Dr. Mila Koeva

Associate Professor
University of Twente
ITC Faculty
m.n.koeva@utwente.nl

Photograph: NASA/REID WISEMAN/EPA

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Innovations in Land Administration
3D Cadastre, AI4LA and Digital Twins

HIGH TECH
HUMAN TOUCH

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DIGITAL TWINS

WHAT?

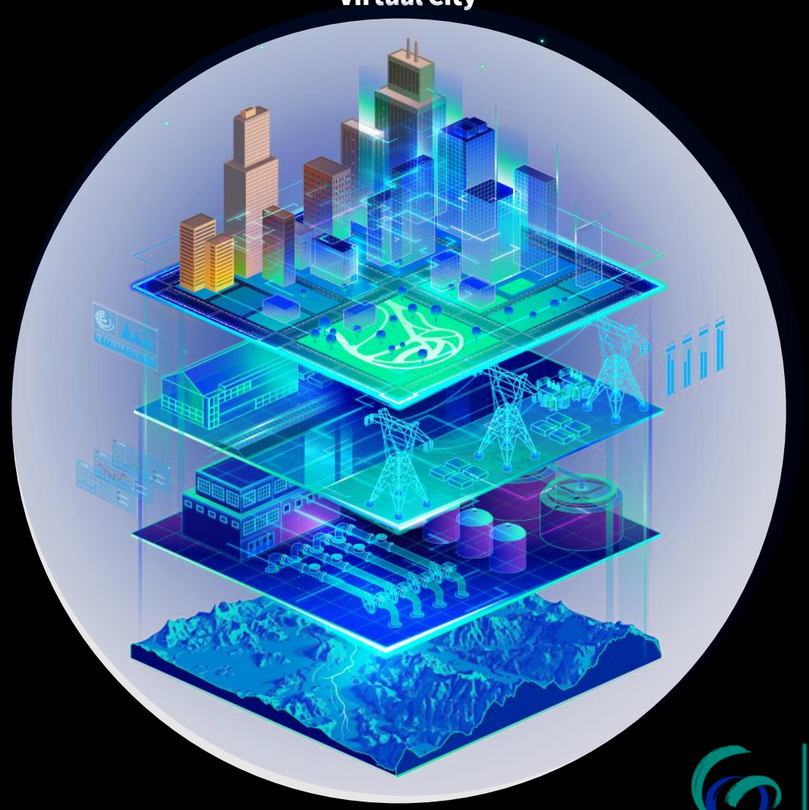
"Digital replica of the physical living environments that supports decision-making through the seamless integration of a myriad of data and analytics techniques.

As such, DT is not a mere geometric (2D and 3D) representation of static assets but a dynamic/live model that represents their past, current, and future states."

https://www.utwente.nl/en/digital-society/research/themes/digital-twin-geohub/

Physical City

Virtual City



Digital Twin Geohub
University of Twente

https://www.utwente.nl/en/digital-society/research/digitalisation/digital-twin-geohub/

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DIGITAL TWINS

WHAT?

2D/3D city model
2D/3D Cadastral model

+

Real-time data

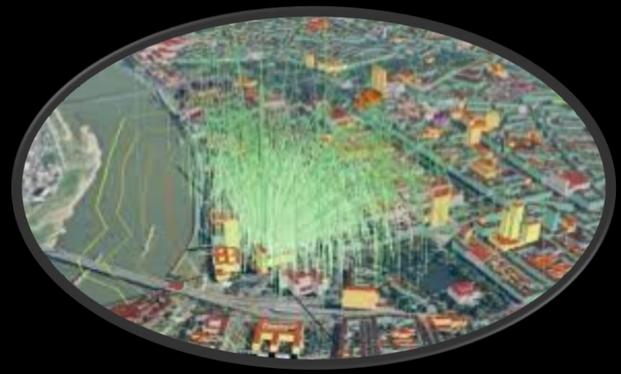
Continuous data update

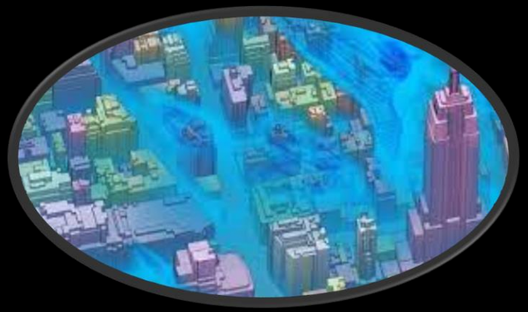
User requirements

Open data

=

What if scenarios?





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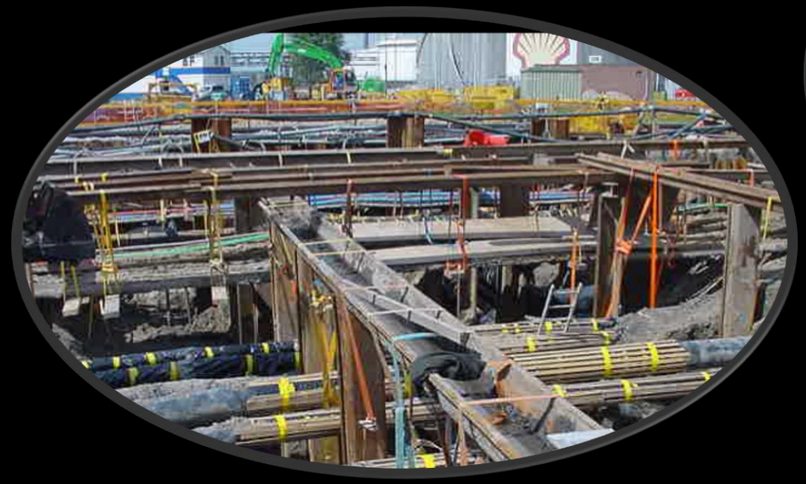
DIGITAL TWINS

WHY?

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

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



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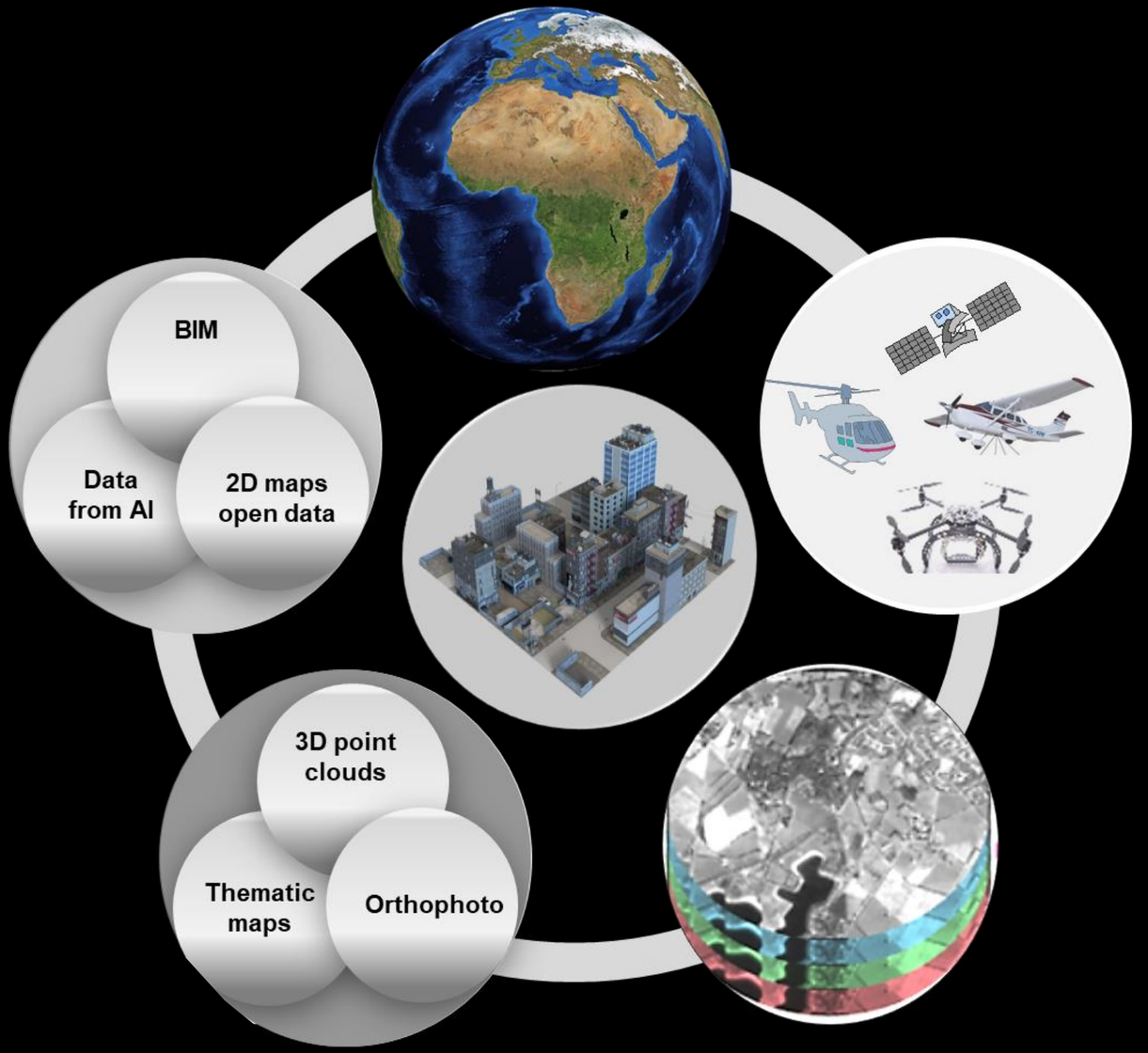
DIGITAL TWINS

HOW?

Real World



Cloud Computing
3D Database

Sensors and platforms

Geo-Information extraction

Images and LiDAR

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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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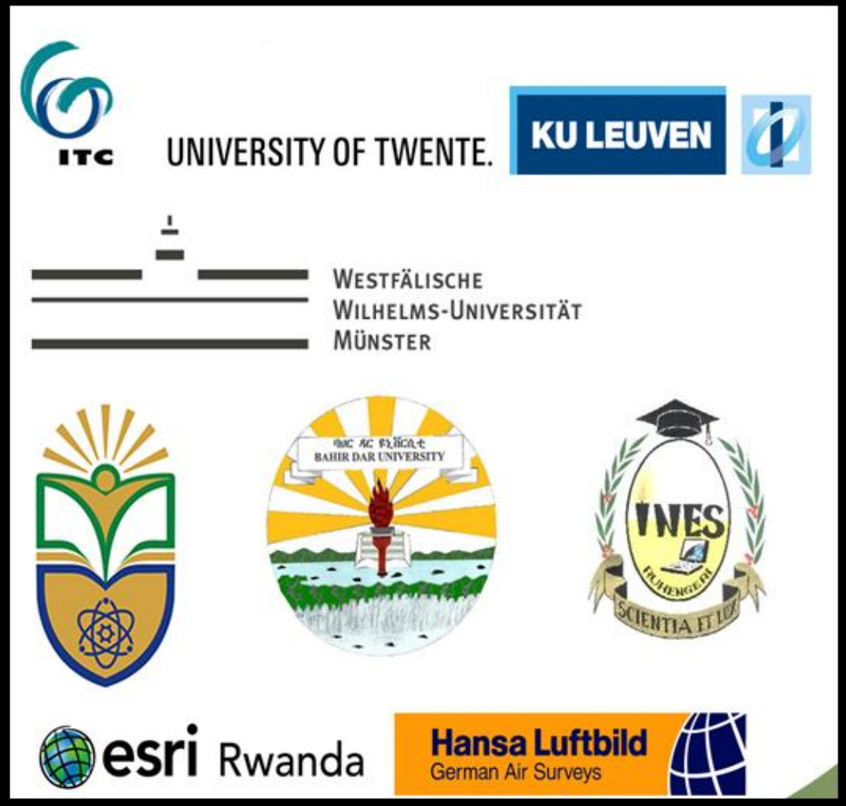
DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

EU H2020 – ICT – 2015
Research and Innovation Action
Duration: 48 months 2016-2020
Consortium: 8 partners
Budget: 3.9 M Euro



ITS4LAND innovations for land tenure

www.its4land.com

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DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

Publish and Share
LADM geocloud services/Common User Interface

UAV Orthogenerator

Boundary Delineator

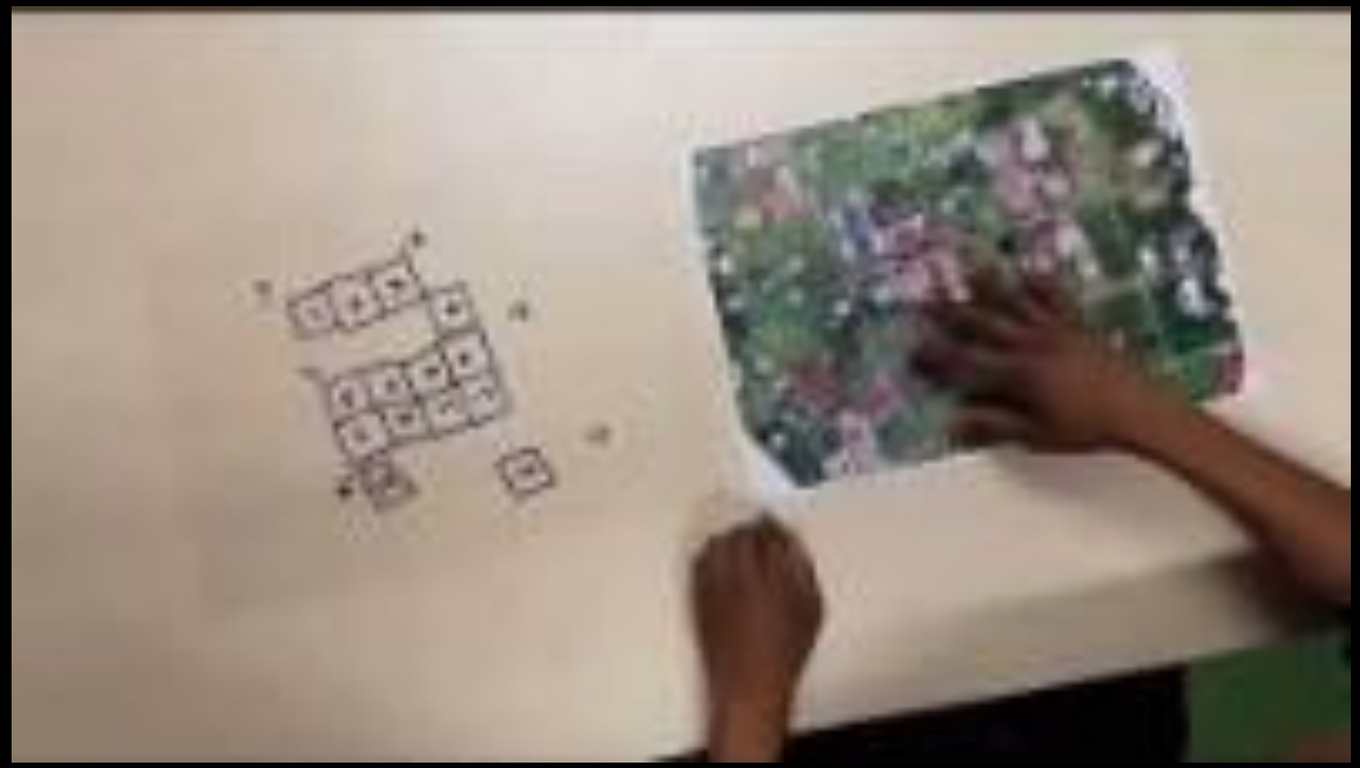
SmartSkeMa

DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

UAV (drones) 4LA

AI4LA

DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)



