IST research challenges and developments:
Floods, Water Scarcity and Extreme Events

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20th October 2023

Floods, Water Scarcity and Extreme Events

LNEC Congress Center | Lisbon | Portugal | 19-20 October 2023

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Instituto Superior Técnico

Instituto Superior Técnico

» IST was established in 1911 and became the School of Engineering, Science and Technology of UTL (1927) and ULisboa (2013)

» Mission: to contribute to the development of society, promoting and sharing excellence in **higher education and research** in the fields of Architecture, Engineering, Science and Technology
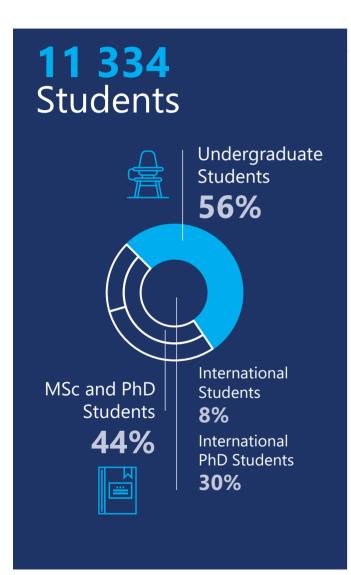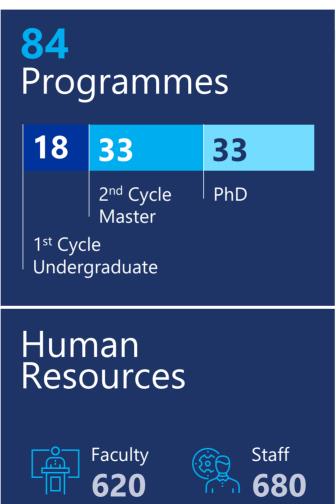

Alameda Campus — Lisbon

TagusPark Campus — Oeiras

Loures Campus

Instituto Superior Técnico (2021)

11 334 Students

Undergraduate Students 56%

MSc and PhD Students 44%

International Students 8%

International PhD Students 30%

84 Programmes

18	33	33
1st Cycle Undergraduate	2nd Cycle Master	PhD

Human Resources

Faculty 620

Staff 680

Research

PhD Holders 720

Scientific publications (ISI-WoS) 2695

Active inventions
Nacional 278
Internacional 121

Active R&D Projects 1210

International Partnerships

+700 Mobility Agreements

+40 Double Degrees

Other

Students employed before grad. 46%

Students employed 6 months after grad. 87%

Técnico Spin-offs 58

Research Units

Research Units

» Research and Development at Técnico Lisboa is organized in centers and Institutes

    » **23 Research Units**

    » **9 Associated Laboratories**

Research Units

Organized in 7 Scientific Domains

Basic Sciences

PHYSICS
MATHEMATICS
CHEMISTRY
BIOLOGICAL SCI.
GEOLOGY

MATERIALS, MICROTECHNOLOGY & NANOSCIENCE

- Architectural and Advanced Materials
- Micro/Nano Technologies and Nanosciences
- Electronics, Biological and Biomedical Devices

APPLIED LIFE SCIENCES

- Applied Microbiology
- Biomedical Eng.
- Genomics and Systems Biology
- Modelling of Biological Systems
- Bioengineering and Biotechnology
- Cell and Tissue Engineering and Regenerative Medicine

TECHNOLOGY MANAGEMENT & ENTREPRENEURSHIP

- Decision Science and Management Eng.
- Operations Logistics and Supply Chains
- Strategy, Innovation and Entrepreneurship
- Public Policies

ENGINEERING & PRODUCTION TECHNOLOGIES

- Space, Aeronautics and Oceans
- Process Eng.
- Manufacturing, Automation and Industry 4.0
- Marine Technologies

ENERGY, ENVIRONMENT & MOBILITY

- Decarbonization and Climate challenges
- Energy efficiency, renewables, Hydrogen and energy storage
- Territorial Management Urban Planning and Construction
- Geomodelling and Geophysics
- Transportation Systems and smart cities

