Dynamic Decision-Making Framework for Sustainable IoT: Methodological developments and case study

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Dynamic Decision-Making Framework for Sustainable IoT

Methodological developments and case study

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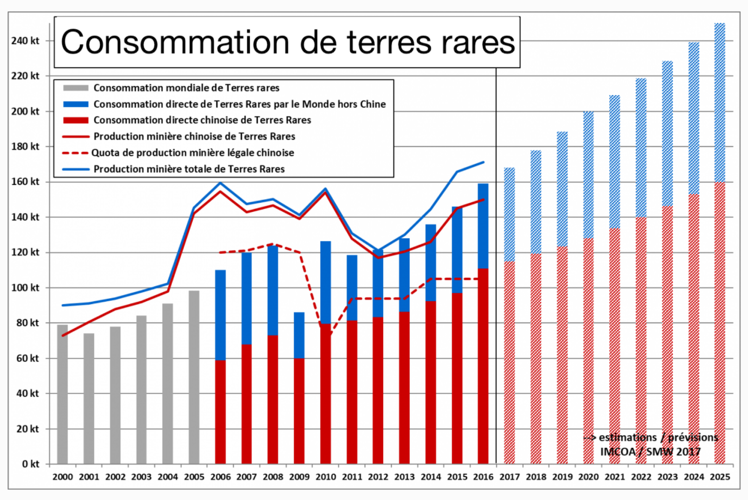
CONTEXT

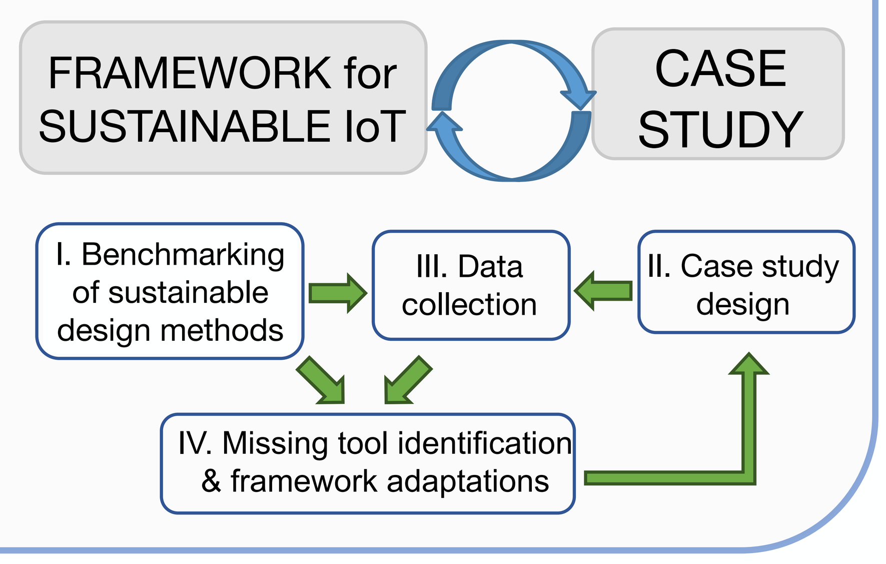
- Exponential dissemination of connected electronics devices
- Digital society **benefits**
- Need for more energy and critical materials
- Geopolitical, environmental and social **issues**



- Need to **anticipate the** possible **impacts** of the proposed technology

RESEARCH APPROACH

- There is **no eco-design tool** to support the IoT industry towards sustainable solutions.
- Need to develop **holistic decision-making methodologies** for the IoT industry.
- Use of a **case-study** to support the methodology development and its validity.

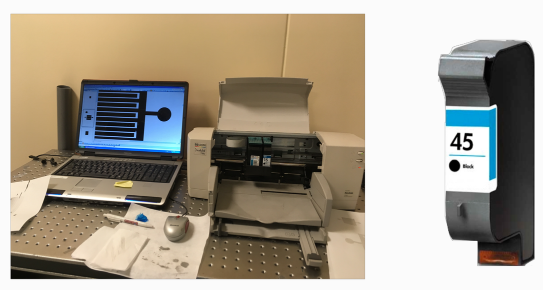


CASE STUDY

Low-cost connected sensor for water quality monitoring

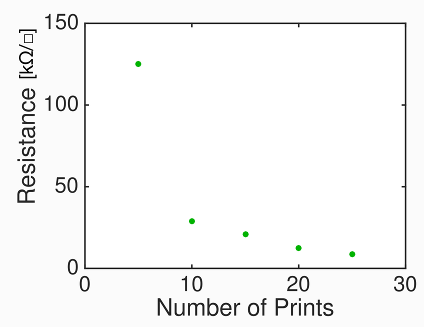
- Access to safe and sufficient water is essential to the development of human communities.
- Water quality assessment is crucial for the detection of waterborne pathogens, such as E. coli.
- **Paper-based sensors** are inexpensive and sustainable platforms, profiting from the porous nature of paper for fabrication of disposable **sensing tools for environmental monitoring**.
- Paper offers compatibility with electro-chemical detection since electrodes can be easily defined on paper by a variety of **printing techniques**.