ITS4LAND innovations for land tenure

www.its4land.com

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DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

- LA needs are less vertexes and regularized closed vector polygons
- Fully Convolutional Networks (FCN)
- Discrete raster probability output

Input

CNN output

vectorized

+ regularized

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DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

Aircraft/aerial image
2017 RGB
0.29 m spatial resolution
50 km^2 area coverage
March/April

UAV image
2019 RGB
0.11 m spatial resolution
9 km^2 area coverage
November

Cadastral boundaries
Reference dataset

https://2023.ieeeigarss.org/view_paper.php?PaperNum=3925#top

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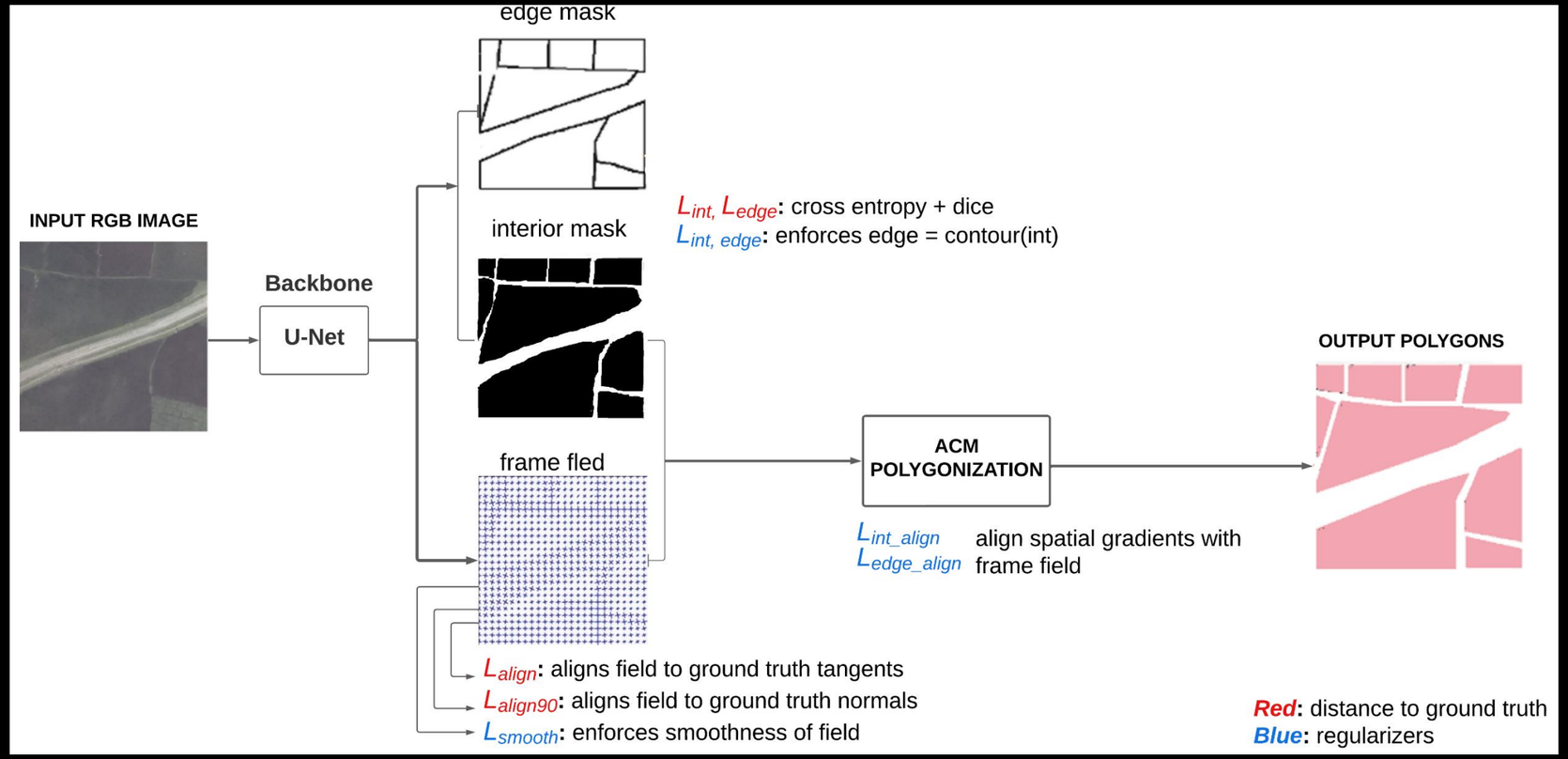
DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

Multitask Learning

- U-Net
- Frame Field Learning
- Active Contour Model



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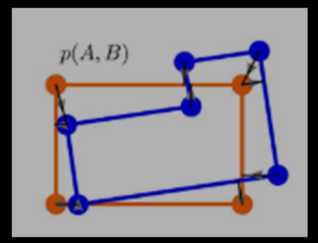
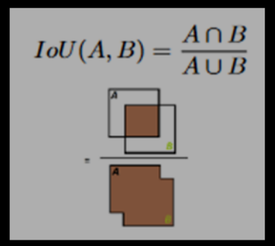
DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

Model	Dataset	PoLiS	IoU
With FFL	UAV	2.81	0.84
	Aircraft	8.64	0.79
No FFL	UAV	4.75	0.81

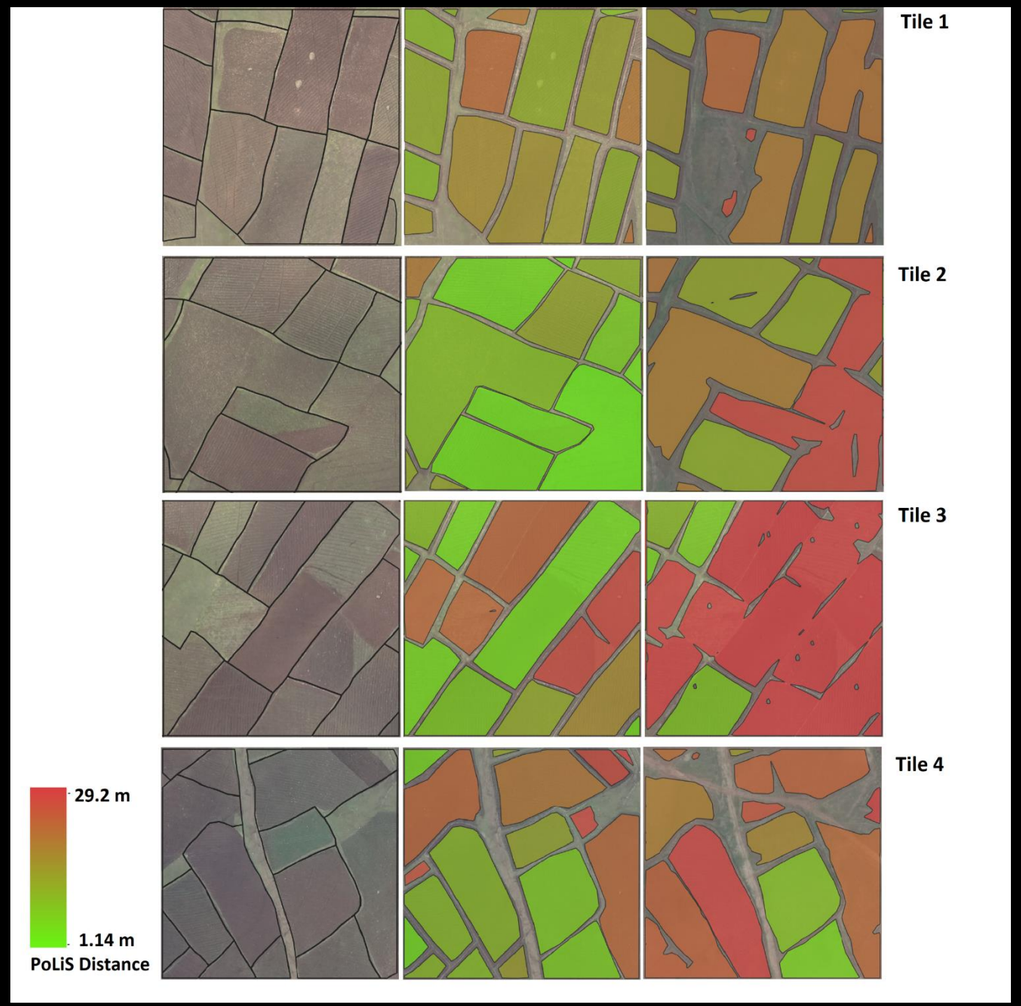


$$IoU(A,B) = \frac{A \cap B}{A \cup B}$$



Extracted
Reference
Polis difference

0-1 (complete overalap)



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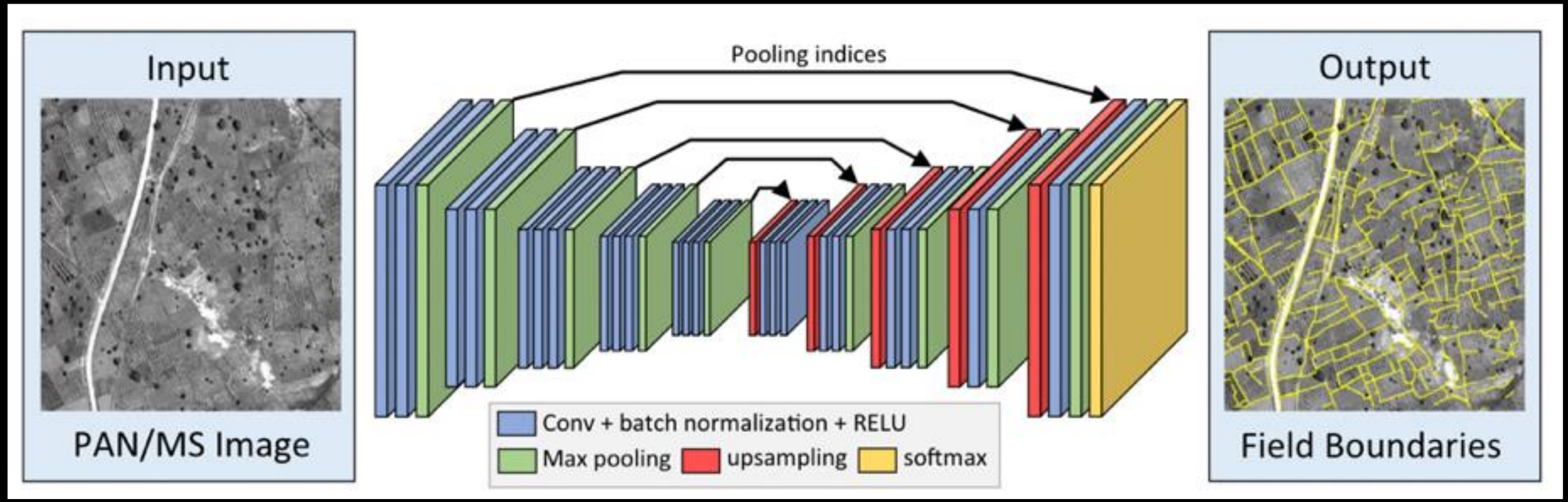
DIGITAL TWINS FOR
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)



kadaster & ITC

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3D Cadastre

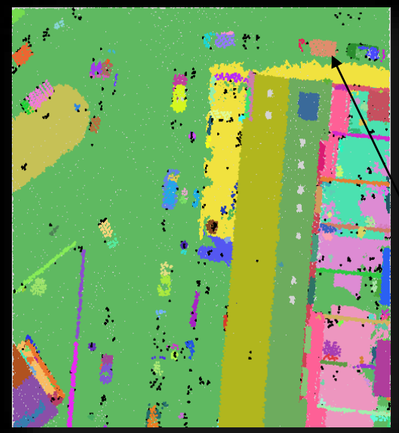
DIGITAL TWINS FOR PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

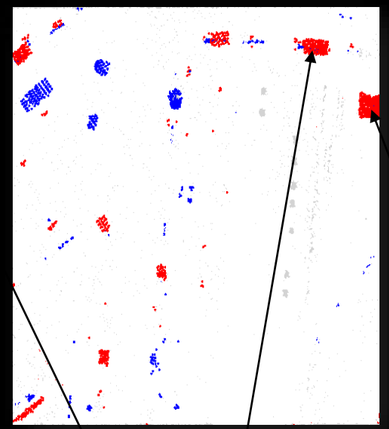
Challenges for Updating 3D Cadastral Objects using LiDAR and Image-based Point Clouds

Part of: 5th International FIG Workshop on 3D Cadastres
• list the conference papers

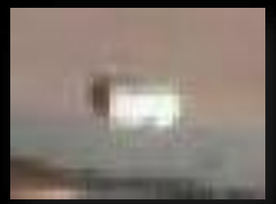
Title
Challenges for Updating 3D Cadastral Objects using LiDAR and Image-based Point Clouds

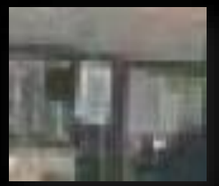
Author
Koeva, Mila
Oude Elberink, Sander





