Circularity measurement and assessment in water towards standardised approaches

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Quick introduction

Prof. Evina Katsou
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Our expertise

- Water management & wastewater treatment

- Data acquisition & data analytics (Machine Learning and Artificial Intelligence)

- Circularity & Sustainability measurement & assessment (methods, tools & indicators)

Our projects

iQonic
ZBre4k
INTCATCH 2020
SMART-Plant
Circular City
BL2F
Circ4Bio
water mining
DEEP PURPLE
CRONUS
RESILEX
iWAYS
HYDROUSA
Triple Carbon Reduction
SYMBIOREM
JACOBS
love every drop anglianwater
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Do we have the methods and tools to measure and quantify circularity in water systems? How far are we from standardized indicators/approaches?

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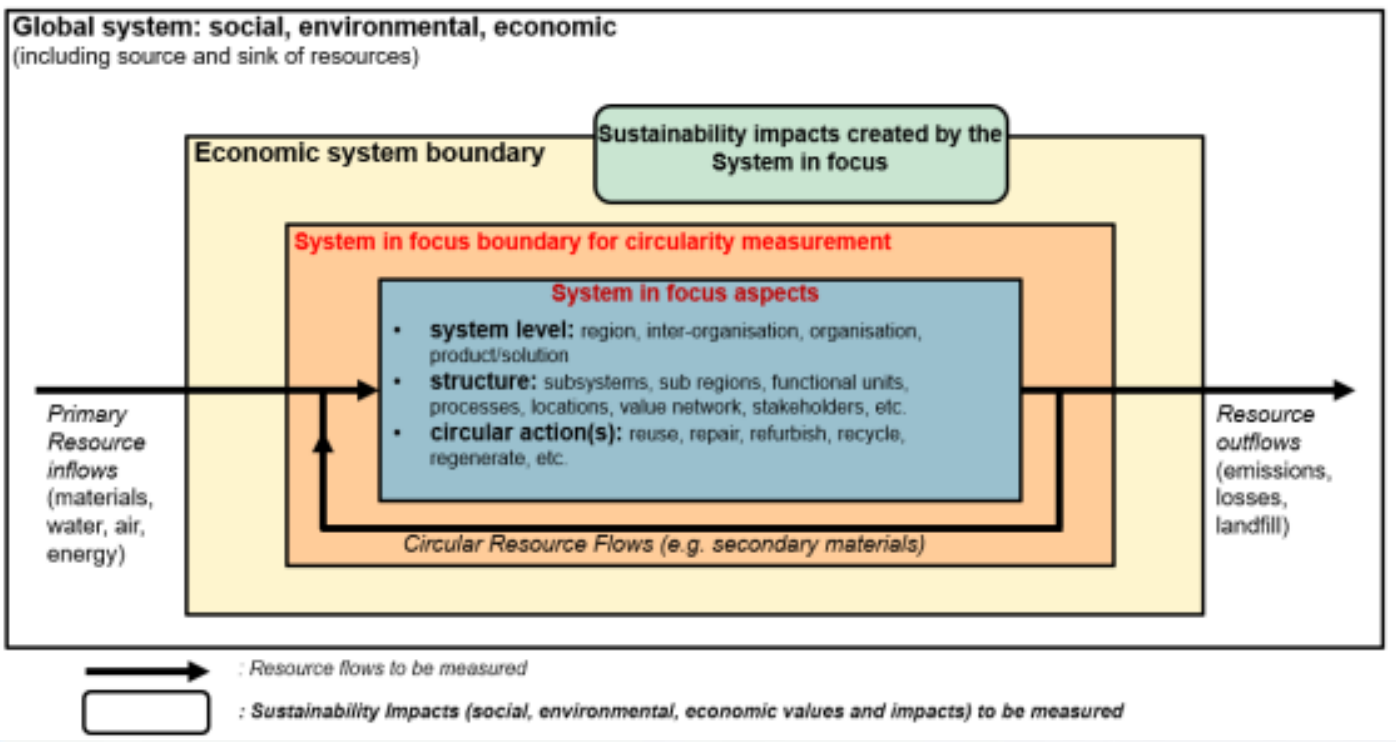
Circularity Measurement & Assessment – The new ISO framework



