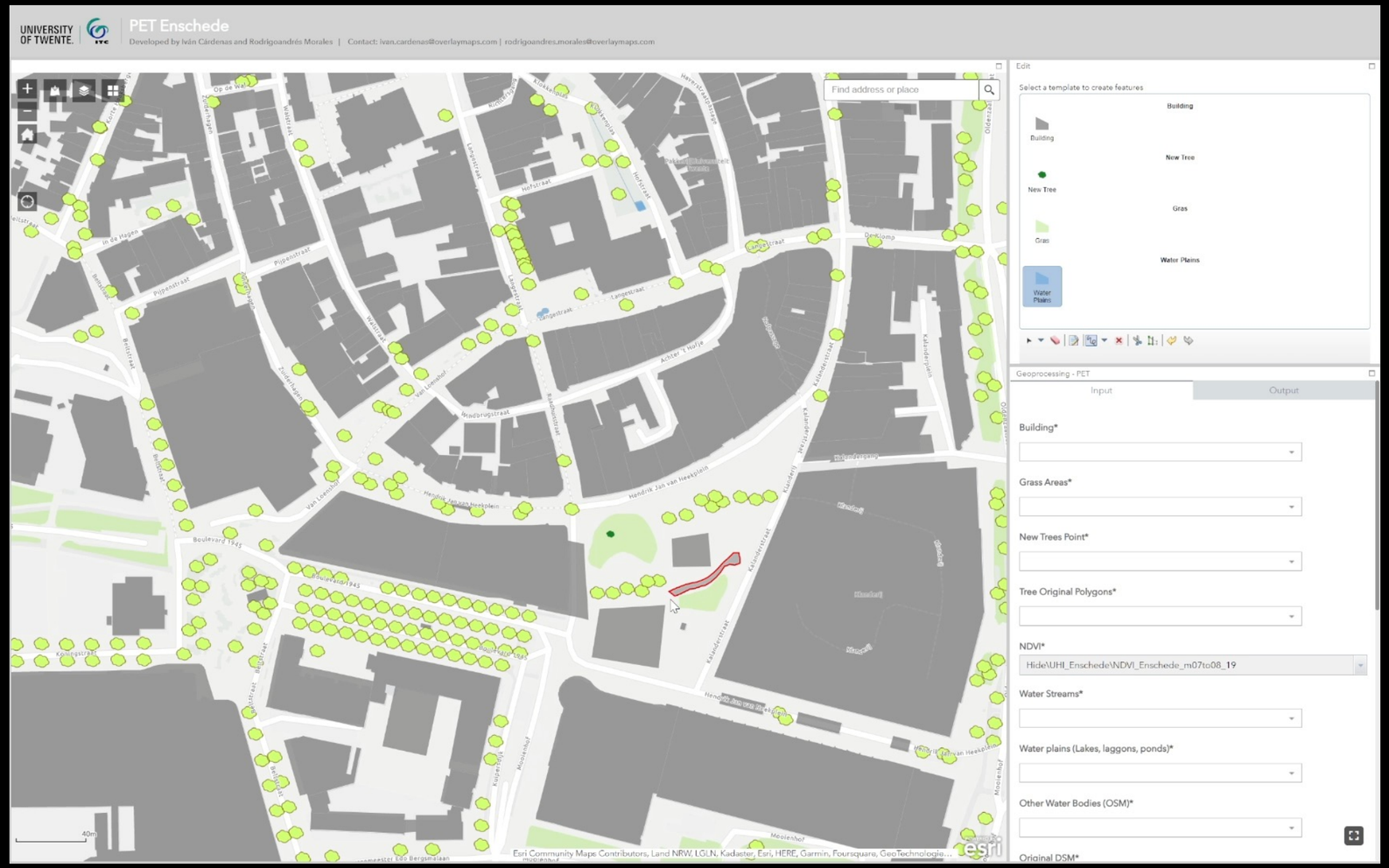
A standardized Physical Equivalent Temperature urban heat map at 1m spatial resolution to facilitate climate stress tests in the Netherlands

(Koopmans et al., 2020)

$$PET_{sun} = -13.26 + 1.25T_a + 0.011Q_s - 3.37\ln(u_{1.2}) + 0.078T_w + 0.0055Q_s \ln(u_{1.2}) + 5.56\sin(\phi) - 0.0103Q_s \ln(u_{1.2}) \sin(\phi) + 0.0546B_b + 1.94S_{vf}$$

$$PET_{shade,\ night} = -12.14 + 1.25T_a - 1.47\ln(u_{1.2}) + 0.060T_w + 0.015S_{vf}Q_d + 0.0060(1 - S_{vf})\sigma(T_a + 273.15)^4$$

DIGITAL TWIN
PET CALCULATION FOR UHI MITIGATION



Online tool

Video

Cárdenas, I. L., Morales, R., Koeva, M., Atun, F., & Pfeffer, K. (2023, August 31). Digital Twins for Physiological Equivalent Temperature Calculation Guide. Zenodo. https://doi.org/10.5281/zenodo.8306456