Challenges with dynamic objects





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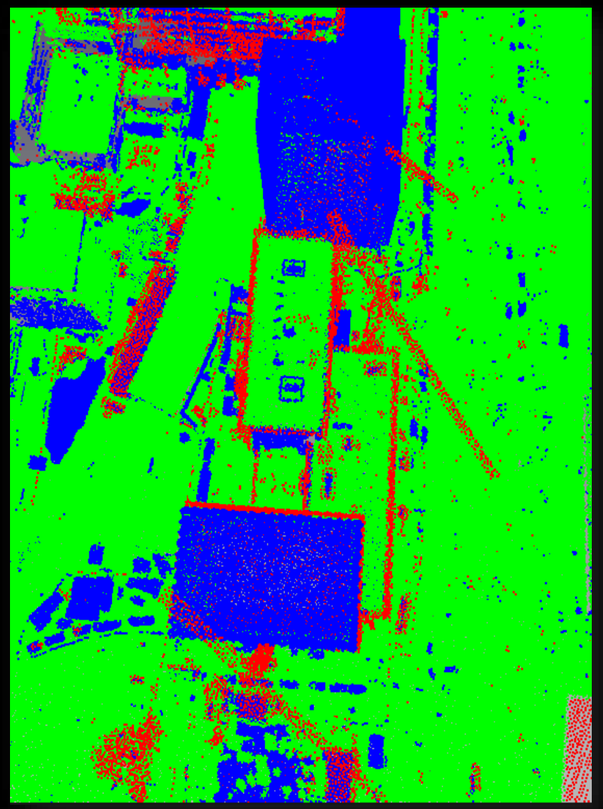
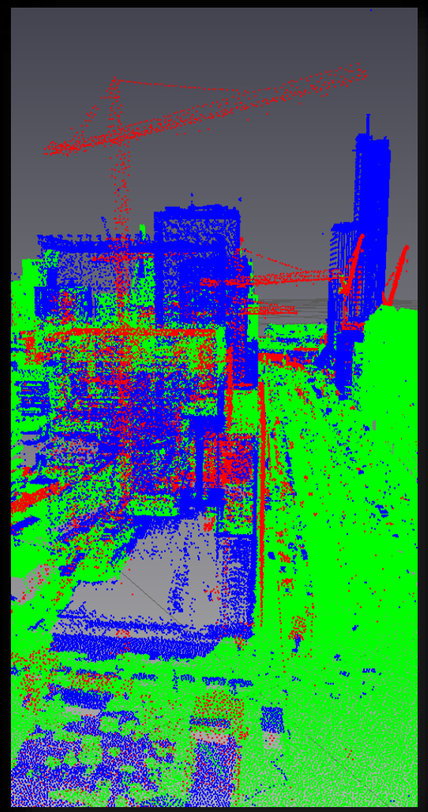
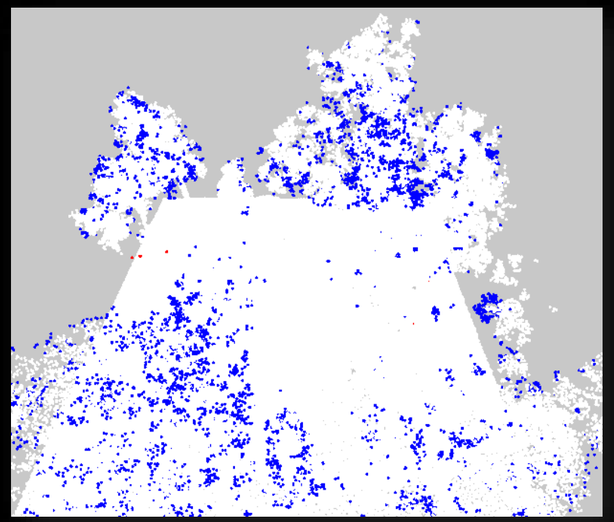
3D Cadastre

DIGITAL TWINS FOR PEOPLE, LAND AND URBAN SYSTEMS (PLUS)





Temporal challenges



Challenges due to vegetation

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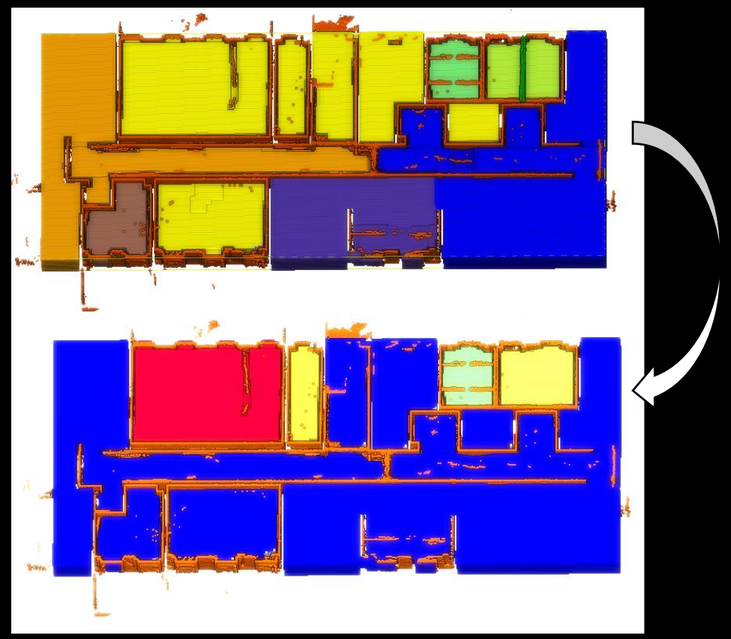
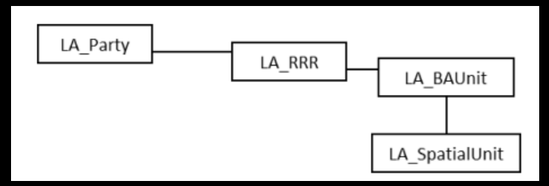
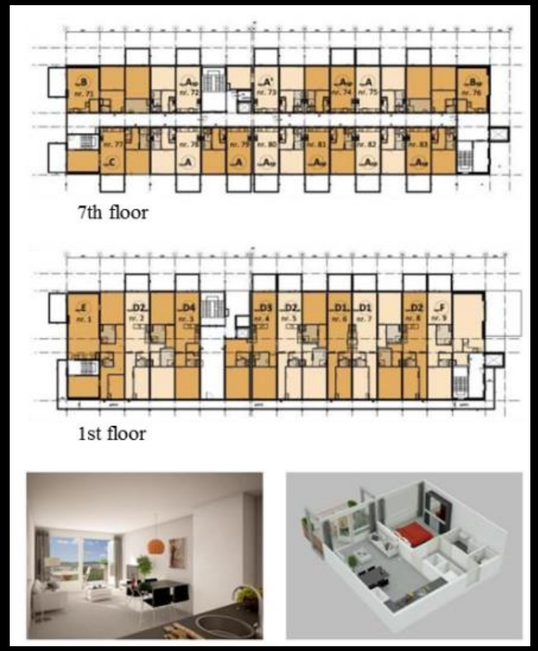
3D Indoor Cadastre

DIGITAL TWINS FOR PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

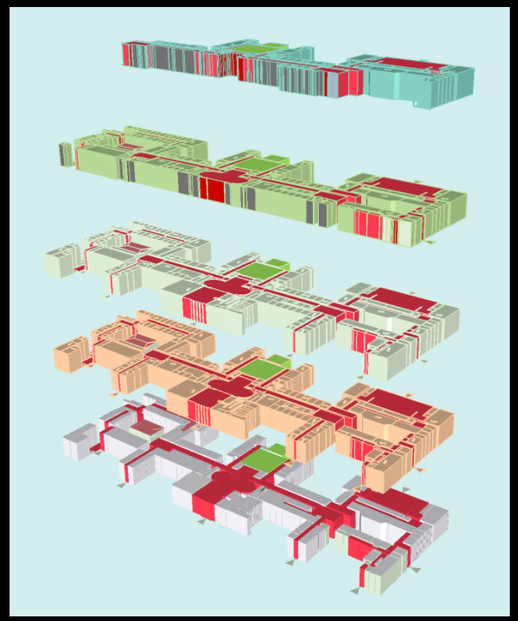




Basic classes of the LADM (ISO 19152:2012)



Change from a nursing house
to a residential apartment (Zaken, 2015)



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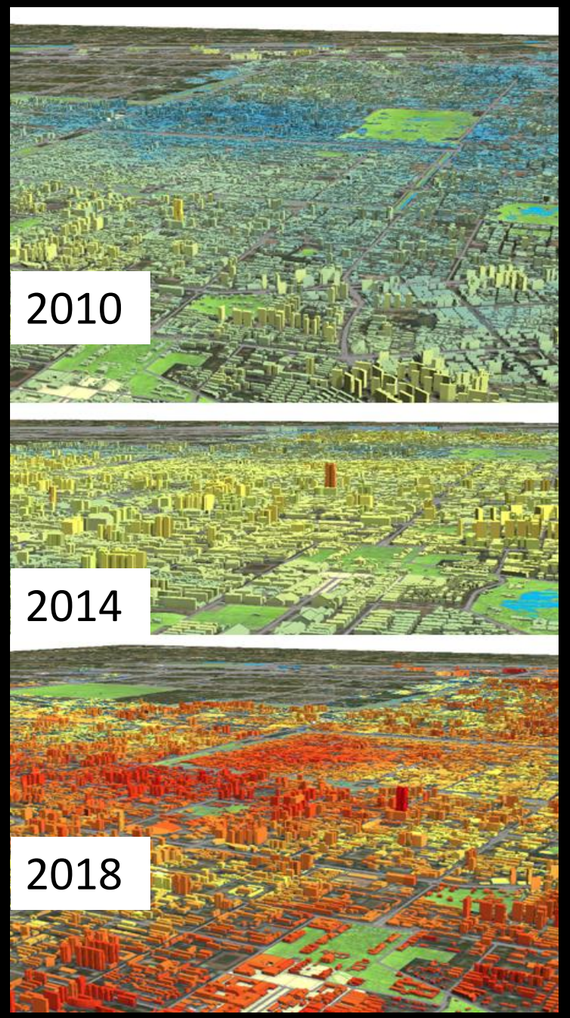
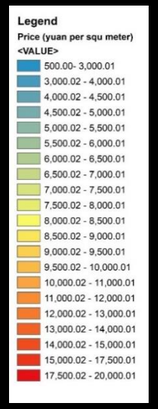
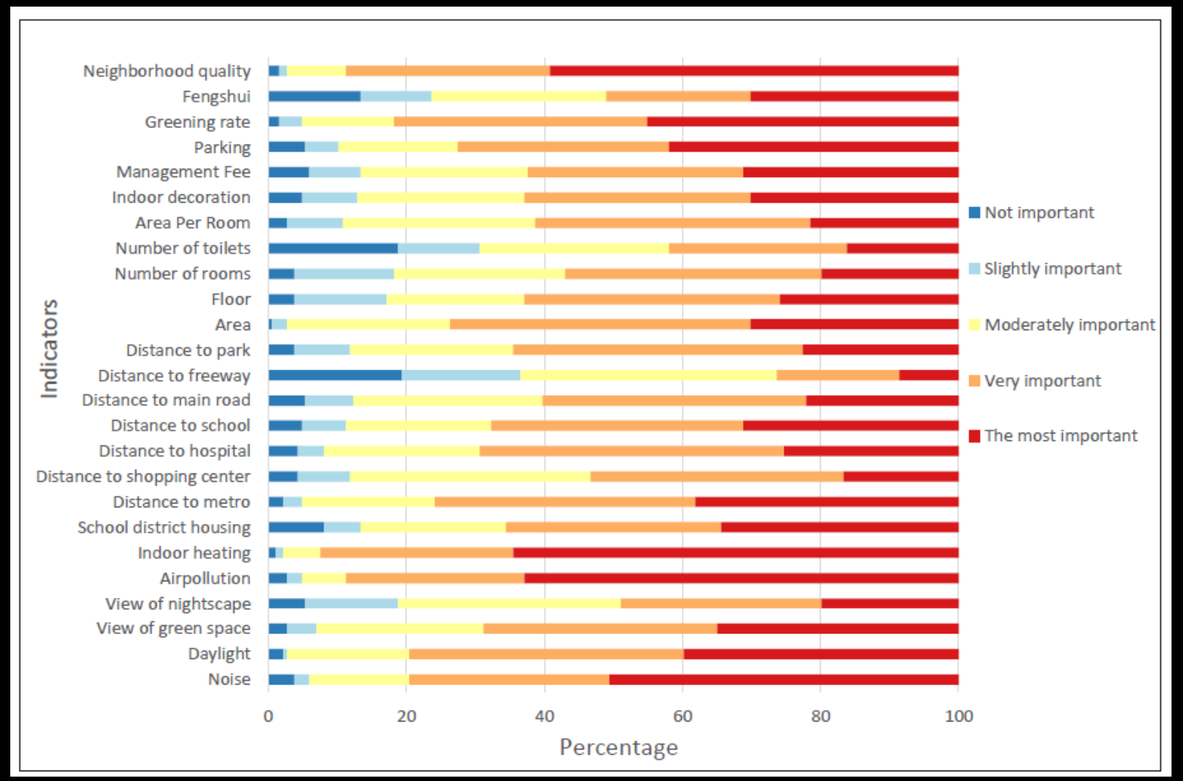
3D Valuation

DIGITAL TWINS FOR PEOPLE, LAND AND URBAN SYSTEMS (PLUS)







Xi’an, Shaanxi China

10752 km^2

- Ying, y. (2019). Assessment of 2D and 3D methods for property valuation using remote sensing data at the neighborhood scale in Xi’an, China.
- Li, r. (2019). Developing a 4D property valuation model based on geospatial data at city scale (Xi’an, China).
- Zhang, J. (2019). Developing a comprehensive framework for property valuation using 3D and remote sensing techniques in China

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3D Valuation

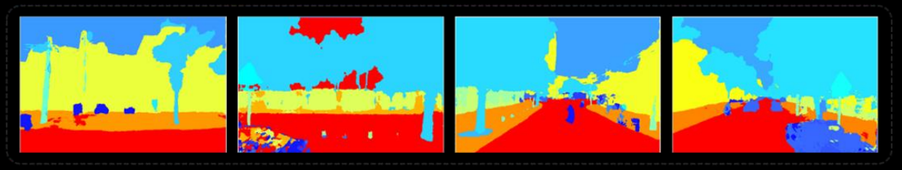
DIGITAL TWINS FOR PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

279663 images

850×680 pixels

The input data

Semantic segmentation result



Statistical analysis

road	0.158660963	road	0.105463	road	0.196006	road	0.156193
sidewalk	0.113625668	sidewalk	0.109153	sidewalk	0.103422	sidewalk	0.071012
building	0.423386096	building	0.082081	building	0.128036	building	0.118205
wall	0	wall	0.055955	wall	0.020605	wall	0.024045
fence	0	fence	0.117591	fence	0.021621	fence	0.006676
pole	0.015886631	pole	0.005906	pole	0.006631	pole	0.005099
traffic_light	0	traffic_light	0	traffic_light	0.000261	traffic_light	0
traffic_sign	0.001790374	traffic_sign	0.015653	traffic_sign	0.000798	traffic_sign	0.013386
vegetation	0.088211765	vegetation	0.488402	vegetation	0.291022	vegetation	0.404764
terrain	0	terrain	0	terrain	0.005897	terrain	0
sky	0.182660963	sky	0.002631	sky	0.200021	sky	0.10917
person	9.63E-05	person	0.001867	person	0.00468	person	0.005005
rider	0	rider	0	rider	0.000699	rider	0.001433
car	0	car	0.007677	car	0.006094	car	0.071042
truck	0	truck	0.006347	truck	0.000907	truck	0.008571
bus	0	bus	0	bus	0.003658	bus	2.14E-06
motorcycle	0.015328342	motorcycle	0.000116	motorcycle	0.006661	motorcycle	0.004958
bicycle	0.000352941	bicycle	0.001157	bicycle	0.001925	bicycle	0.000439