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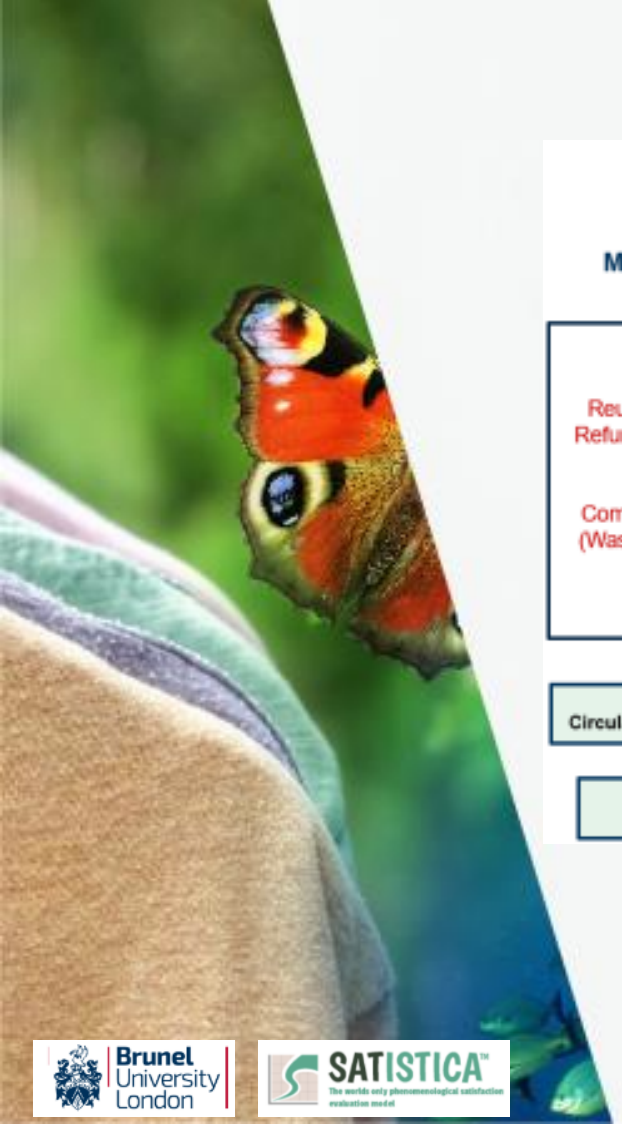
Circularity Measurement & Assessment



Circularity measurement taxonomy

"Measuring a systemic approach to maintain a circular flow of resources"

Monitoring circular actions

Reduce,
Reuse, Repair/Maintain,
Refurbish, Remanufacture,
Repurpose,
Recycle,
Composting, Valorisation,
(Waste to energy, Landfill)

Resource flow measurements

Resource flows
(e.g. virgin material, flows crossing boundaries)

Resource circularity

- Retain
- Regenerate
- Create

Circularity indicator categories

Input/output resource flows; resource losses (waste), emissions, water & air, energy, economic
(normative & informative indicators)

Circularity indicators

Assessing Sustainability impacts of circular actions

Social impact & value
(e.g. health, safety of labour, consumers, citizens, social value)

Environmental impact & value
(e.g. CO2 footprint, energy use, water use and quality, climate change, (less) pollution, biodiversity)

Economic impact & value
(e.g. Creation or loss of jobs, market prices, law, regulations, investment & tax systems, life cycle costing)

ISO 59010
Circular actions and indicators

Calculations, aggregation

Complementary methods & indicators

Systemic approach to measurement (addressing life cycles, indicators, resource use and impacts)