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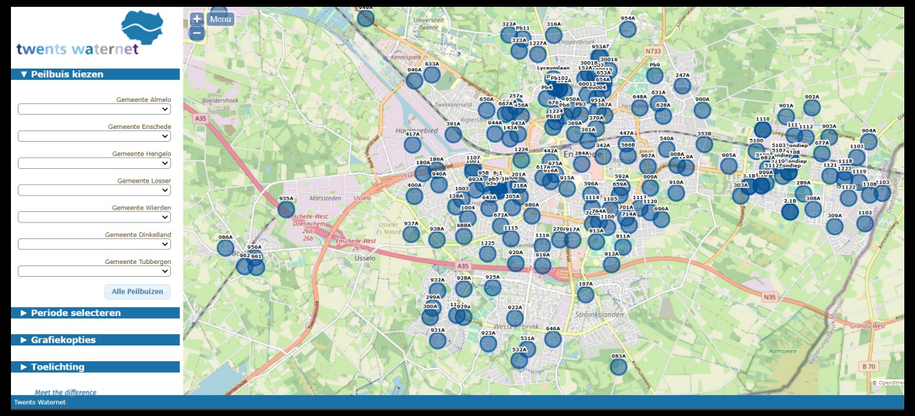
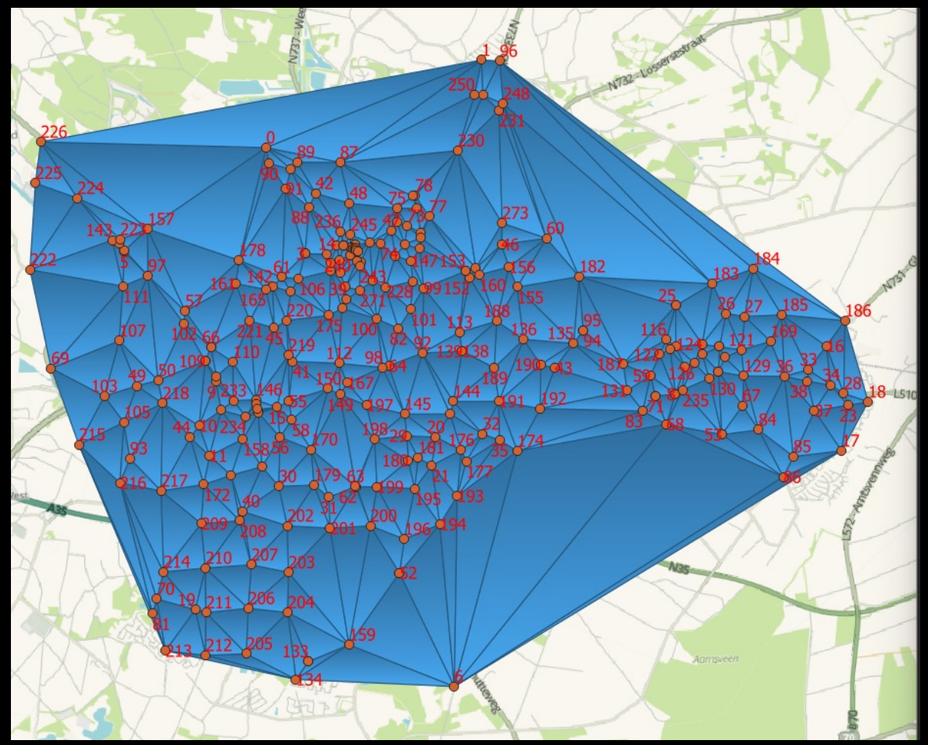
DIGITAL TWIN
GROUND WATER TABLE MONITORING





MEASUREMENTS:

REAL TIME DATA

MONITORING OF:

GWT DEPTH
WEATHER

UPDATES:

DIGITAL TWIN

CONSIDERS:

GEOMETRY
LOCATION
STATIC+REAL TIME
OBJECTS

SUPPORTS:

INFORMATION

TO CONTROL:

ASSETS
GROUNDWATER TABLE WARNINGS
WATER PUMPS

APPLIED TO:

PHYSICAL WORLD >>> ON / OFF

CONSIDERS:

GROUND WATER TABLE
TREES (ROOTS)
BUILDINGS
WATER PUMPS
TRASH CANS
PIPES-DUCTS-CABLES

DECISION MAKING:

PUMP ACTIVITY

CONTROL:

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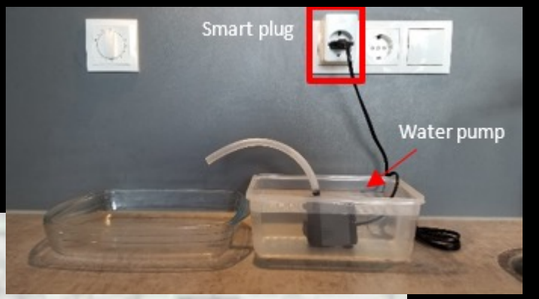
DIGITAL TWIN
GROUND WATER TABLE MONITORING



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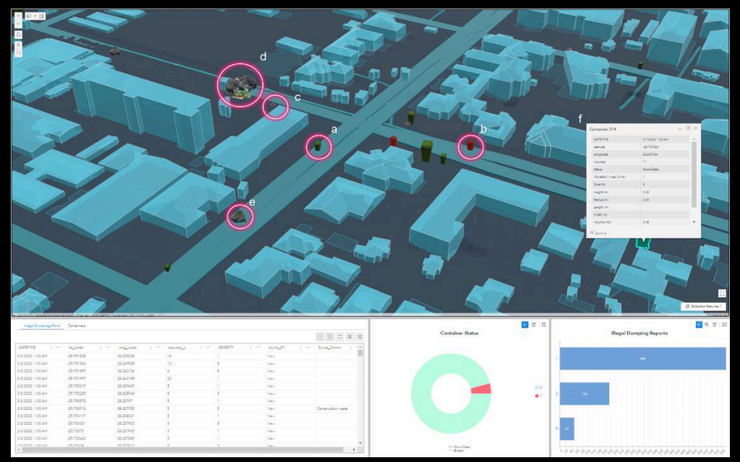
WASTE MANAGEMENT

Input	**A geospatial vector point layer with the attributes: Waste daily production (in m^3), Current waste generation (of the simulated hour), Accumulated waste (m^3), Container Volume (m^3), Saturation (%)**
Output	Random accumulation of waste in each container location Accumulated waste Saturation of each container