INFORMATION & COMMUNICATION TECHNOLOGIES

- Computing and Informatics
- Digital transformation
- Robotics
- AI and Intelligent Systems
- Telecommunications and CoberSecurity

8

Research Units

Organized in 7 Scientific Domains | **Sub-domains**

MATERIALS, MICROTECHNOLOGY & NANOSCIENCE

- Architectural and Advanced Materials
- Micro/Nano Technologies and Nanosciences
- Electronics, Biological and Biomedical Devices

APPLIED LIFE SCIENCES

- Applied Microbiology
- Biomedical Eng.
- Genomics and Systems Biology
- Modelling of Biological Systems
- Bioengineering and Biotechnology
- Cell and Tissue Engineering and Regenerative Medicine

TECHNOLOGY MANAGEMENT & ENTREPRENEURSHIP

- **Decision Science and Management Eng.**
- Operations Logistics and Supply Chains
- **Strategy, Innovation and Entrepreneurship**
- **Public Policies**

Basic Sciences

PHYSICS
MATHEMATICS
CHEMISTRY
BIOLOGICAL SCI.
GEOLOGY

ENGINEERING & PRODUCTION TECHNOLOGIES

- **Space, Aeronautics and Oceans**
- **Process Eng.**
- Manufacturing, Automation and Industry 4.0
- **Marine Technologies**

ENERGY, ENVIRONMENT & MOBILITY

- **Decarbonization and Climate challenges**
- Energy efficiency, renewables, Hydrogen and energy storage
- **Territorial Management Urban Planning and Construction**
- **Geomodelling and Geophysics**
- **Transportation Systems and smart cities**

INFORMATION & COMMUNICATION TECHNOLOGIES

- Computing and Informatics
- Digital transformation
- Robotics
- AI and Intelligent Systems
- Telecommunications and CoberSecurity

Research Units: 4 units

Floods, Water Scarcity and Extreme Events

Research Units: 4 units

Floods, Water Scarcity and Extreme Events

» Civil Engineering Research and Innovation for Sustainability (CERIS)

» Centre for Natural Resources and the Environment (CERENA)

» Centre for Innovation in Territory, Urbanism and Architecture (CiTUA)

» Marine, Environment and Technology Centre (MARETEC)

Higher Education Programmes

Higher education programmes

3rd cycle: Climate Change and Sustainable Development Policies

>> Doctoral Programme

>> Aims to identify, analyze and put into practice new sustainable development strategies in the context of the growing risk of anthropogenic climate change during the 21st century

>> Three universities

>> First intake in the academic year 2009/2010

>> 3-year duration

>> Offers 10 courses in social sciences, physics, natural sciences and engineering in the first two semesters

>> Single PhD degree awarded by one of the two Portuguese universities

U LISBOA | UNIVERSIDADE DE LISBOA

NOVA
UNIVERSIDADE NOVA DE LISBOA

UEA University of East Anglia

Higher education programmes

3rd cycle: Sustainability Science

» **Doctoral Programme**

  » Aims to promote excellent and internationally competitive advanced training, transversely integrating solid and up-to-date knowledge for sustainable development

  » 17 Faculties and Institutes of ULisboa

  » 4-year duration

  » Offers 10 courses in resources, food and society in the first two semesters

  » Doctoral programme accredited in 2017

U LISBOA

DOCTORAL DEGREE IN
SUSTAINABILITY
SCIENCE

REASOn | REsources, Food and Society

Higher education programmes

2nd cycle: GroundwatCH | Groundwater and Global Change: Impacts & Adaptation

» **ERASMUS MUNDUS Joint Master in Hydrogeology and Climatology**

» Addresses groundwater issues for adaptation to climate change and reduction of socio-economic vulnerability in regions limited freshwater availability

» Three universities

» Four semesters (2y, 120 ECTS)

» Three editions subjected to competitive funding calls (2015–19, 2019-24, 2024-26)

» Awards 15 MSc grants/y

1st Semester: Lisbon
Period: **September - February**
Instituto Superior Técnico (Portugal) is the largest and most prestigious school of engineering in Portugal. It provides the program participants with the Environmental Engineering perspective.