Street visual features and property value using DL

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DIGITAL TWINS FOR PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

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DIGITAL TWIN

Ghodsvali, Maryam. "3D modelling of underground space for urban planning and management-providing basic planning insight." Master's thesis, University of Twente, 2018

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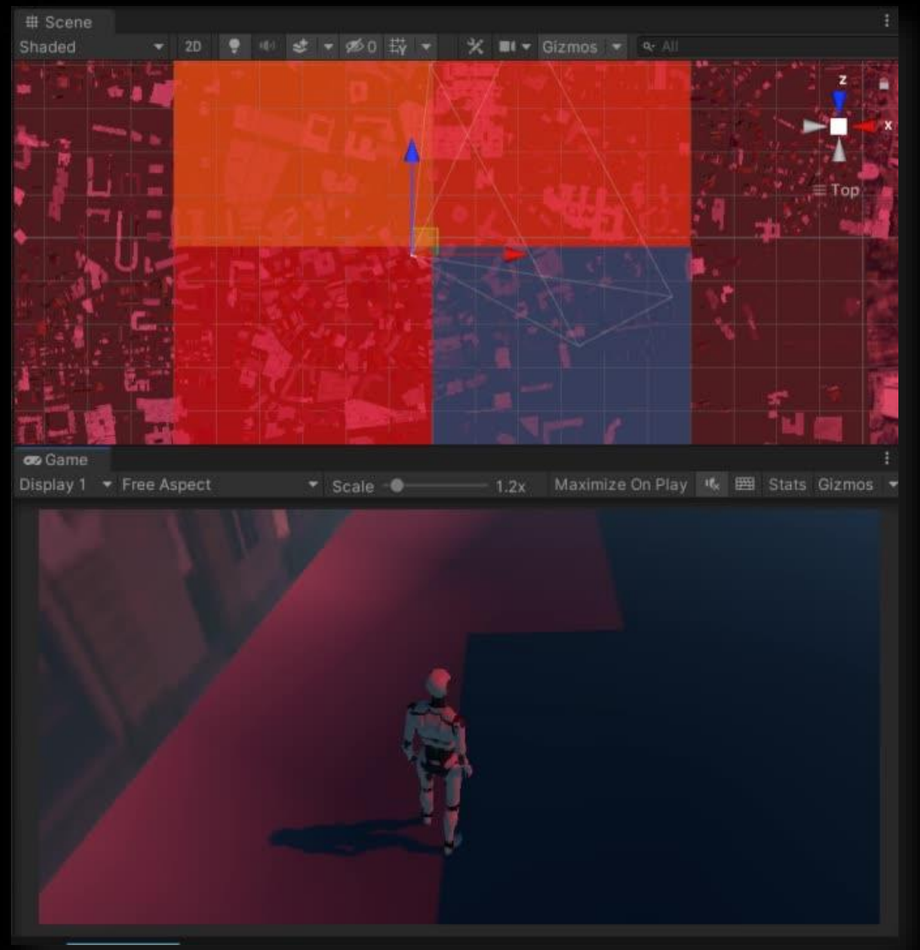
DIGITAL TWIN – ENSCHEDE

URBAN HEAT ISLAND



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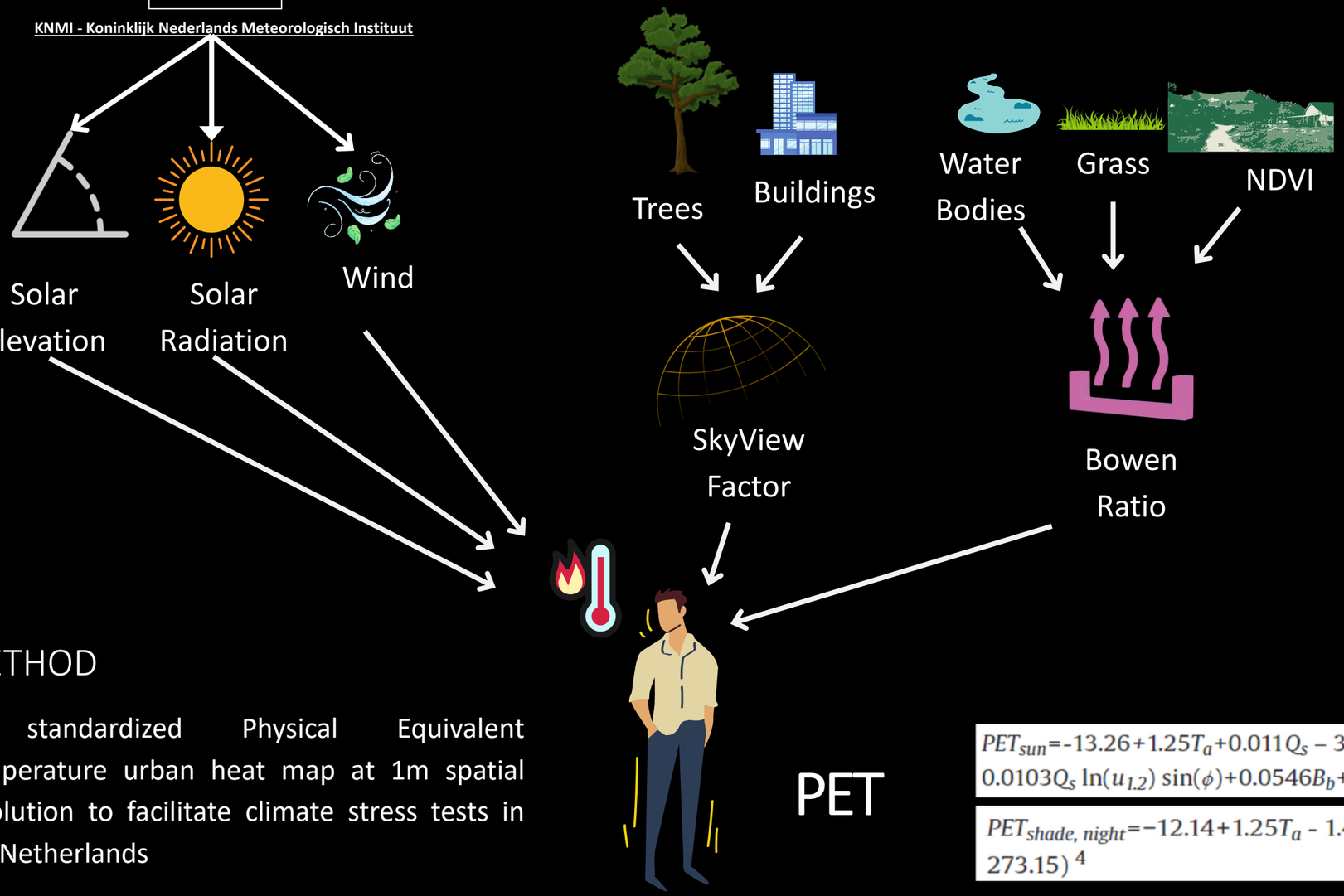
DIGITAL TWIN – ENSCHEDE

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

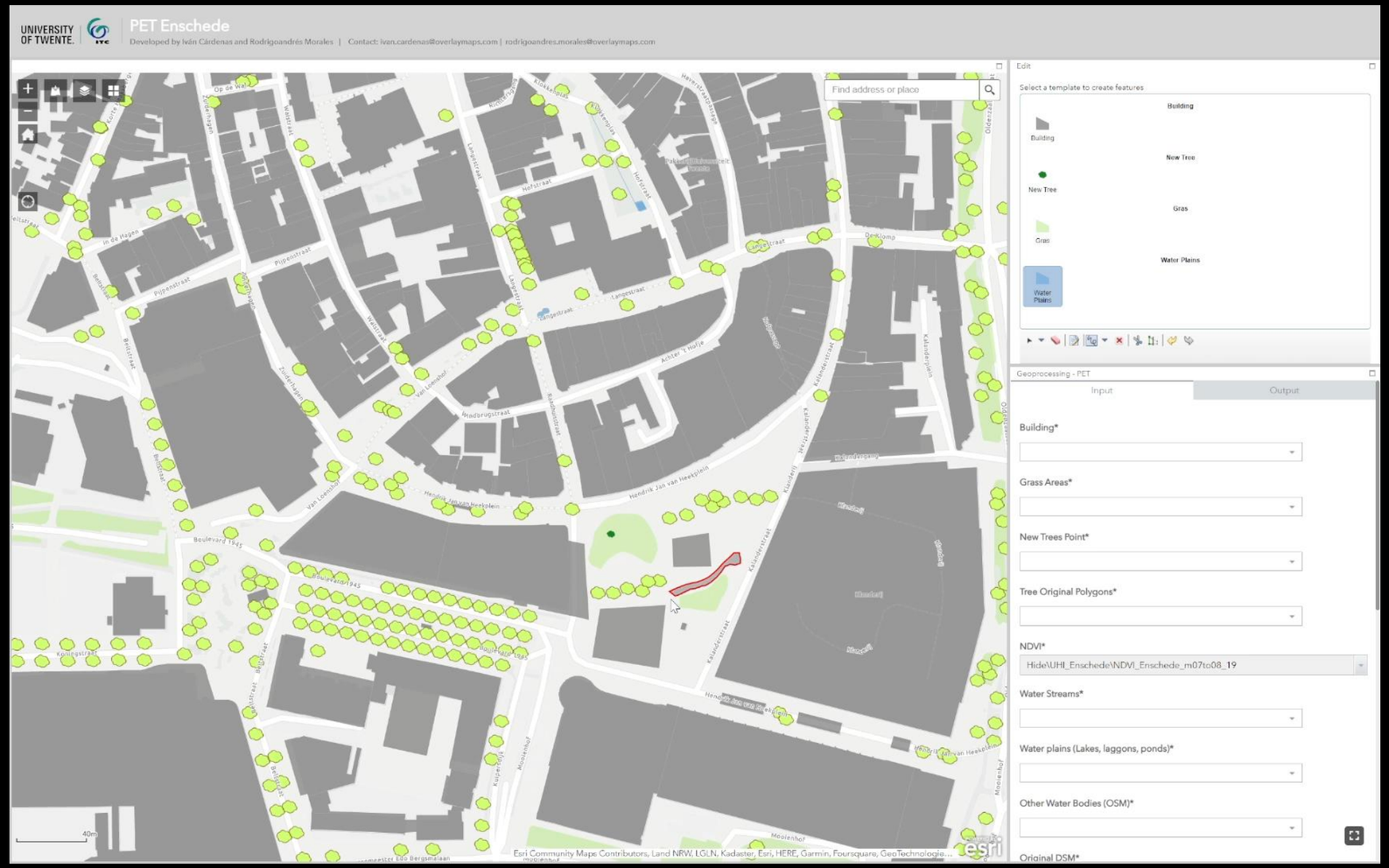
A standardized Physical Equivalent Temperature urban heat map at 1m spatial resolution to facilitate climate stress tests in the Netherlands

(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

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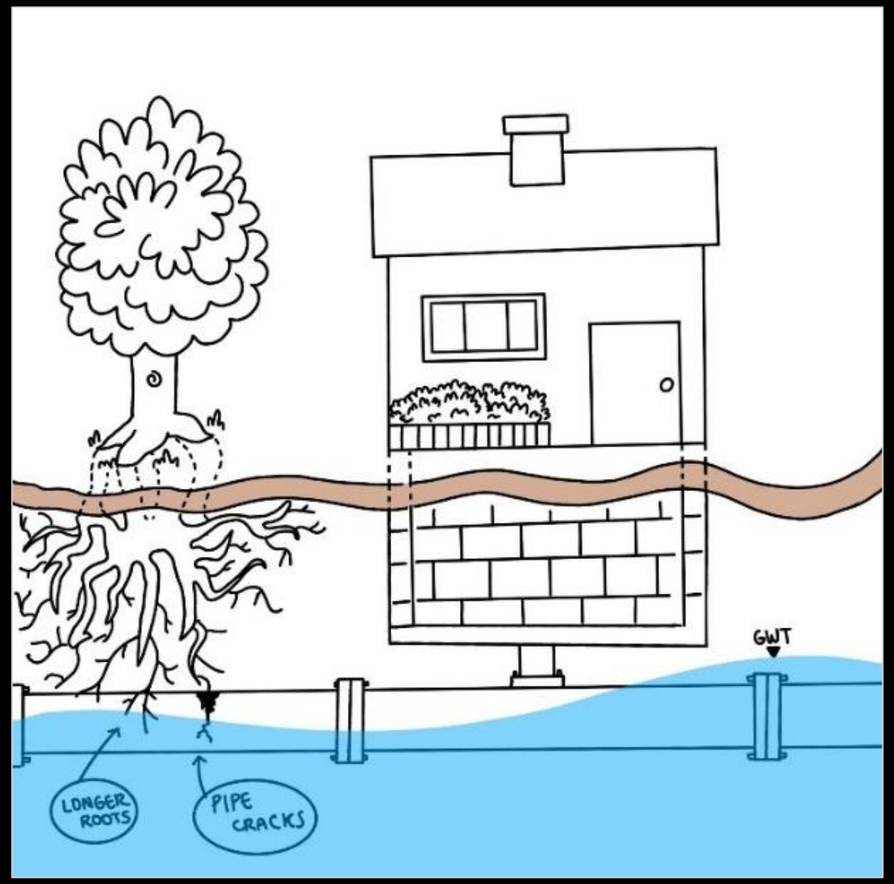
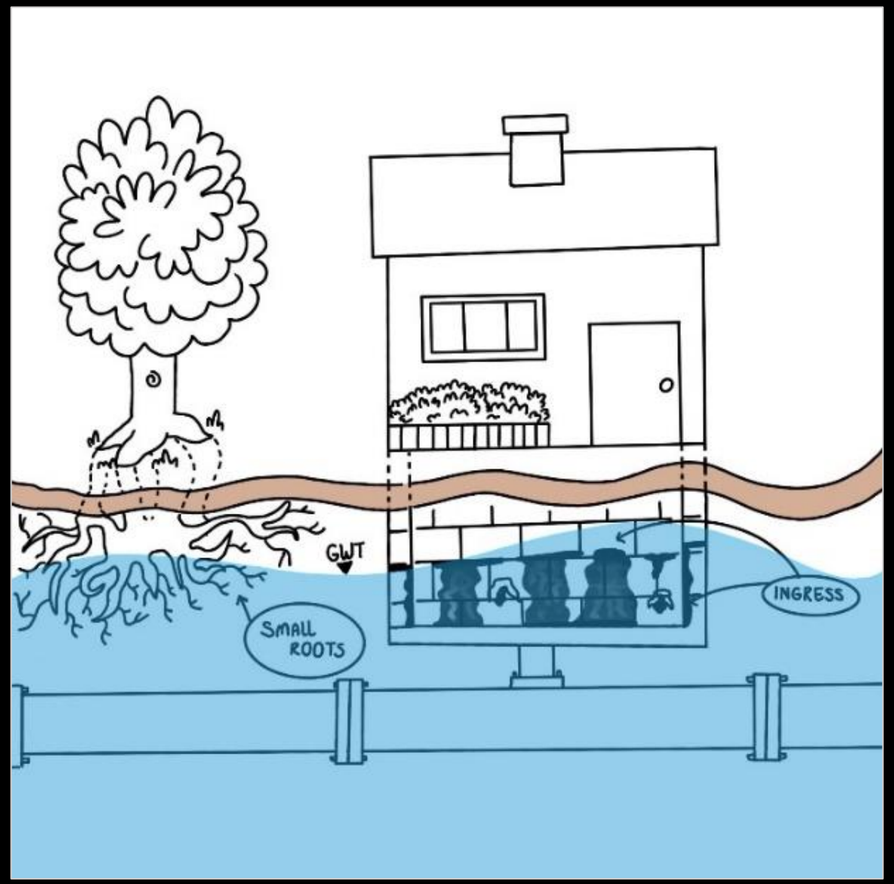
DIGITAL TWIN – ENSCHEDE