Cárdenas, I., Koeva, M., Davey, C., Nourian, P. (2024). Solid Waste in the Virtual World: A Digital Twinning Approach for Waste Collection Planning. In: Kolbe, T.H., Donaubauer, A., Beil, C. (eds) Recent Advances in 3D Geoinformation Science. 3DGeoInfo 2023. Lecture Notes in Geoinformation and Cartography. Springer, Cham. https://doi.org/10.1007/978-3-031-43699-4_4

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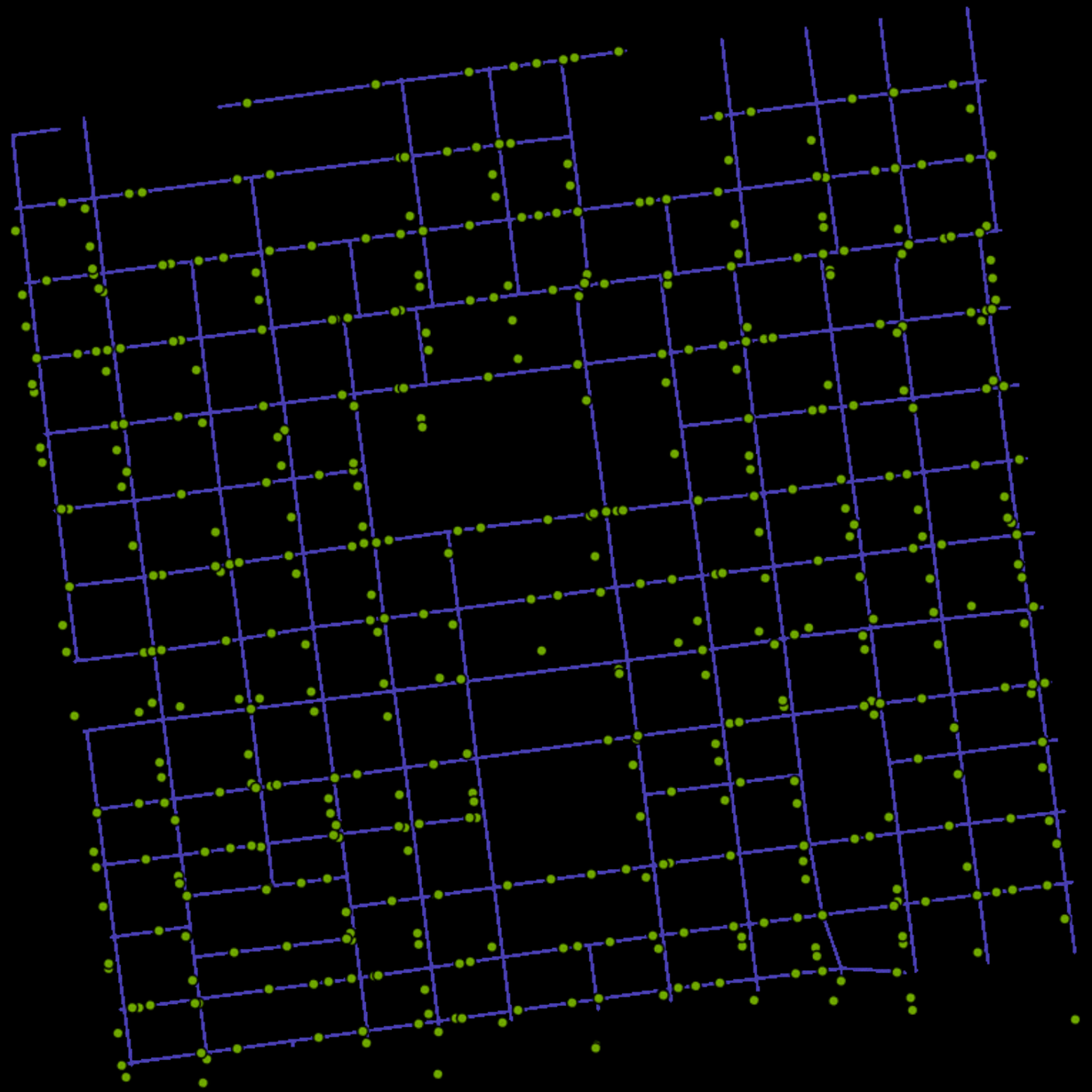
DIGITAL TWINS
FOR ASSET MANAGEMENT