2nd Semester: Delft
Period: **March - July**
You will study at **IHE Delft** (the Netherlands). It is the largest international graduate Water Education Institute in the world that has provided graduate education to more than 15,000 water professionals from over 162 countries.

3rd Semester: Dresden
Period: **September- February**
The **TU Dresden** (Germany) is one of the 10 largest and best universities of engineering and technology in Germany. It offers renowned expertise in climate and hydrology with its well-matched combination of engineering, geo and natural sciences.

https://www.groundwatermaster.eu/

Higher education programmes

SWARM | Strengthening MSc Curricula in Water Resources Management

>> Erasmus+ Capacity building in Higher Education project (E+CBHE)

>> 13 universities, 1 company (2018-2022)

>> Objectives:

>> Promote the education of experts for water resources management in the Western Balkans

>> Develop new and innovative master programmes in the field of water resources management

>> Design and implement seven new and up-to-date laboratories in Western Balkans Universities

>> Develop and implement Life-Long Learning courses for the water sector

June 2019: training in Norwegian University of Life Sciences

Higher education programmes
CIDMA | *Climate Change Induced Disaster Management in Africa*

» Erasmus+ Capacity Building in the field of Higher Education

» 8 universities, 17 Associated Partners in Mozambique (2019-2023)

» Objectives:

  » Create and develop up-to-date courses in disaster management using geospatial information technology

  » Train faculty members

  » Implement the developed courses in Mozambique universities at MSc level, both in person and by e-Learning

  » Improve laboratory infrastructures in Mozambique universities

  » Develop and implement a Disaster Management Tool to be used in developed courses

December 2022: Dissemination workshop in Maputo

https://cidmaeu.wordpress.com/

Higher education programmes

GreeNexUS

GreeNexUS | Green-health-safety Nexus for new Urban Spaces

» Marie Curie Doctoral Network (2023-2028)

>> Offers a multidisciplinary approach to promote urban greening, territorial regeneration and safety/accessibility/walkability of urban infrastructures, addressing climate change and preventing exacerbating inequalities in vulnerable groups.

>> 9 universities, 3 R&D, 5 companies, 1 municipality, 2 NGO (9 countries)

>> 10 doctoral students

https://greenexus.unibo.it/about/

Research Lines and Developments

Water resources management

Monitoring and mitigating **desertification**

Promoting the efficient **use of water**

Management of waterfront areas

Groundwater management

Promoting sustainable **soil conservation**

Promoting the integration of **reused water** in water cycle

Inundation and **contamination** management

Flood risk assessment, mitigation and prevention

Research lines and developments

Water resources management

» **AQUAdapt:** aims to promote the resilience of river ecosystems to climate change

» Development of a high-resolution monitoring and warning system, integrating modelling, forecasting and planning techniques

» Testing nature-base solutions in degraded zones of protected/agricultural areas

» **Aguamod:** aims to develop a Water Resources Management Platform during scarcity periods in the SUDOE Region, combining the assessment of the water needs with numerical models

» Includes decision-making tools for simulating future scenarios and for plotting spatial results on climate, hydrology, land and water uses.

Research lines and developments

Water resources management

» **OMeGA:** Development of a decision support tool to the management of water stored in irrigation reservoirs

>> Providing, in real time, high-resolution results from hydrological and meteorological models

>> Allows to forecast inflows, real availability and the quality of the stored water

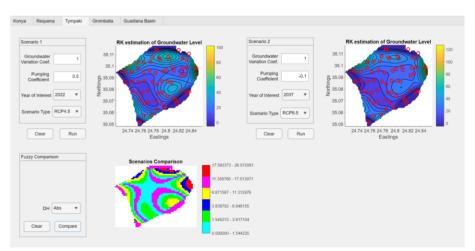>> Applied to Sorraia river Basin (Montargil and Maranhão reservoirs)

www.omega-go.pt

Research lines and developments

Groundwater management

>> **Melodies:** Development of a cloud computing platform to process large amounts of environmental Open Data to be used for different engineering and research purposes