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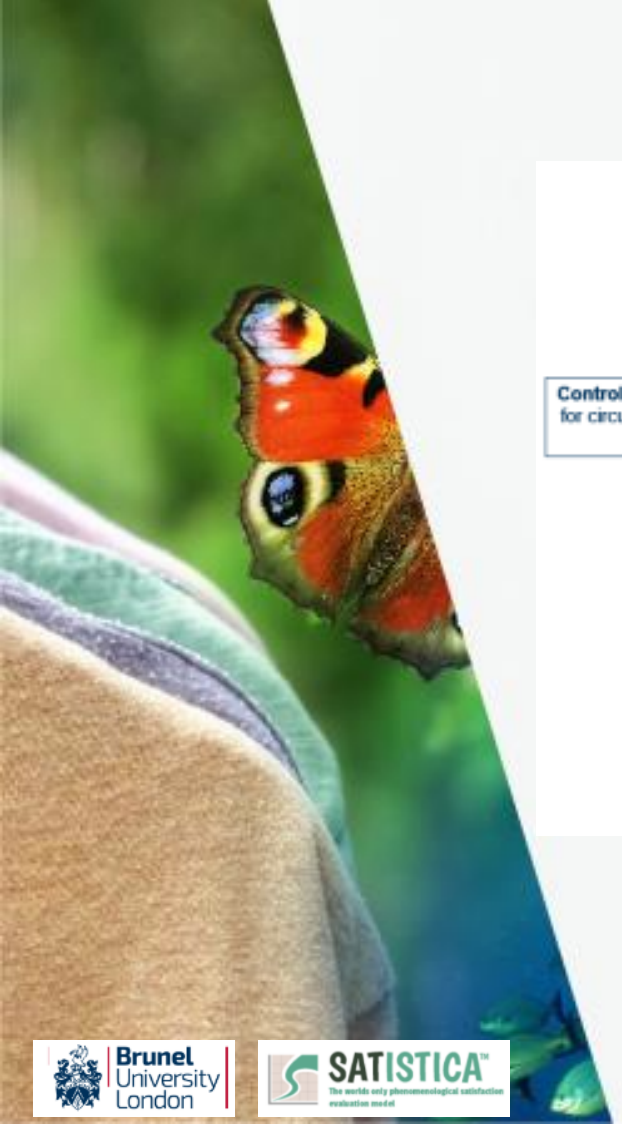
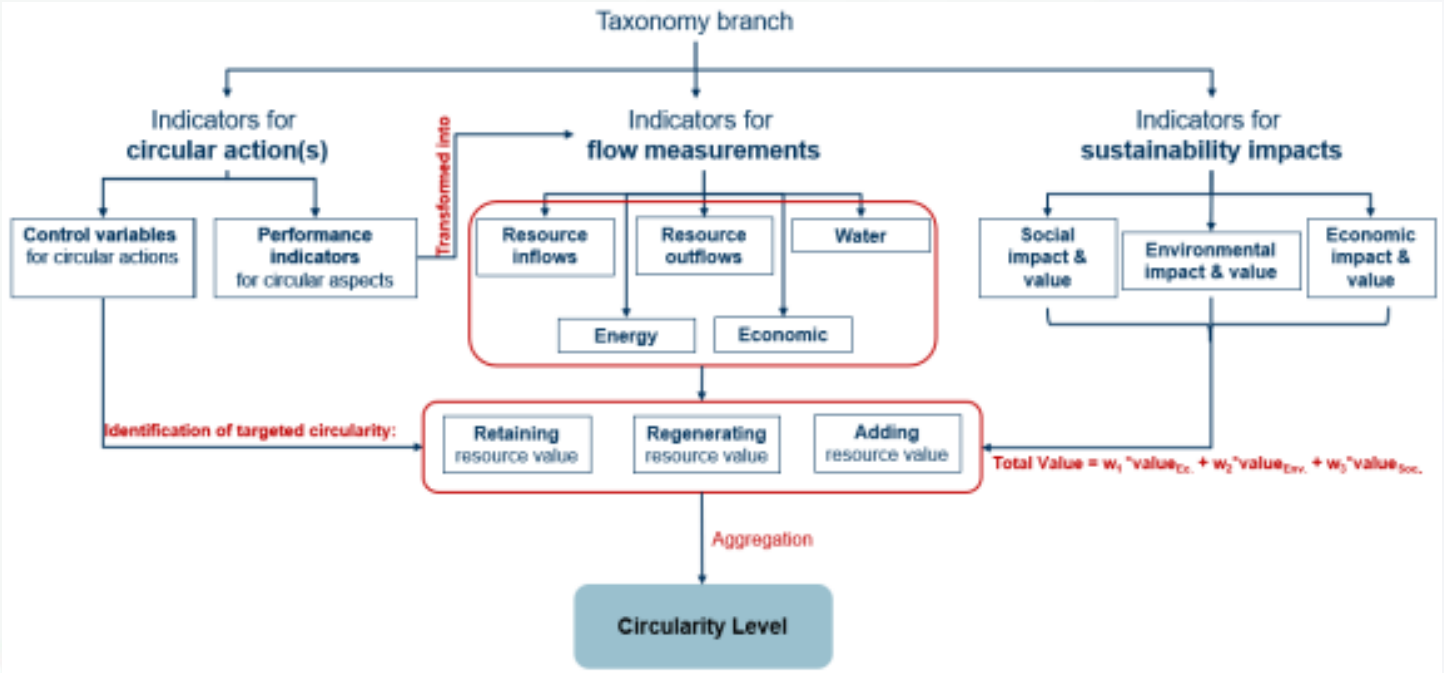
Circularity Indicators – choice & calculation





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SATISTICA™ The world's only phenomenological satisfaction evaluation model