GROUND WATER TABLE MONITORING & TREE ROOTS DEVELOPMENT





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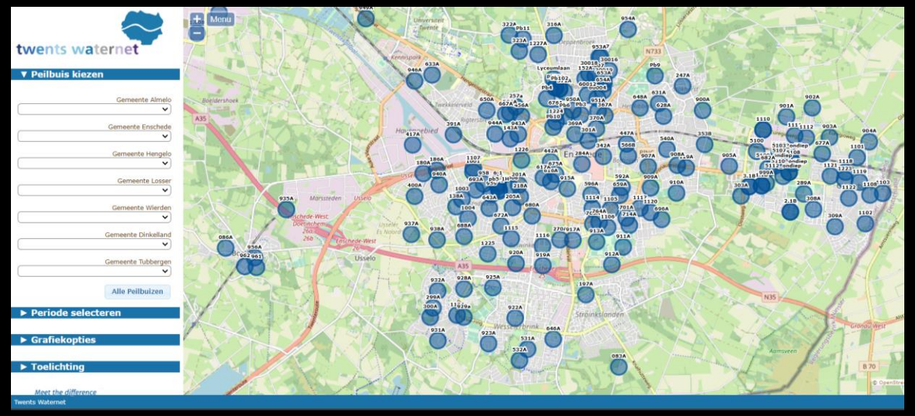
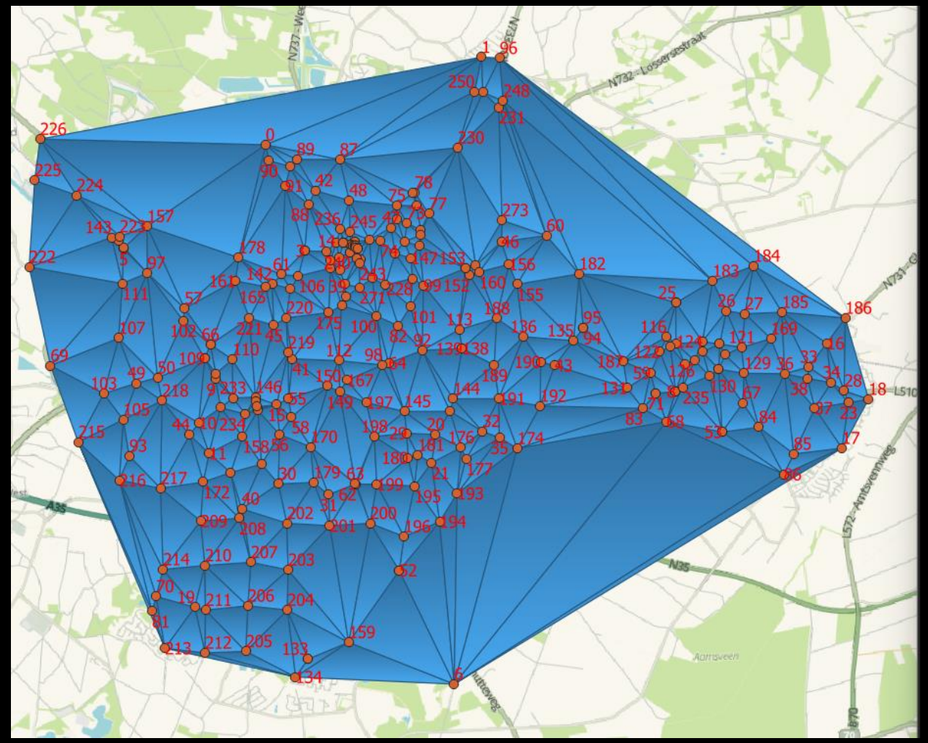
DIGITAL TWIN
GROUND WATER TABLE MONITORING





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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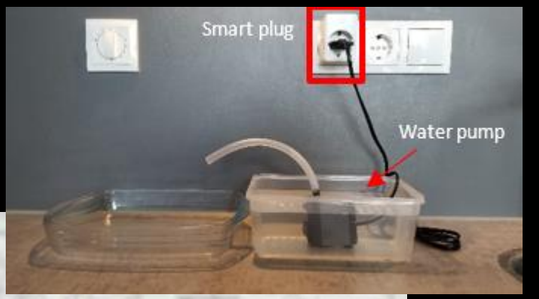
DIGITAL TWIN
GROUND WATER TABLE MONITORING



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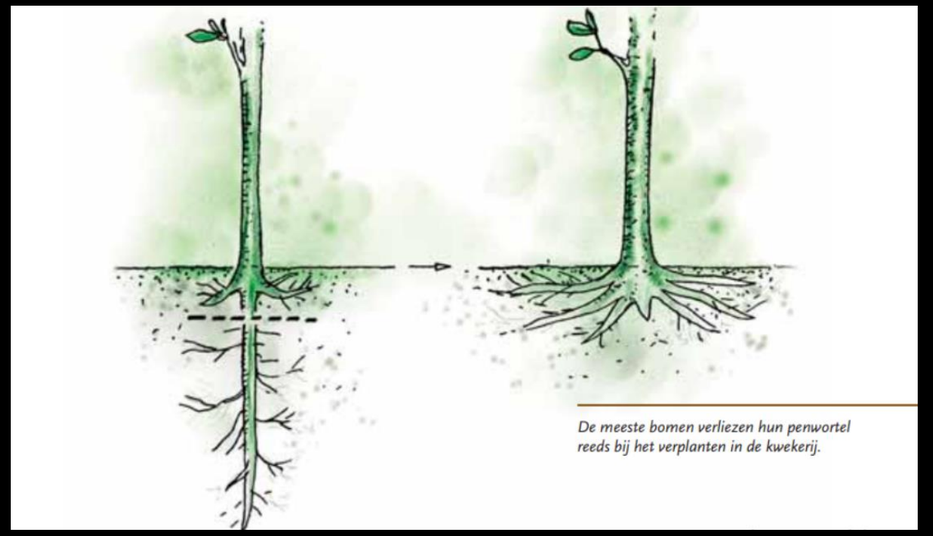
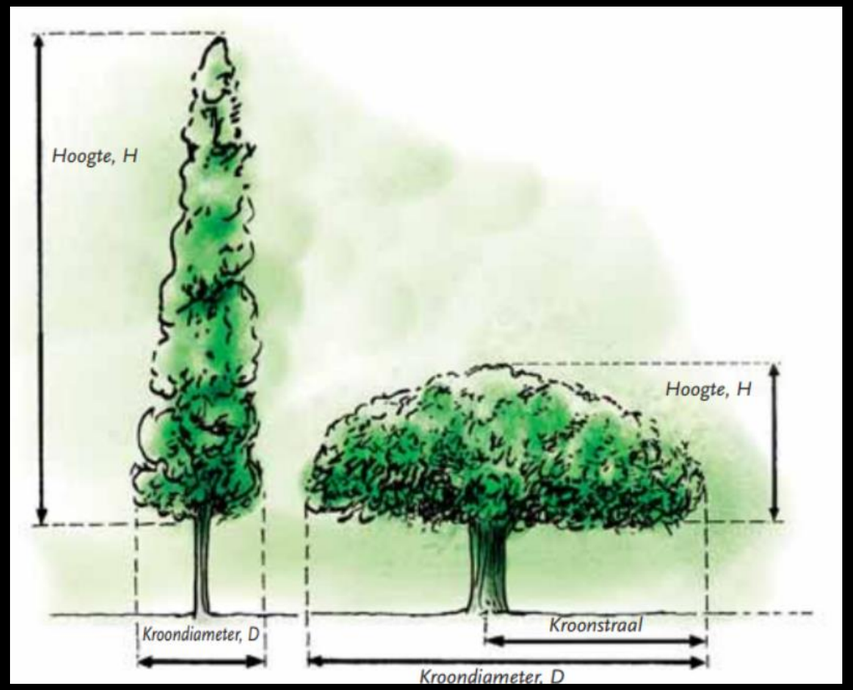
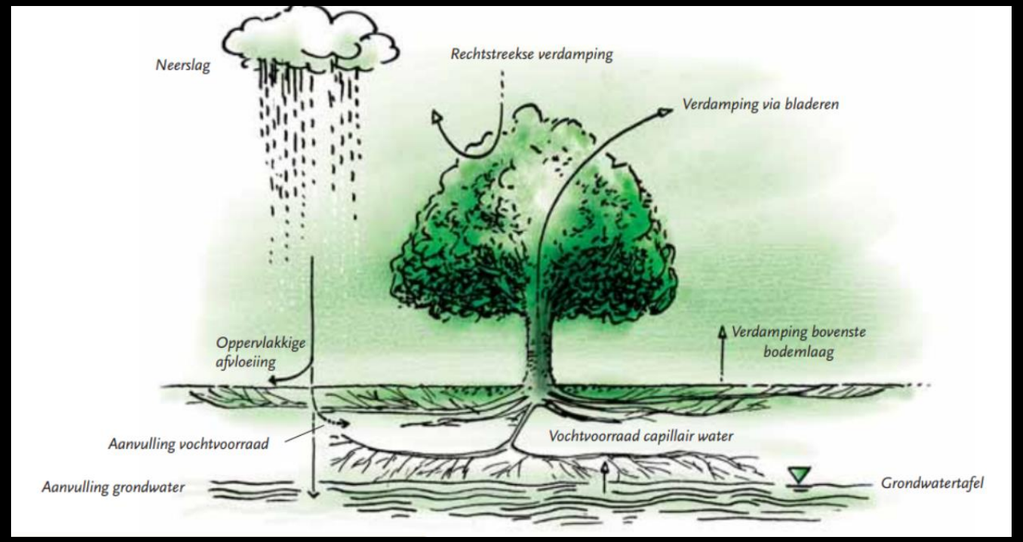
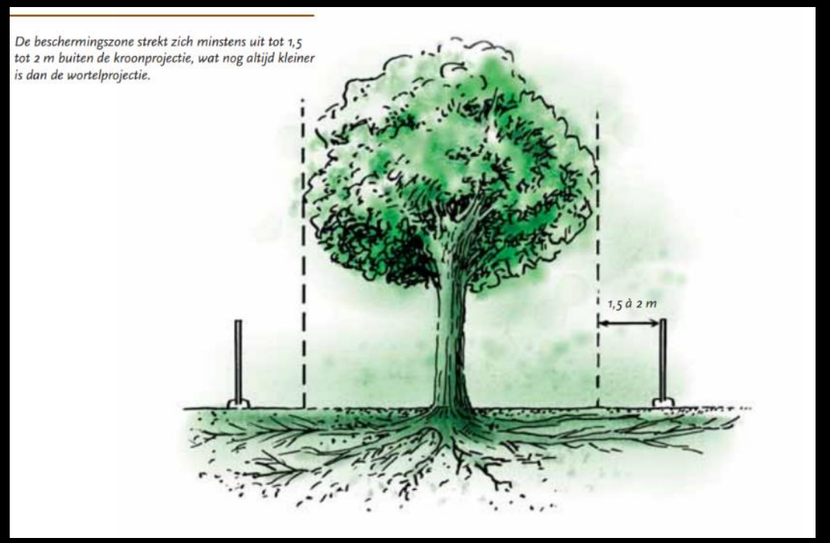
DIGITAL TWIN – ENSCHEDE
TREE ROOTS DEVELOPMENT









[Handbook of Trees 2022]