>> Example: "Groundwater Modelling" combining models and citizen observations to understand and manage groundwater bodies

>> **InTheMED:** Development of innovative and sustainable groundwater management tools and application to analyse remediation strategies in five typical case studies in the Mediterranean area
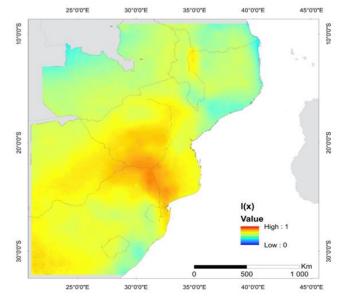

https://inthemedprima.com/

Research lines and developments

Monitoring and mitigating desertification

>> **DesertWatch:** Development of a monitoring desertification tool (*DesertWatch*) that can collect and process up to 11 desertification related parameters, ranging from simple geo-referenced indicators to complex model results of future desertification scenarios.

>> Application to Portugal, Italy, Turkey

>> **Alcantara:** Exploring and extending *DesertWatch* tool with new methods for integration of earth observation data with different spatial and spectral resolutions

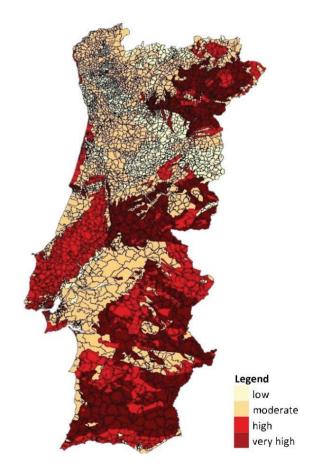>> Application to Southern African region

24

Research lines and developments

Promoting sustainable soil conservation

» **SOIL4EVER:** Development of *WebGIS platform* for monitoring soil salinity to assess the soil degradation risk and to promote the use of sustainable agricultural practices

» **SOILCOMBAT:** Contribute to combating desertification, restoring and promoting sustainable use of terrestrial ecosystems and ensure resilient agricultural practices that improve land/soil quality.

» **HYDROVAR:** Increasing knowledge of national soils, development of soil management tools, and better planning of sustainable soil conservation policies.
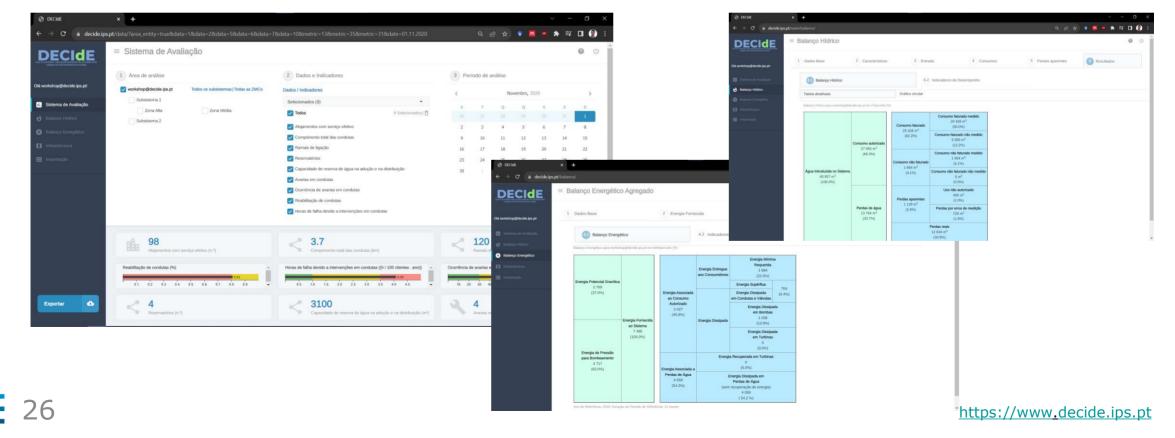