Data collection

- Cameras on Service Trucks
- Semi-Automatic Recognision



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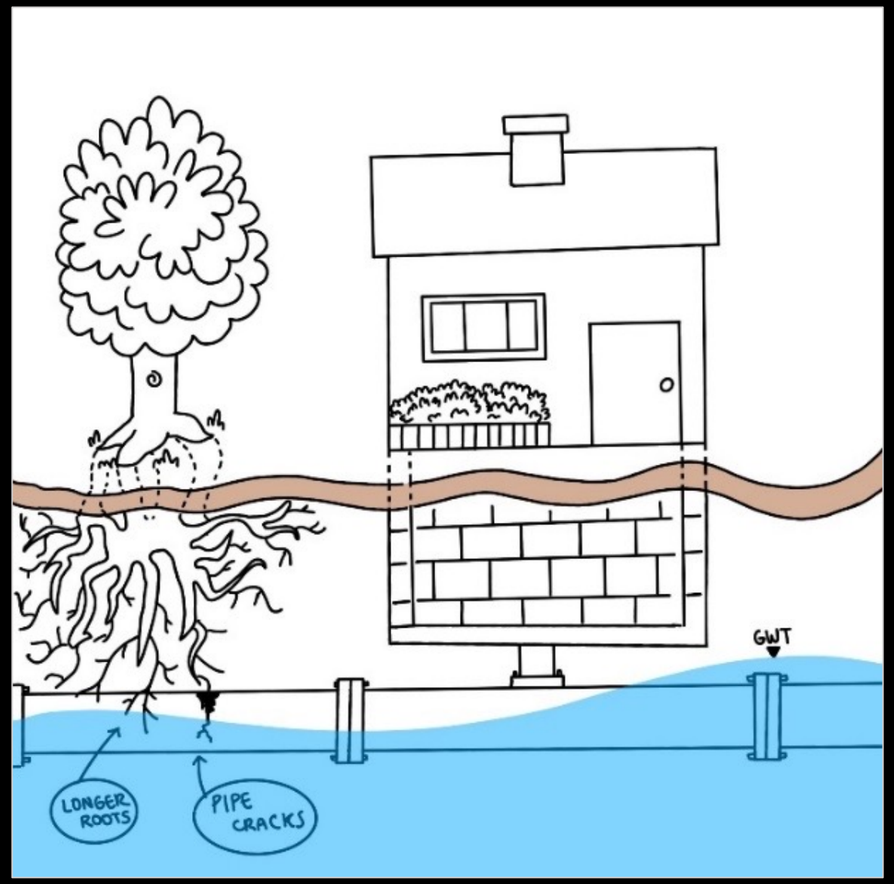
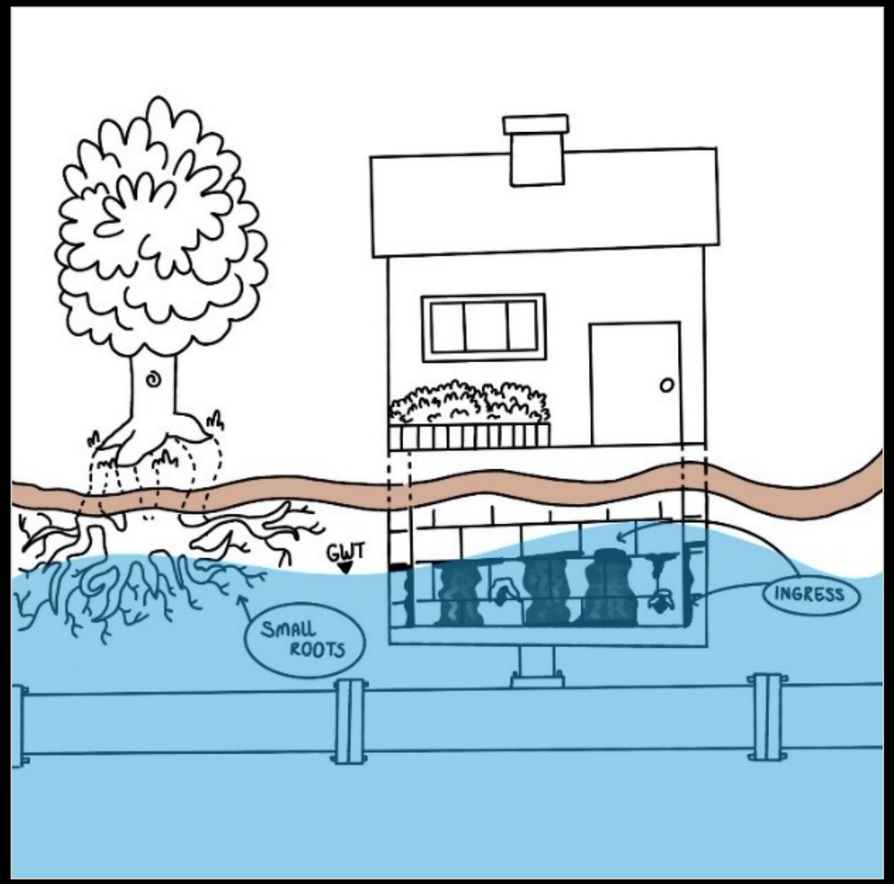
DIGITAL TWIN