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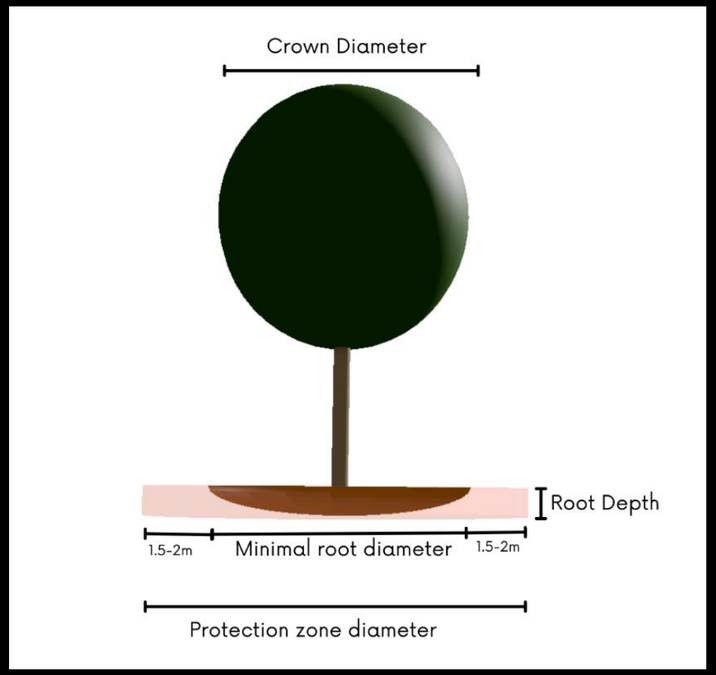
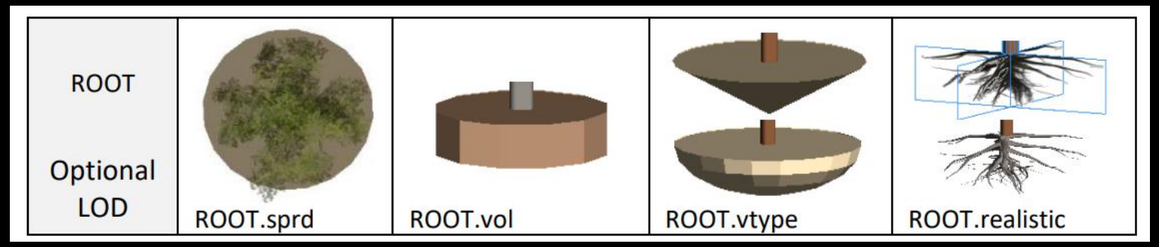
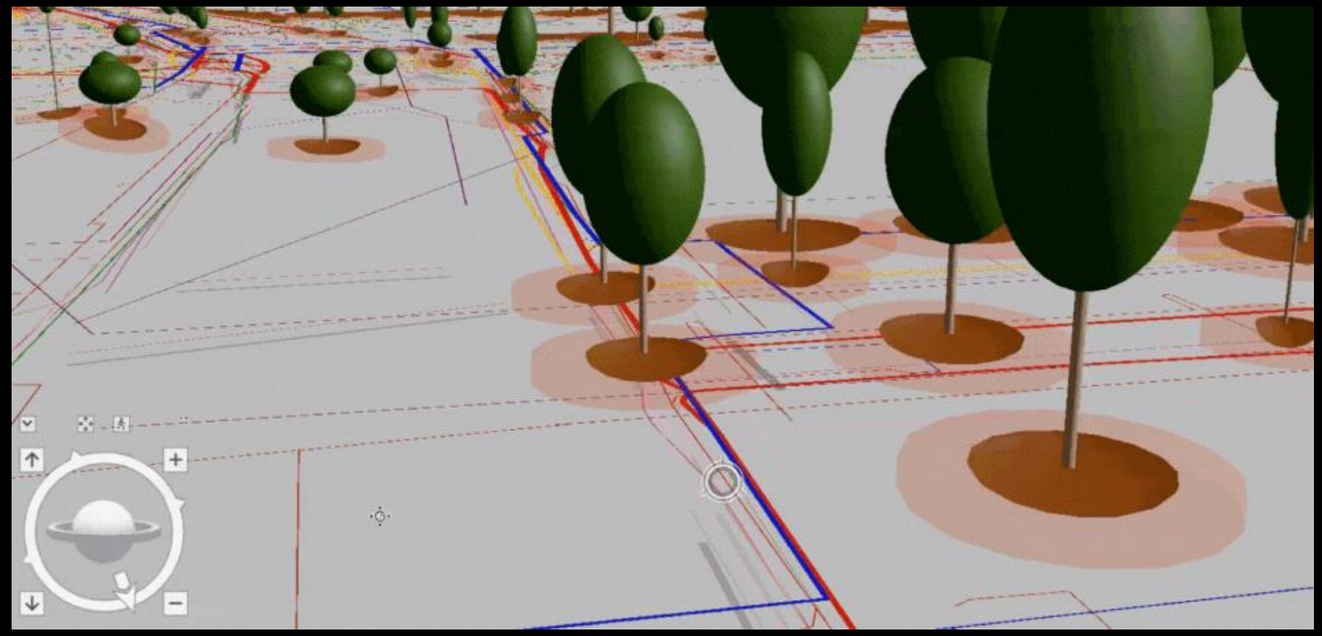
DIGITAL TWIN – ENSCHEDE

TREE ROOTS DEVELOPMENT





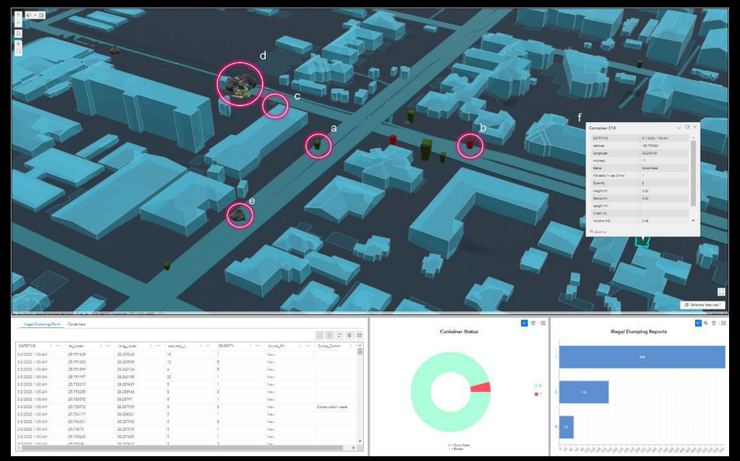
(Ortega-Córdova, 2018)



The available tree points per neighbourhood in Enschede

DIGITAL TWIN
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



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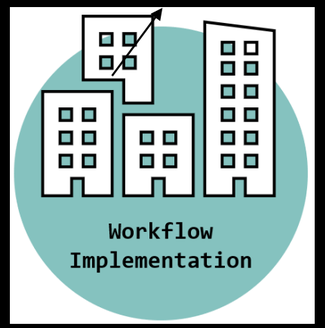
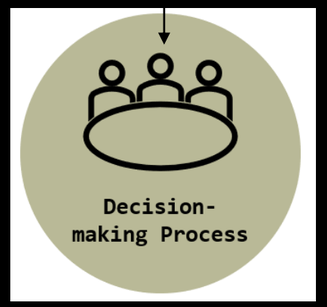
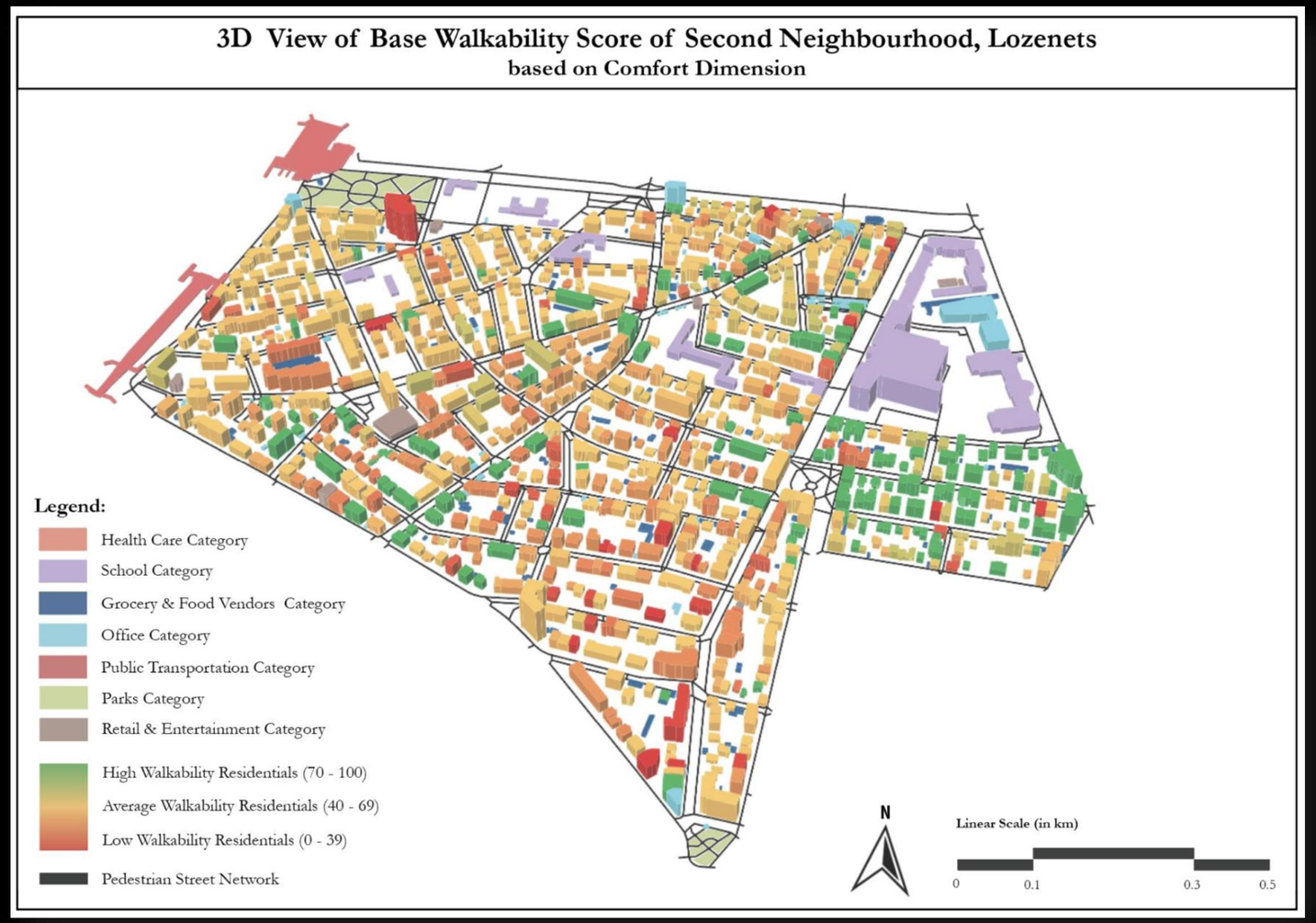
DIGITAL TWIN
GENERATIVE DESIGN FOR WALKABILITY







- 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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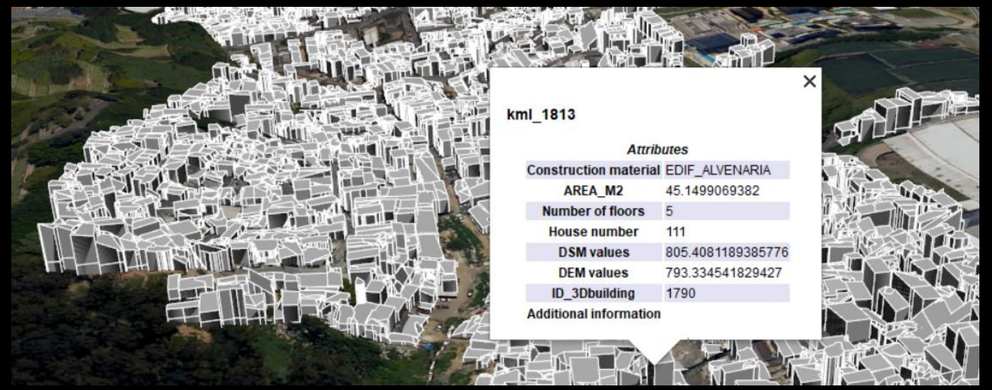
DIGITAL TWIN
UAV FOR DT



- Khawte, Sharvi Samir (2022) *3D modelling of slums based on UAV data. (Master's thesis, University of Twente).*
- Digital Twin Creation for Slums in Brazil Based on UAV Data, Khawte, S.; Koeva, M.; Gevaert, C. M.; Elberink, S. O.; Pedro, A. A., 3D GeoInfo 2022

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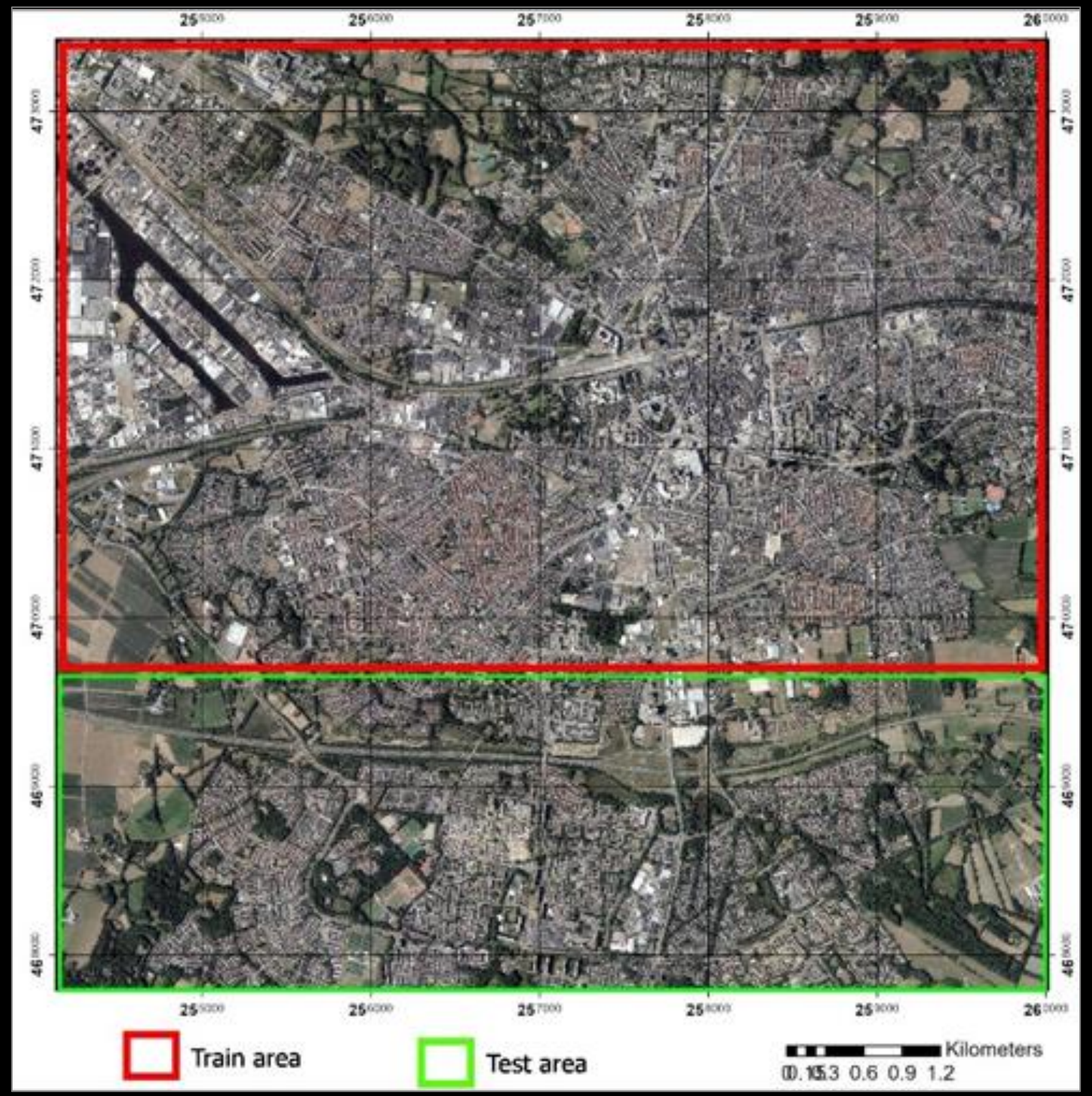
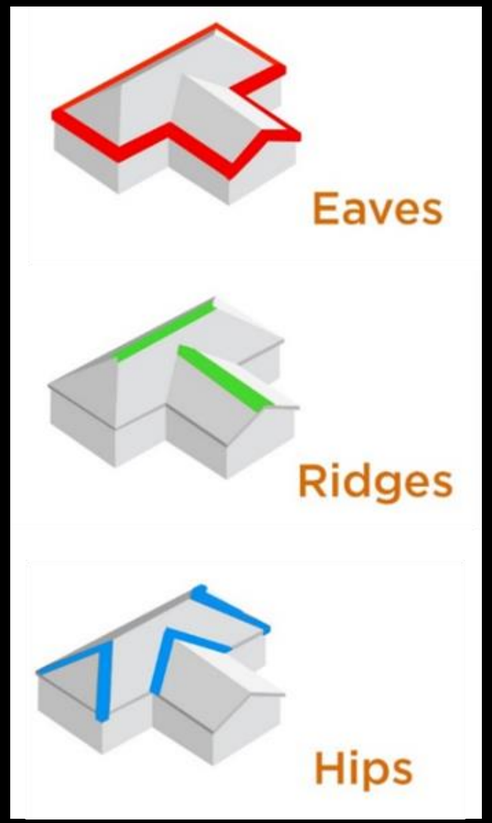
AI FOR 3D BUILDINGS NEEDED FOR DIGITAL TWINS