Legend
low
moderate
high
very high

Desertification risk

Research lines and developments

Promoting the efficient use of water

>> **DECidE and WISDom:** Decision support platforms to improve the water distribution networks management integrating different tools (DECIdE: water and energy balances, KPY calculation)
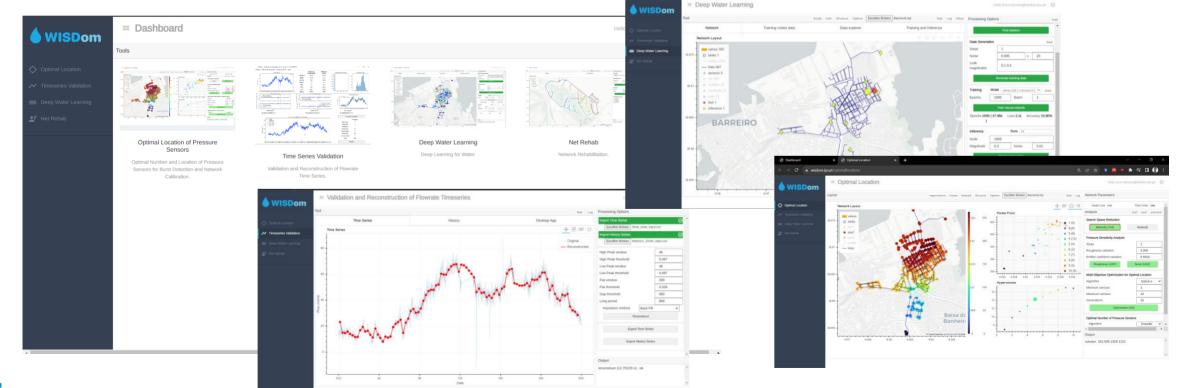
https://www.decide.ips.pt

Research lines and developments

Promoting the efficient use of water

>> **DECidE and WISDom:** Decision support platforms to improve the water distribution networks management integrating different tools (WISDom: sensor location, anomaly detection, burst location & sizing)

https://www.wisdom.ips.pt

Research lines and developments

Promoting the efficient use of water and energy

» **AQUA:** Assessment of Water & Energy Efficiency in Urban Green Spaces

» New water and energy balances

» Application to three garden types (an ancient garden, urban park with a traditional irrigation system, a modern garden with a smart irrigation system)

» Ancient gardens are more efficient as the vegetation is less water demanding and smart irrigation system effectively reduce water consumption by 50%
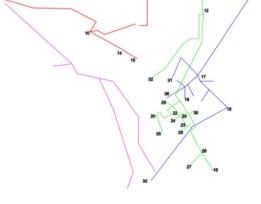
System input volume (drinking water; groundwater; harvested rainwater; reclaimed water)	Effective use	Consumption for irrigation	Landscape water requirement
		Consumption for other uses	Uses in toilets, restaurants, drinking fountains, lakes, etc.
	Water losses	Apparent losses	Unauthorised consumption
			Metering inaccuracies
		Irrigation losses	Evaporation losses, soil deep percolation and runoff
		Network real losses	Leakage in the irrigation network (pipes, tanks, etc.)

https://www.aqua.ciuhct.org

Research lines and developments

Promoting the integration of reused water in the UWC

Green Walls

» **Nature-based solutions for safely and efficiently integrating grey/stormwater into the urban water cycle**

TWIST » Assessment of Green Walls efficiency for greywater treatment through the implementation of living labs

Genesis Project » Assessment of Green Roofs/Walls Environmental, Economic and Social benefits

Genesis Project » Development of the life cycle cost benefit analysis of Green Roofs/Walls