Experimental setup



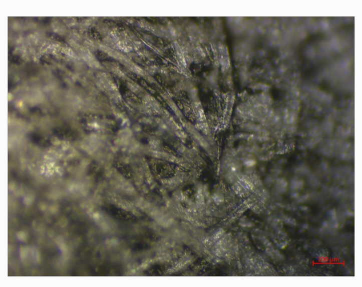
- HP DeskJet 710C
- HP45 rechargeable cartridge

Printed electrodes



- Carboxyl modified MWCNTs
- Commercially available

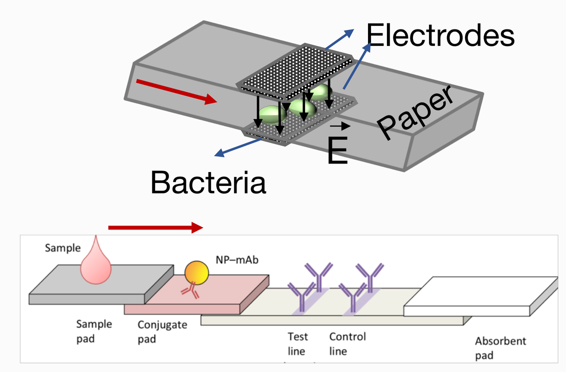
- Homogeneous MWCNTs deposits after 25 prints



Inkjet printed biosensor

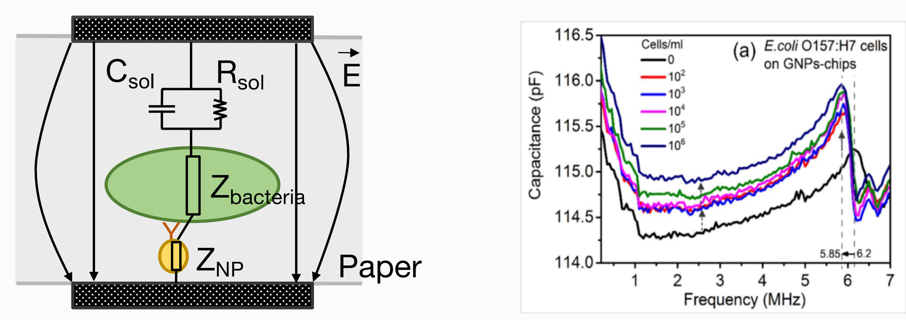
Configuration

- Water flows through the paper
- Selectivity is assured by means of specific antibodies



Detection principle

- Electrochemical impedance spectroscopy (EIS)



These sensors can support low-cost and decentralized quantitative water analysis with a minimal environmental footprint.

Dynamic Decision-Making Framework

- Need for a holistic perspective : **Life Cycle Thinking** approach
- **Assessing the sustainability** of IoT solutions on the whole value-chain requires using multiple criteria in the method of evaluation.

I. Setting the scope — Application and stakeholder analysis

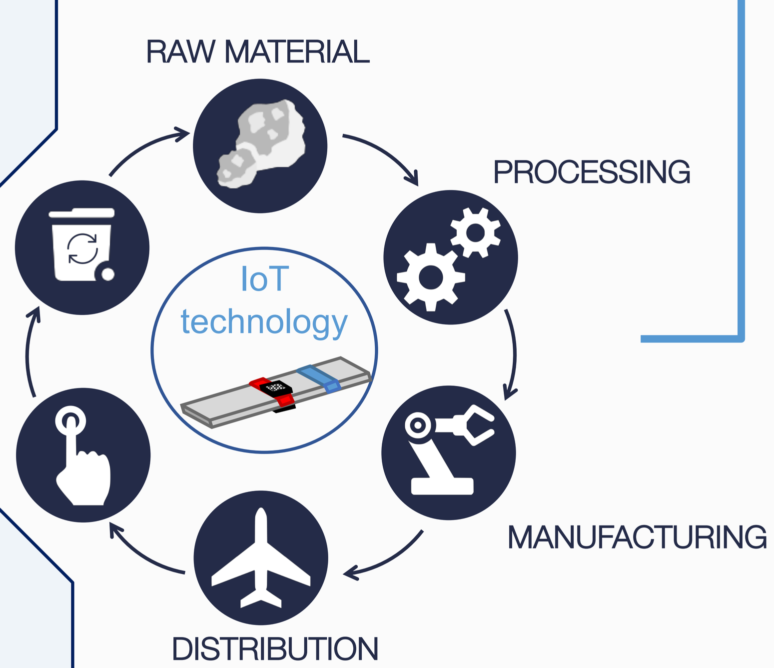
II. Data collection — Quanti- & qualitative **indicators** for IoT solutions

III. Indicator integration — Compute the *sustainability score*

IV. Decision support — Decision making by a scientific-informed debate

END OF LIFE
- Circular Economy indicators in WEEE
- How to measure eco-design ?
- Lifetime, disassembly, repair, reuse
- Efficiency in recovery and reuse

$$\text{Efficiency} = \frac{\text{benefits}}{\text{environmental impacts}}$$



USE PHASE
- Efficiency of the integrated solution (device and information system) ?
- Anticipate unintended societal effects and potential misuses

INDICATOR SELECTION & INTEGRATION
- How to reflect the needs and constraints of the micro- & nanoelectronics industry?

- Design
  - Performance, Modularity, Recycling
- Materials & Manufacture
  - Supply risks of critical materials
  - Lamia Mouloudi (PhD NEED for IoT)
- Environment
  - Energy, CO2 release, Air-Water-Land impacts
  - Ernesto Quintero (PhD NEED for IoT)
- Society
  - Rebound Effect, Consumer integration
  - Justine Marty (PhD NEED for IoT)
- Economics
  - Cost, Benefits
- Regulation
  - Awareness, Critical materials
  - Labels, certificates

The objective is to provide decision-makers at different stages of an IoT value-chain with a global assessment framework that could validate or refute choices regarding the design of an IoT technology.
Moreover, such framework will also support the development of new eco-design policies and eco-labels in the electronic industry.

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