- 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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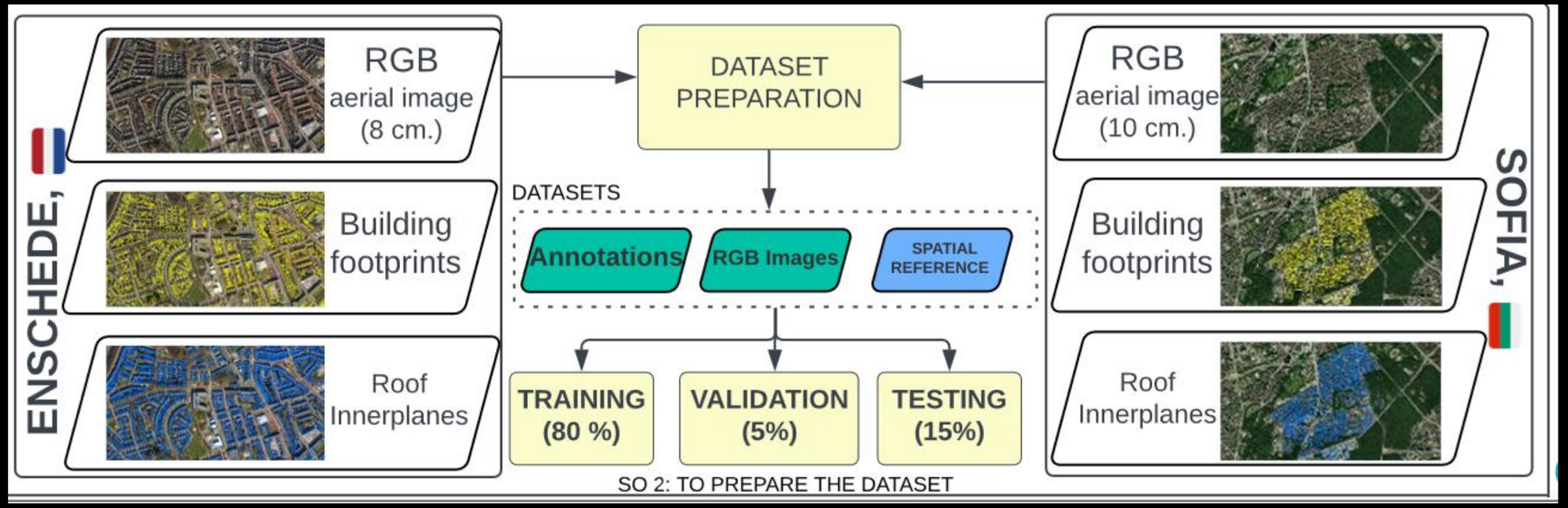
AI FOR 3D BUILDINGS NEEDED FOR DIGITAL TWINS



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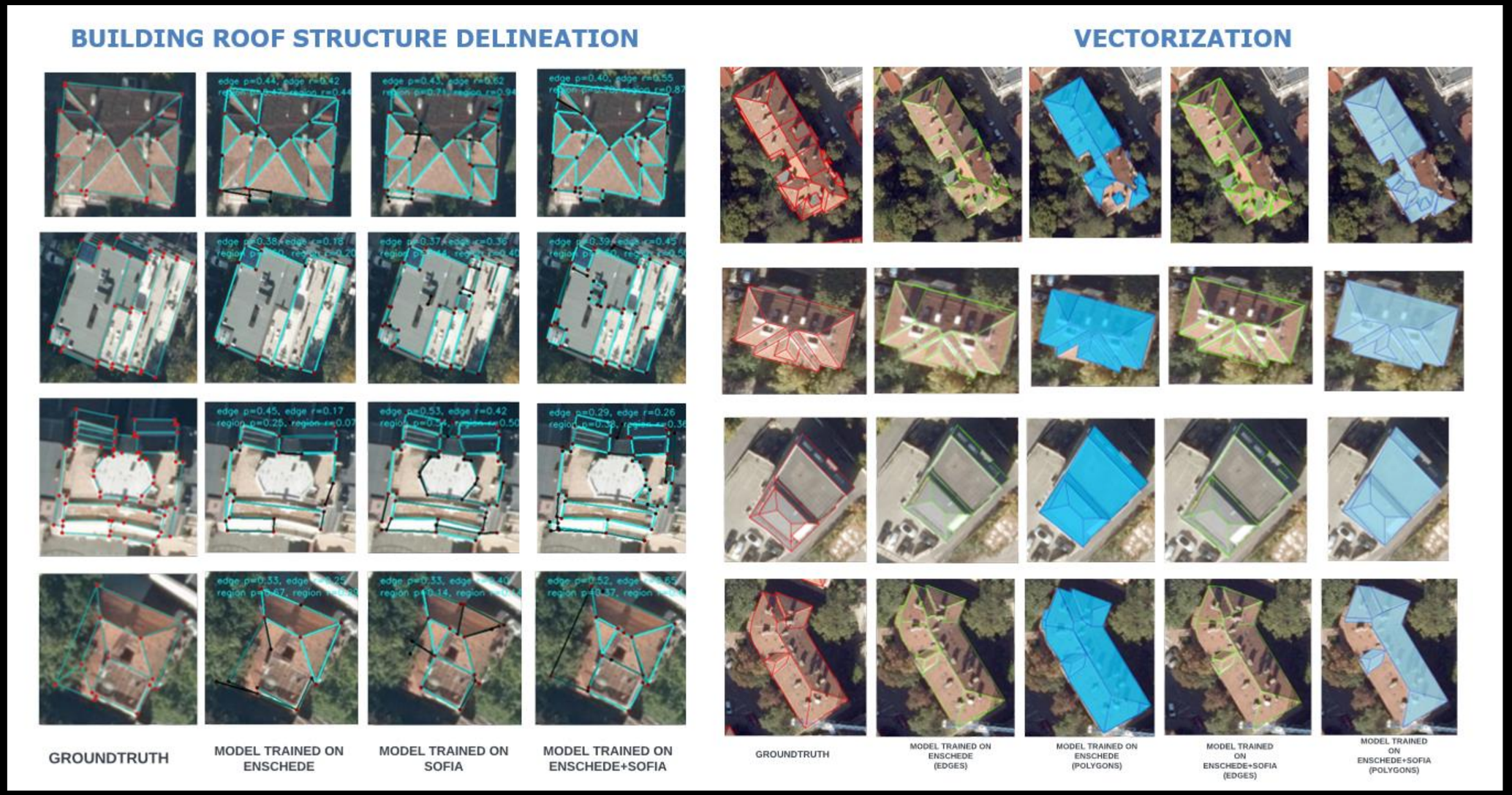
AI FOR 3D BUILDINGS NEEDED FOR DIGITAL TWINS



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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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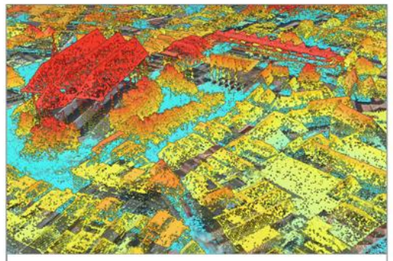
DIGITAL TWIN
SOLAR POTENTIAL ESTIMATION

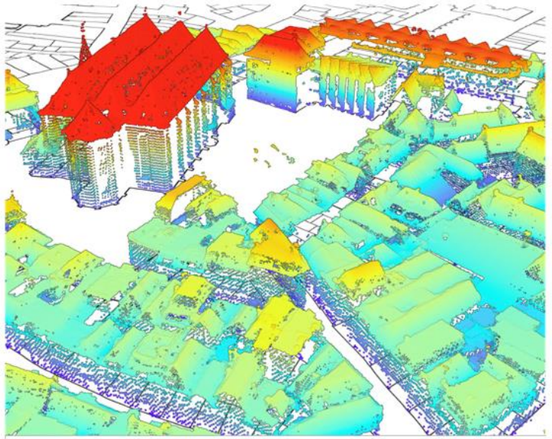


LiDAR point cloud

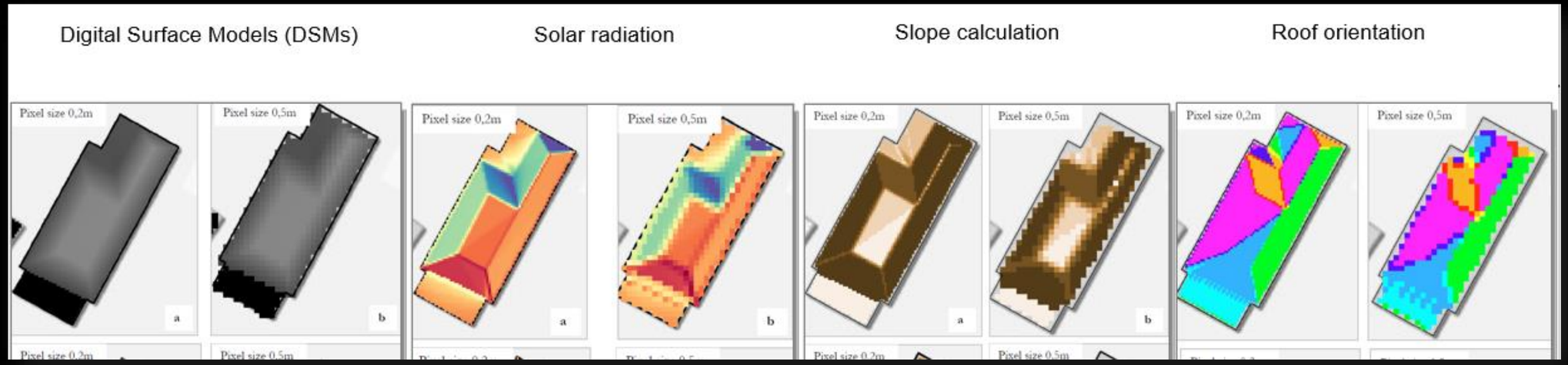
Dense image matching point cloud

Are integrated

ICP algorithm



Integrated point cloud



- *Amiranti, A. Y., Koeva, M. N., Kuffer, M., van Altena, V., & Post, M. (2020). Investigating standardized 3D input data for solar photovoltaic potentials in the Netherlands. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 43, 639-646.*
- *Amiranti, A. Y. (2020). Investigating 3D input data for solar photovoltaic potentials in The Netherlands (Master's thesis, University of Twente).*

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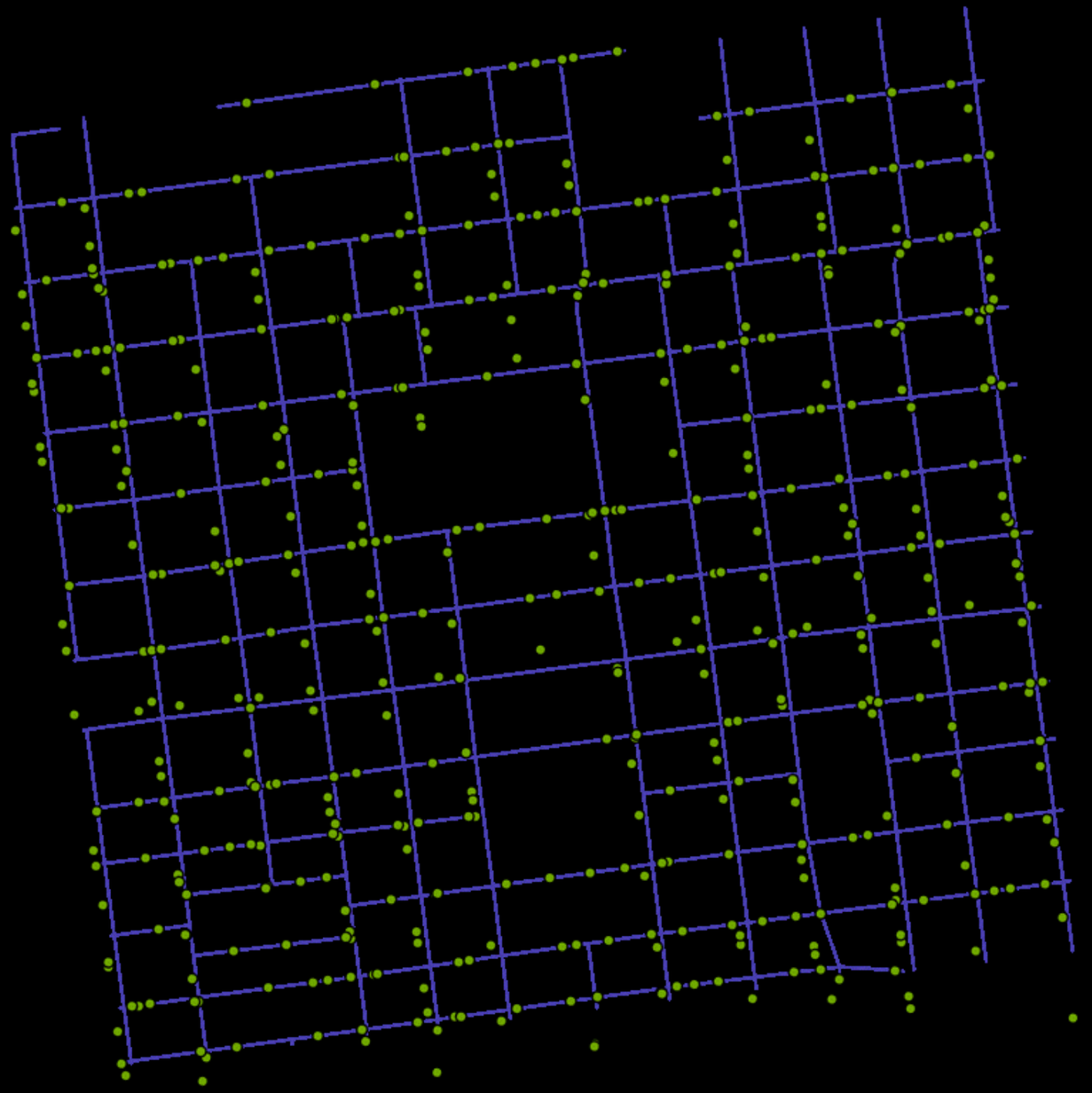
DIGITAL TWIN
ASSET MANAGEMENT