Genesis Project » Analysis of different Green Roofs/Walls alternative solution

Living lab URBAN LISBOA
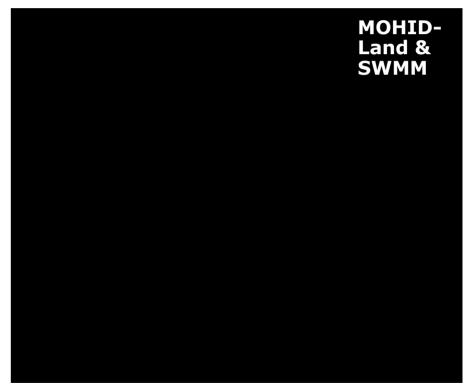
Green Roofs

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https://twistproject.eu/

Inundation and contamination management

» **HAZRUNOFF:** Framework for early warning, detection, follow-up, and early response to different types of flooding and hazmat pollution in inland and transitional waters, combining:

    » In-situ sensing technologies (automatic stations, indicators, lab measurements, Internet of Things approaches)

    » Remote sensing technologies using drones and satellites

    » Holistic high-resolution modelling (meteorological, watershed, estuarine/pollutant dispersion models)

    » Operational tools for event awareness and crisis management

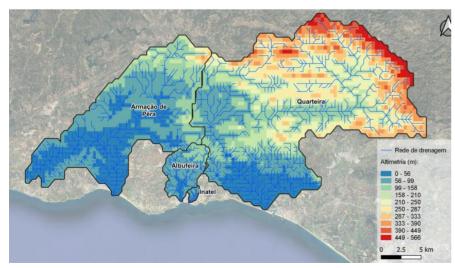   » Contingency planning and adapted protocols for response and communication

MOHID-Land & SWMM

Sacavém, Loures Region
[36 s]
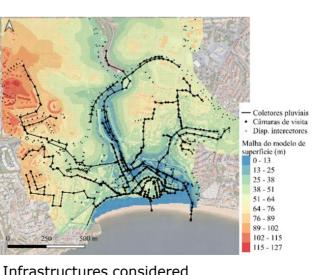
http://www.hazrunoff.eu/

Research lines and developments
Inundation and contamination management
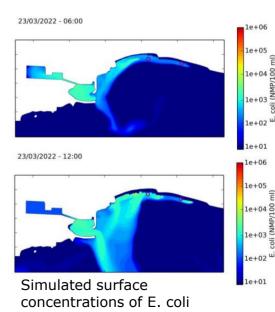
» **SINERGEA:** Development of an intelligent system (platform) to support the efficient use of resources and the emergency management of inundation and contamination in coastal cities, allowing

  » the improvement of energy efficiency in drainage systems

  » the protection of urban beaches by preventing waters' contamination by urban discharges

  » the risk management of urban flood events

Elevation plot of urban drainage basins (Albufeira-Quarteira)

Infrastructures considered for MOHID Land/SWMM modelling

Simulated surface concentrations of E. coli

http://sinergea.lnec.pt/index_pt.html

Research lines and developments

Planning and management of waterfront areas

>> To develop a critical analysis of urban waterfronts around the Tagus Estuary

>> >> Map and assess planned strategies, policies, projects, and programmes that have an impact on these territories

>> >> Identify key stakeholders, analyze potential conflicts, and evaluate risk perceptions

>> >> Promote public participation to "think and build the city" and obtain public perceptions related to urban interventions

>> To establish the critical actions required to foster a sustainable approach to development in the Tagus Estuary waterfront areas

>> >> Analyse the efficiency, integration, and alignment of tools, identify critical areas and define strategies
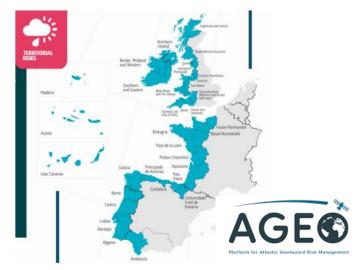
Research lines and developments

Flitood risk assessment, mitigation and prevention

» **AULIS:** development of automatic methodology for the construction/upgrade of inventories of landslides combining remotely sensing (satellite and aerial images) with elevation and field data of very high spatial resolution

   » Tested in Funchal and Ribeira Brava basins, Madeira

Landslides in Madeira island, just a few days after the flashfloods of February 20, 2010