GROUND WATER TABLE MONITORING & TREE ROOTS DEVELOPMENT





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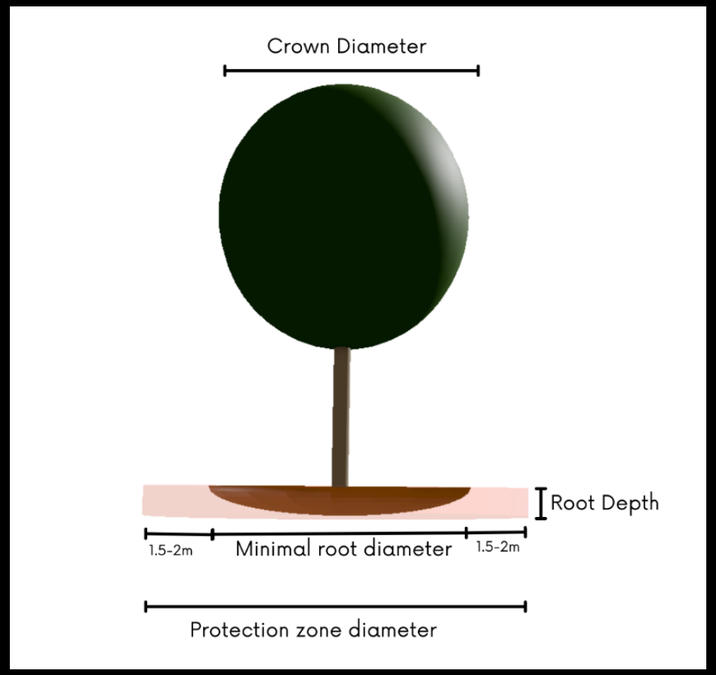
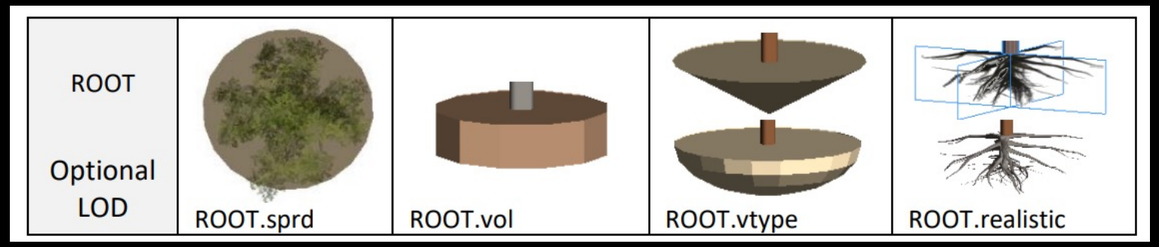
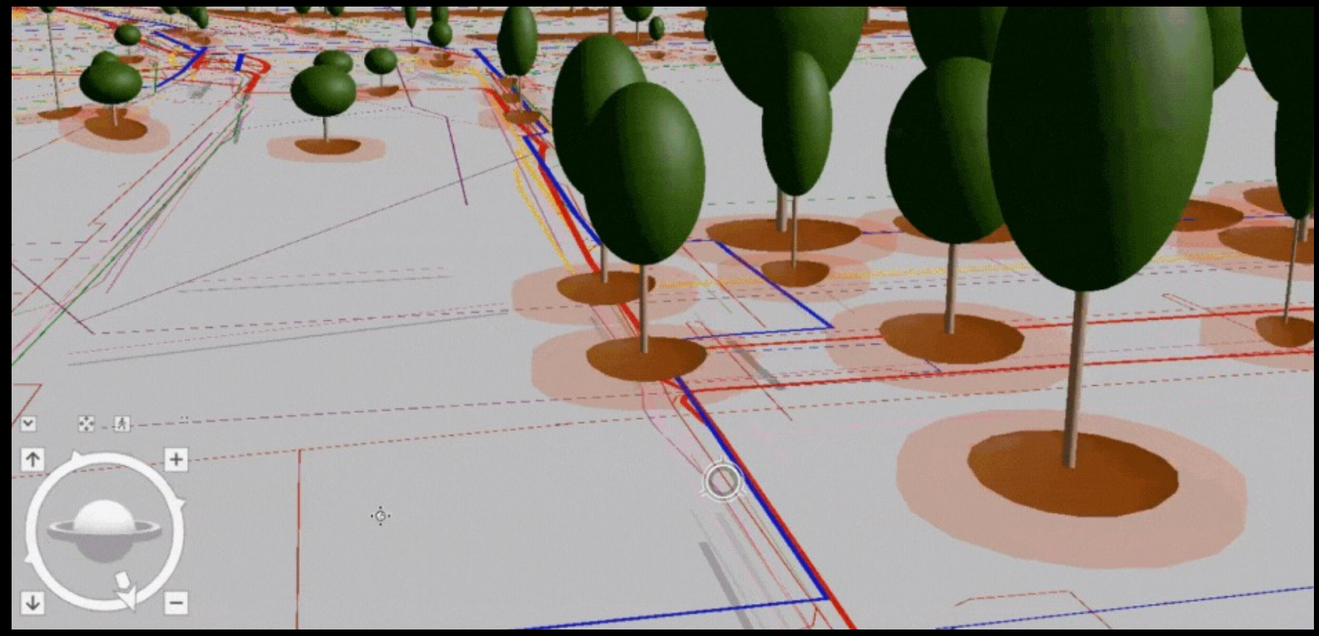
TREE ROOTS DEVELOPMENT



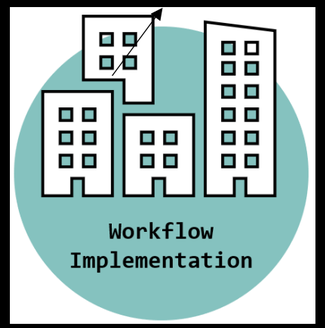


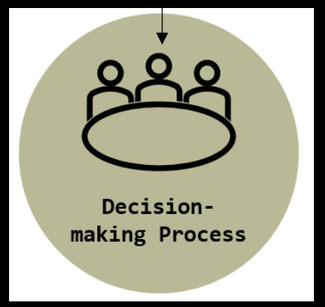
(Ortega-Córdova, 2018)