DIGITAL TWIN
ASSET MANAGEMENT

Data collection

- Cameras on Service Trucks
- Semi-Automatic Recognision



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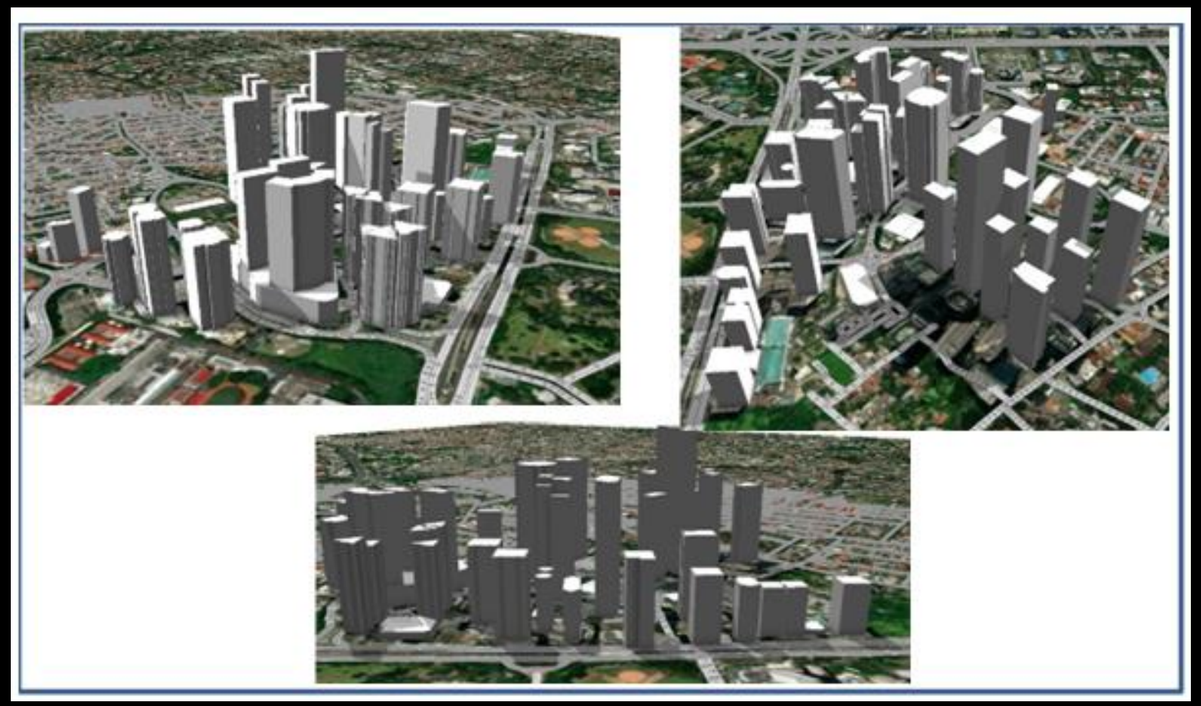
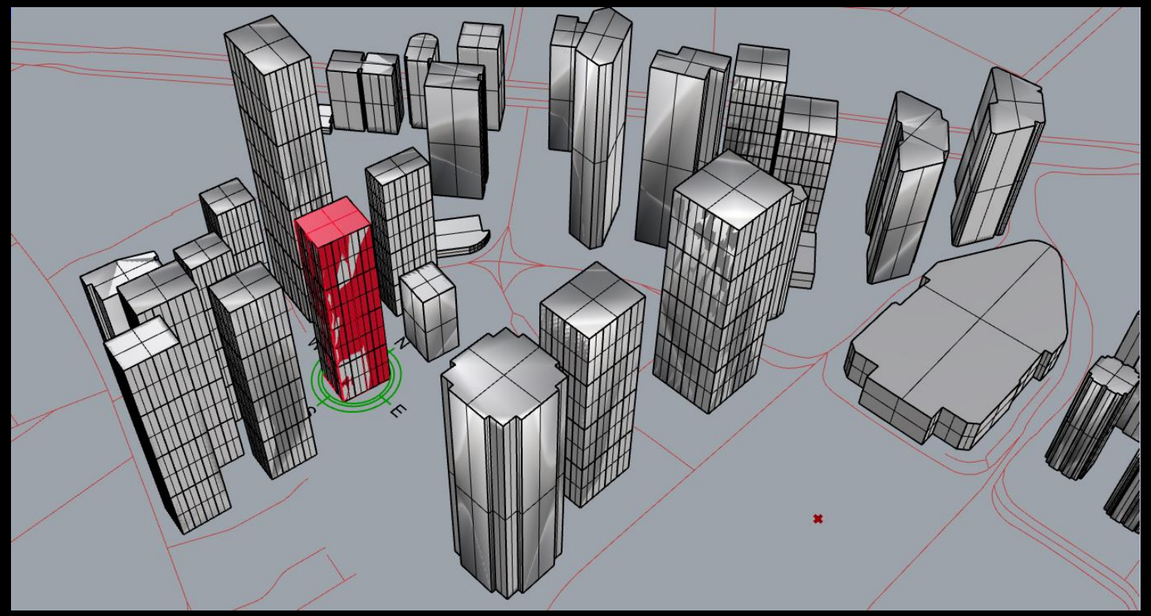
DIGITAL TWIN
SOLAR POTENTIAL ESTIMATION





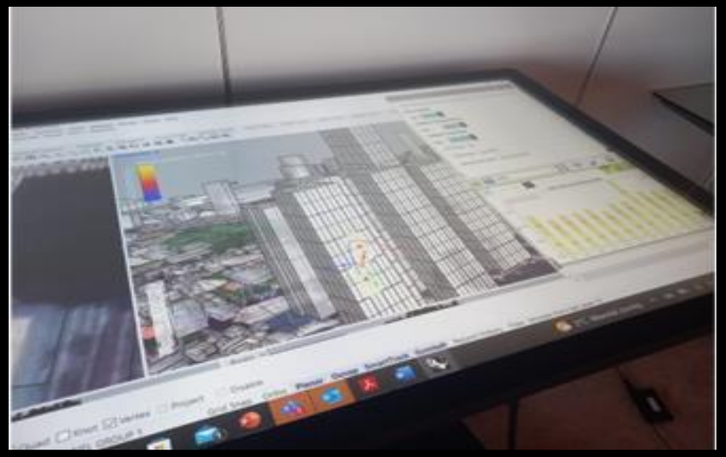
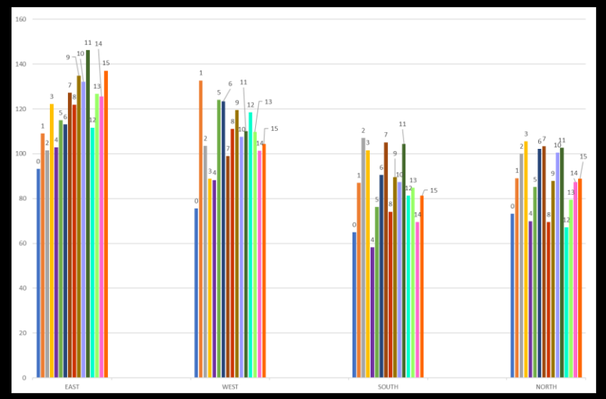


Figure 29 Output on map table (Figure source: Author)



Irradiation per window

List of stakeholders
Greenpeace Indonesia
Ministry of Finance
Audit Board of Indonesia
State electricity company of Indonesia (PLN)
IESR Indonesia
Ministry of State-owned (BUMN)
Ministry of National Development Planning Agency (Bapenas)
BRIN Indonesia
IPB University

DIGITAL TWIN

DIGITAL (T)WIN IT

Explore the possibilities of Digital Twins

*Learn more about **digital replicas** of the **physical living environments** that supports **decision-making** through the **seamless integration** of a myriad of **data and analytics techniques**.*

Development

19-10-2023

Workshops on Digital Twins & infrastructure

Create your Digital Twin city through gaming

Panel discussion and speed dating for fruitful collaborations

Application

20-10-2023

Interact with Digital Twins through gaming

Attend open panel discussions

Jointly discuss the possibilities with Digital Twins

Free & open f

everyo

Interested? Stay up to date by scanning the

1 / 1

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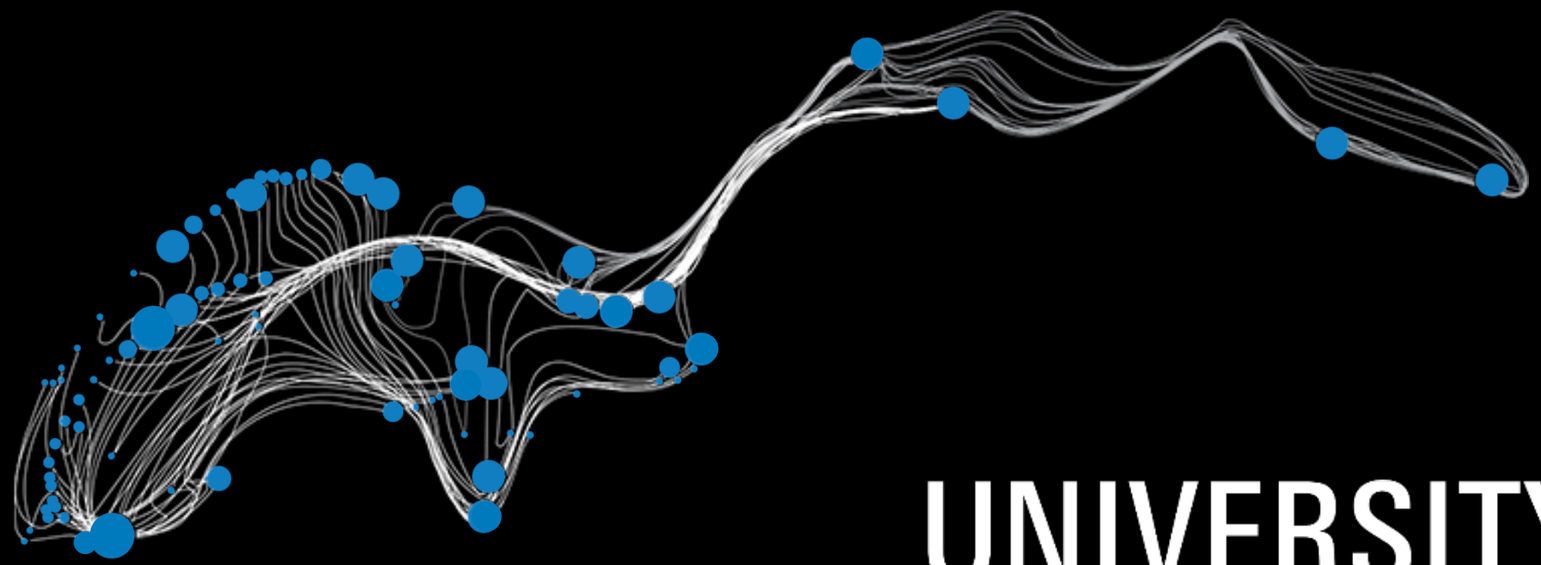

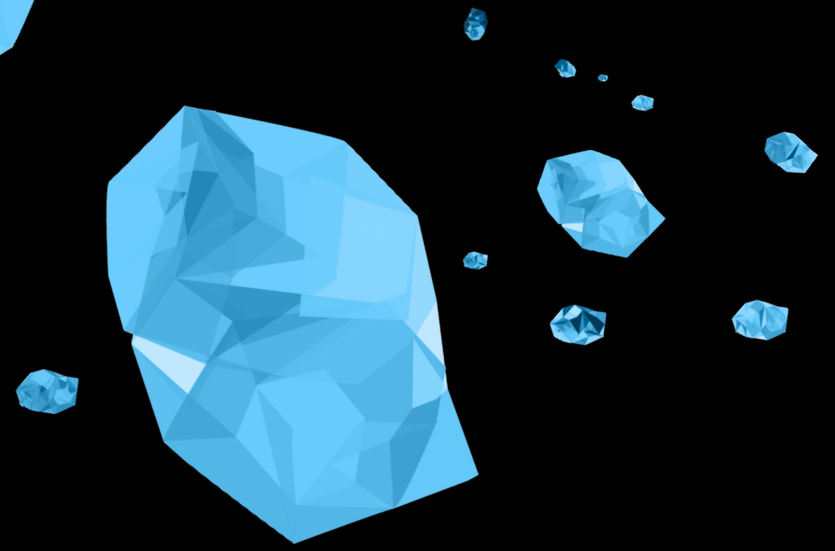

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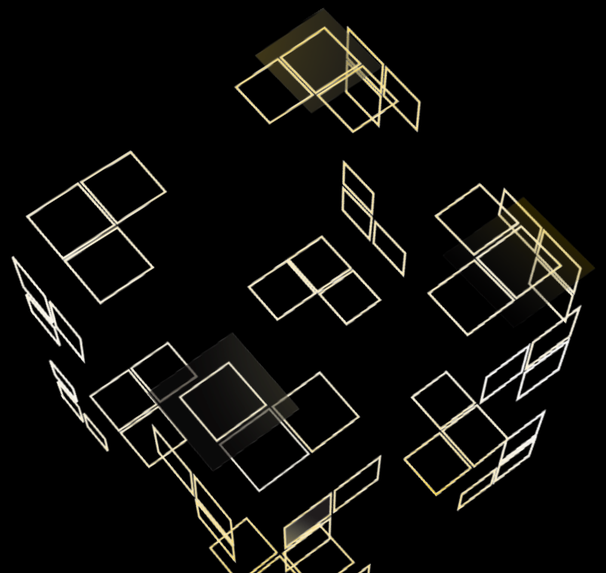

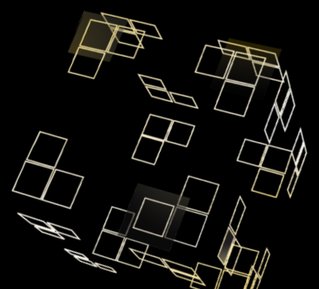

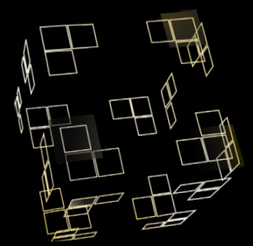

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