» **AGEO:** development of platform with several Citizens' Observatory pilots on Atlantic Geohazards (landslides, flash floods, earthquakes, rockfalls)

   » to involve local communities to actively participate in risk monitoring and to local capacities in the risk management systems

   » to establish recommendations for the creation of future observatories in geohazard management

https://ageoatlantic.eu/

Research lines and developments

Flood risk assessment, mitigation and prevention

» **Score:** Integrated solution of smart technologies and nature-based solutions to increase climate resilience in European coastal cities, including the specific challenges related to sea levels, coastal erosion and extreme weather events
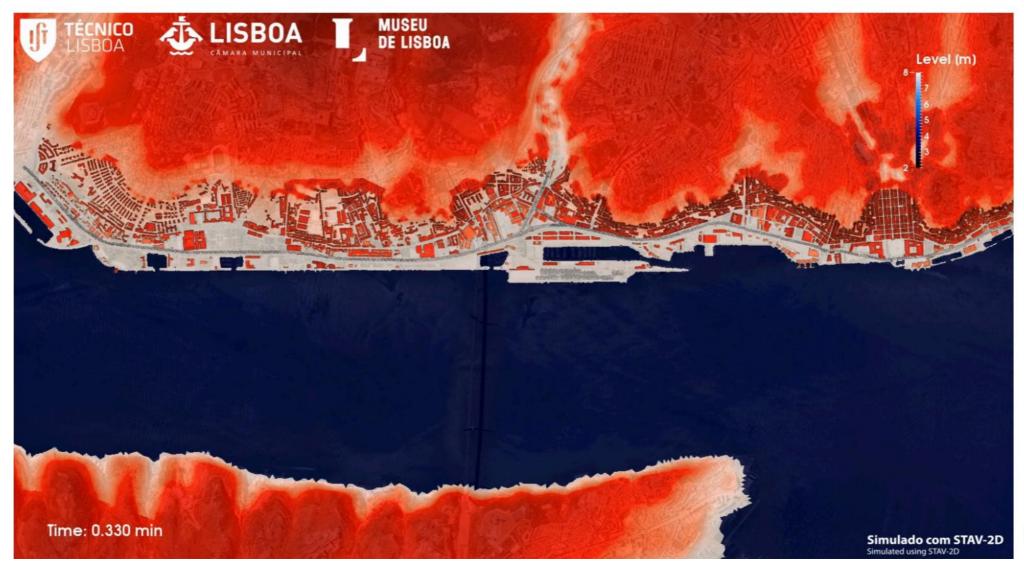

https://score-eu-project.eu/

» **RiverCure:** Improvement of hydrodynamic and morphodynamic mathematical models for flood simulation, water resources management and habitat protection

Computed flood in River Águeda

Research lines and developments

Simulation of the effect nowadays of 1755 tsunami in Lisbon

[48 s]

Future Challenges

Future challenges

» Sensorization and digitalization

   » Further development of different **sensing technologies** and their integration in models, platforms and decision-making tools (*in-situ sensors, drones, satellites, video cameras, opportunistic*)

   » Implementation of **machine learning and AI methods** to process and extract knowledge from Big Data (series; images)

   » Development of **holistic numerical models** (meteorological, surface flows, drainage systems, pollution dispersion) connected with multiple monitoring/sensing systems for real time and **fast-than-real time** simulation and short-term prediction

   » Testing emergent/new technological solutions in pilots and **living labs** (green-blue corridor of Jamor river)

Future challenges

Resilience and adaptation measures

» **Increase resilience to water scarcity**

  » **Integration of non-potable waters** (e.g. treated/grey/storm water) into the water cycle (aquifer recharge, green areas irrigation, street washing)

  » **Redesign water distribution systems**: alternative sources, dual systems, critical infrastructures and operating modes

» **Adaptation measures to extreme floods**

  » Implementation of **nature-based solutions** to mitigate urban/coastal floods

  » **Redesign of cities** (and drainage systems) for increasing resilience towards extreme floods (sponge cities)

  » Development of effective and efficient **flood monitoring, prediction and warning systems**

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