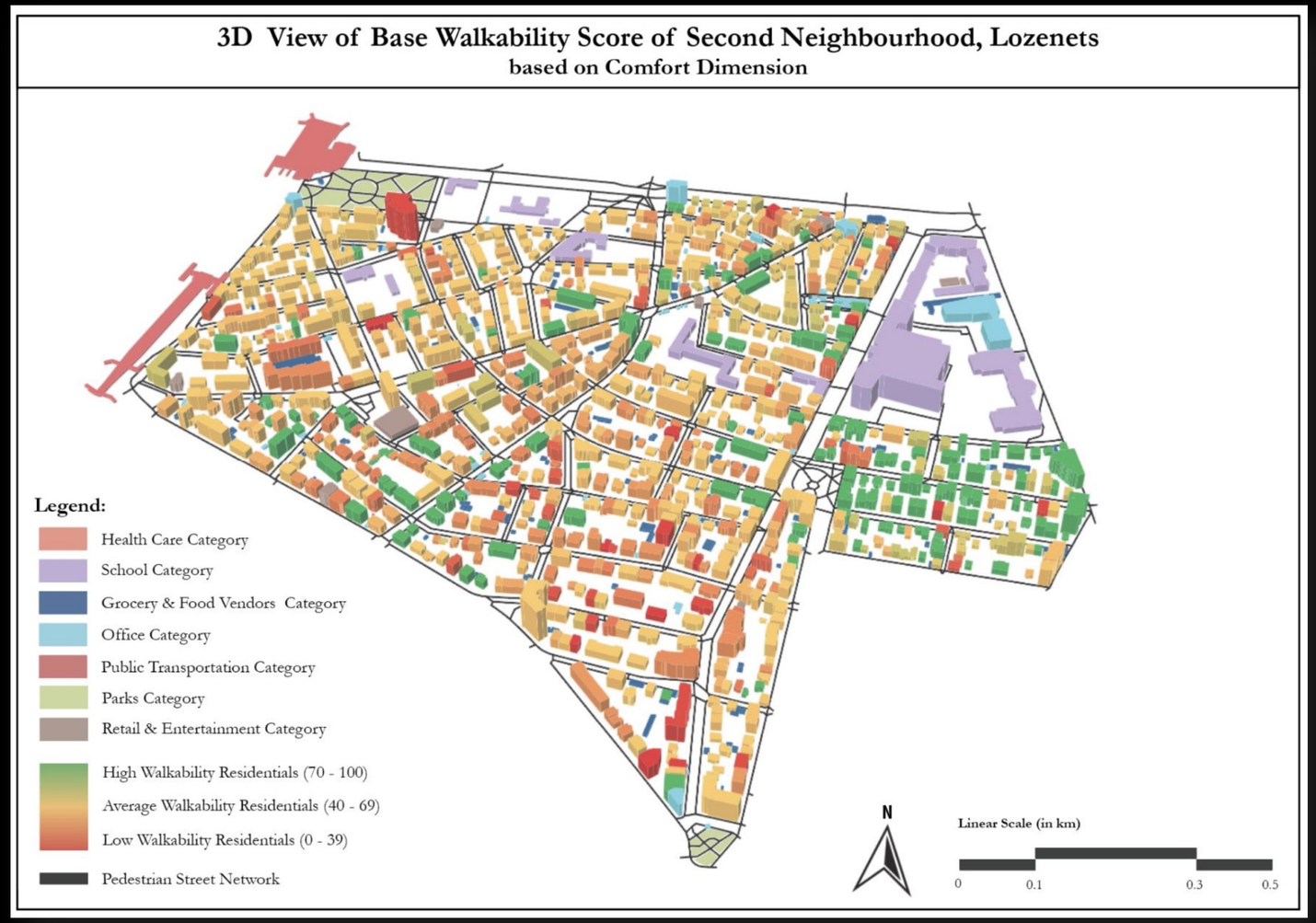


The available tree points per neighbourhood in Enschede

DIGITAL TWIN
GENERATIVE DESIGN FOR WALKABILITY







- Kumalasari, D.; Koeva, M.; Vahdatikhaki, F.; Petrova Antonova, D.; Kuffer, M. Planning Walkable Cities: Generative Design Approach towards Digital Twin Implementation. *Remote Sens.* **2023**, *15*, 1088. https://doi.org/10.3390/rs15041088
- *Kumalasari, Dewi (2022) Generative Design for Walkable Cities: a case study of Sofia. (Master's thesis, University of Twente).*
- *Generative Design for Walkable Cities: A Case Study of Sofia, Kumalasari, D.; Koeva, M.; Vahdatikhaki, F.; Petrova-Antova, D., SCSD 2022*

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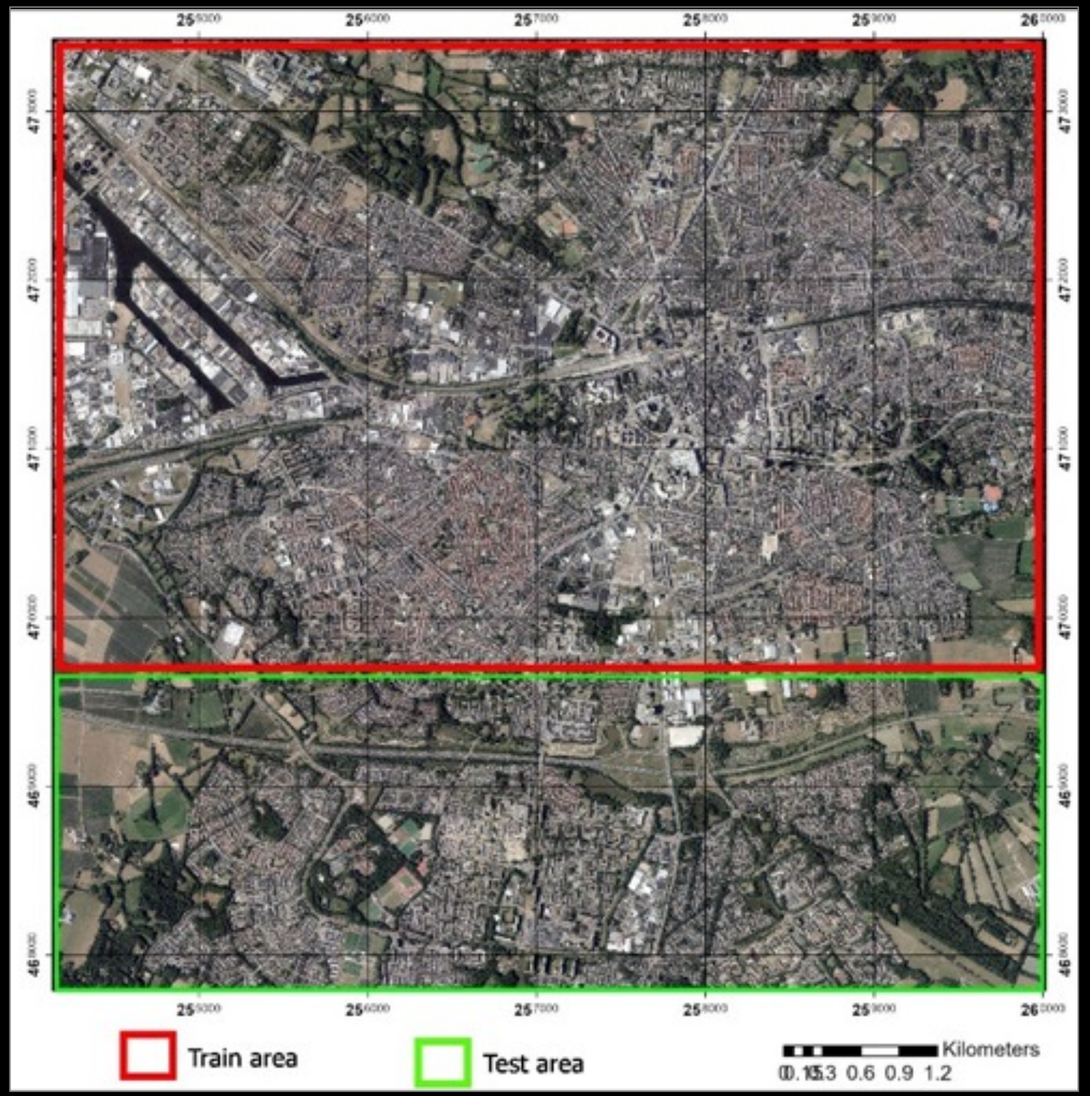
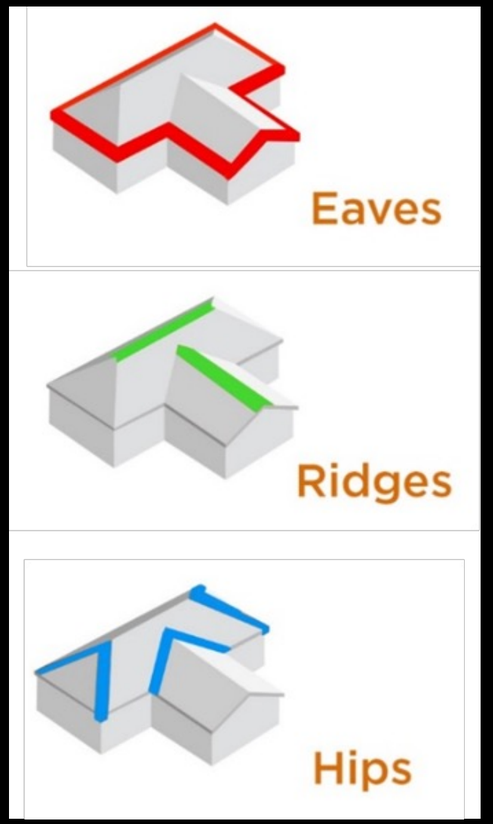
AI FOR 3D BUILDINGS NEEDED FOR DIGITAL TWINS





- Kenzhebay, Meruyert (2022) *Planar roof structure extraction from Very High-Resolution aerial images and Digital Surface Models using deep learning. (Master's thesis, University of Twente).*
- *Golnia M. (2021). Building outline delineation and roofline extraction: A deep learning approach (Master's thesis, University of Twente).*
- *Wufan Zhao, Claudio Persello, Alfred Stein, Building outline delineation: From aerial images to polygons with an improved end-to-end learning framework, ISPRS Journal of Photogrammetry and Remote Sensing, Volume 175, 2021*

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AI FOR 3D BUILDINGS NEEDED FOR DIGITAL TWINS

Class	*Precision*	*Recall*	*F1-score*
Eave	0.82	0.81	0.81
Ridge	0.49	0.61	0.55
Hip	0.23	0.51	0.32
Other	0.97	0.96	0.96
Total	0.63	0.72	0.66

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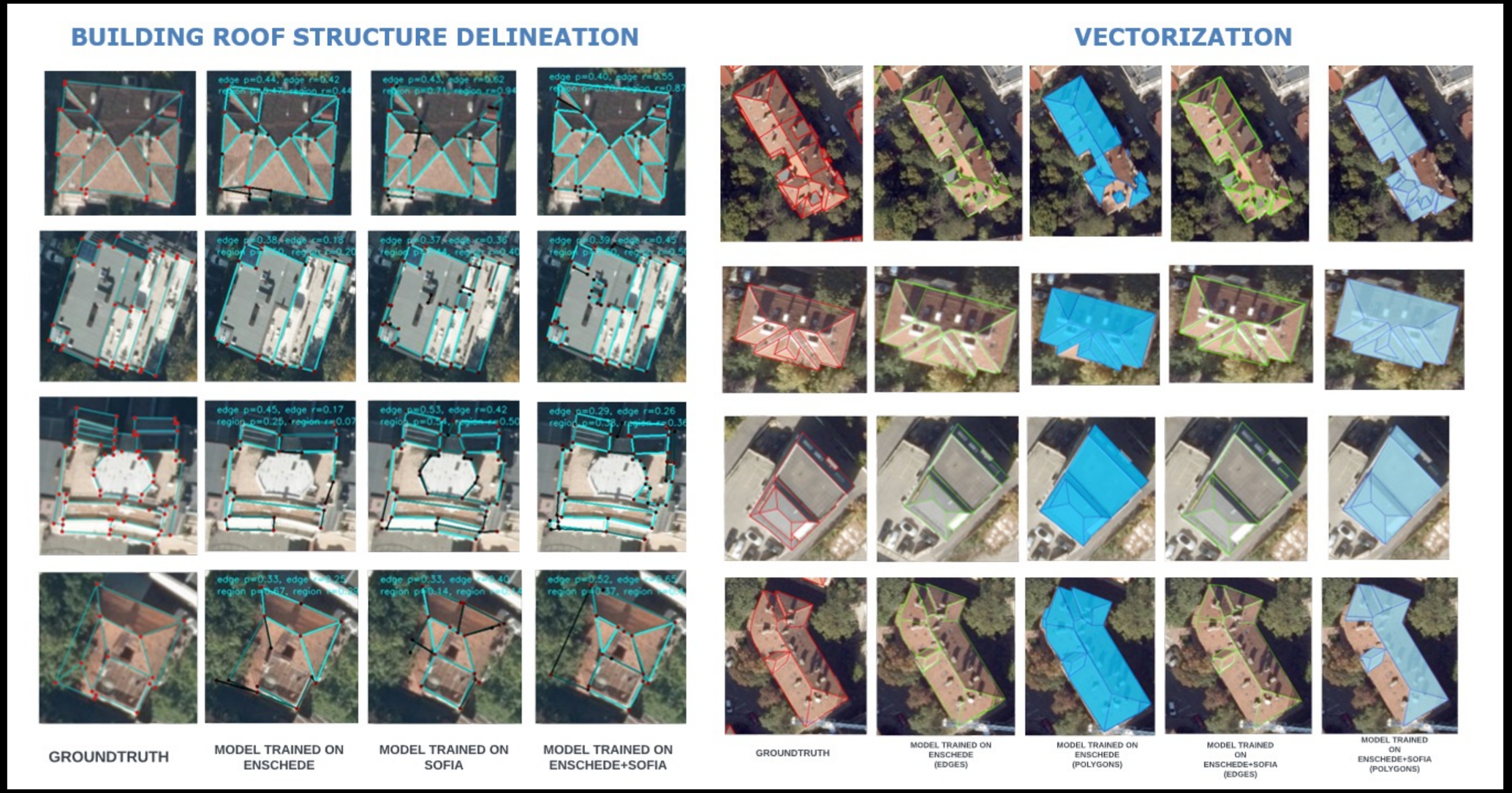
AI FOR 3D BUILDINGS NEEDED FOR DIGITAL TWINS



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RESULTS

Kaartlagen | Legenda

- Lozenets, Sofia,Bulgaria
- 't Zwering - Stadsveld, Enschede,Th...
- Oude Markt, Enschede,The Netherl...
- 3D BAG, Enschede,The Netherlands
- Enschede,TheNetherlands

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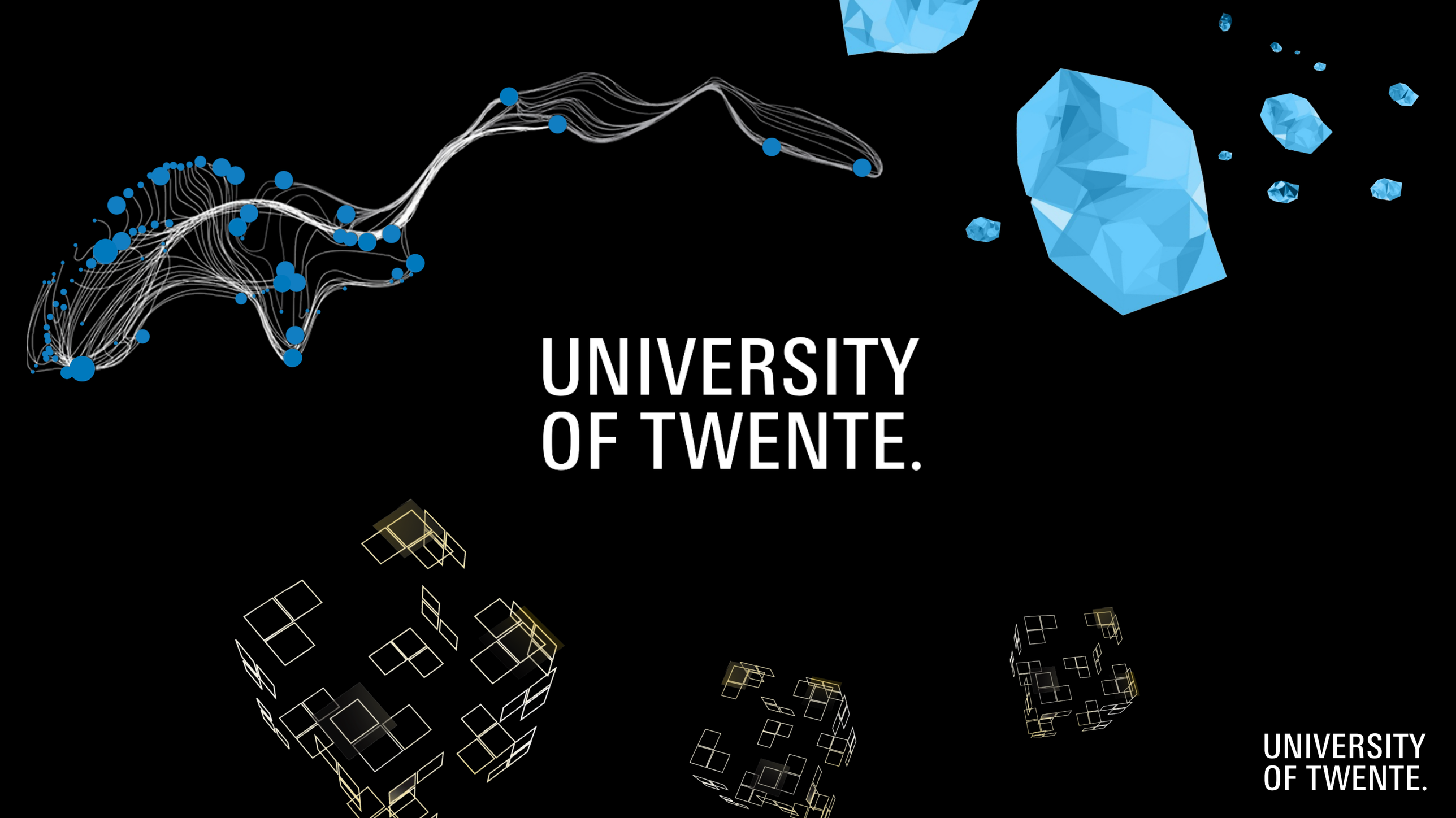

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