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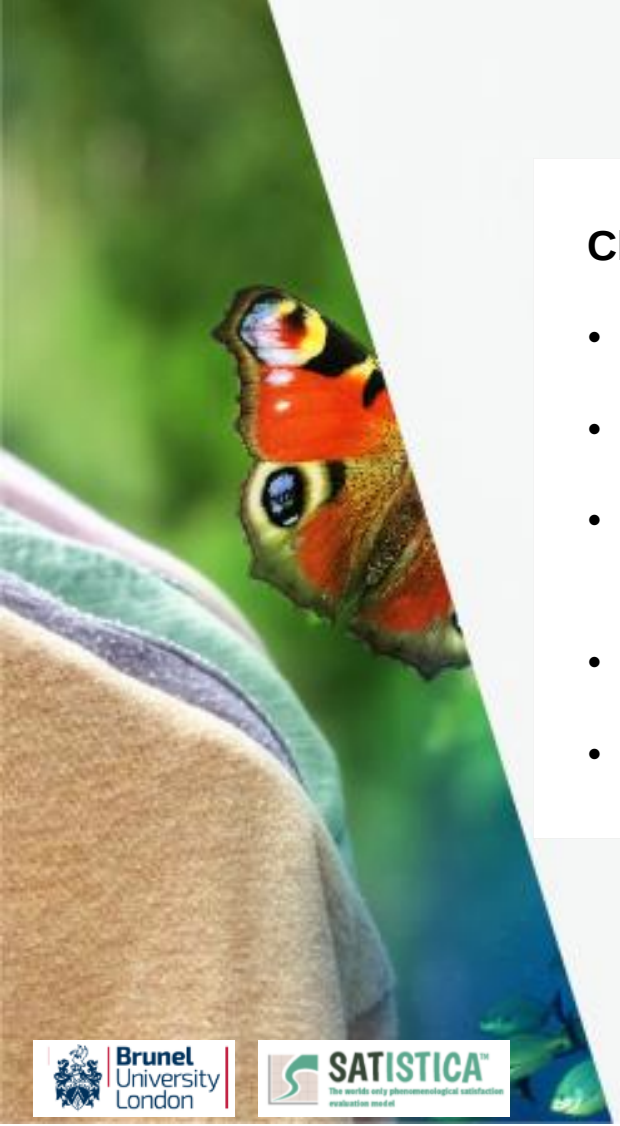
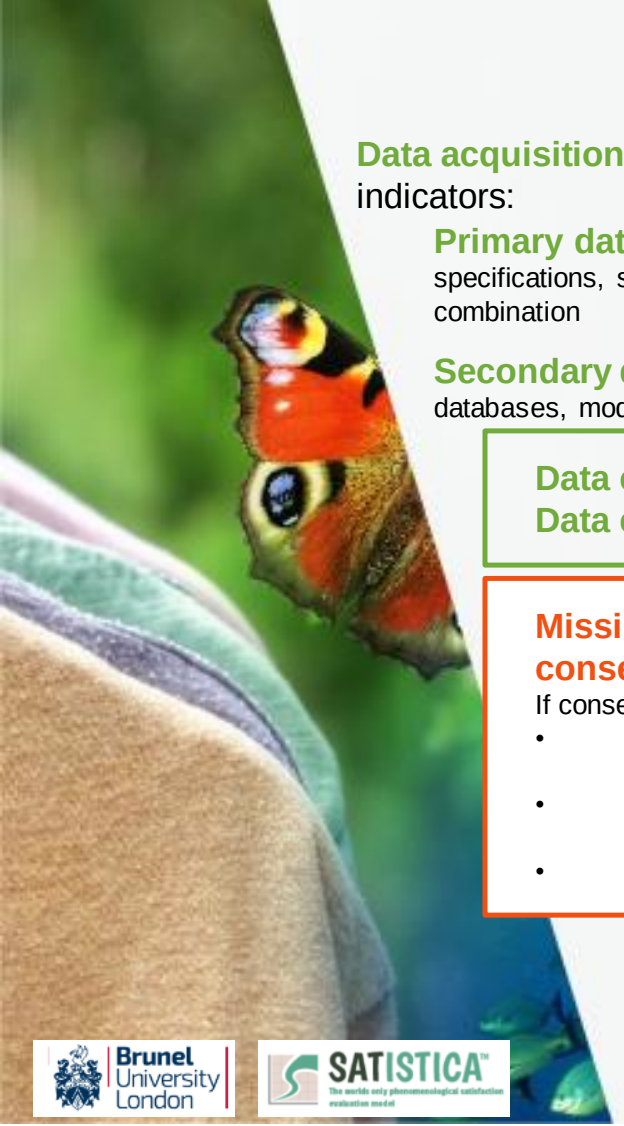


Choice of Circularity Indicators depends on:

- **System level** (e.g. product, organisational, etc.)
- **System sector** (e.g. water, manufacturing, etc.)
- Implemented **circular action(s)** (e.g. reduction of resource use, etc.)
- **Sustainability impacts** linked to circular action(s)
- Meaningful outcome for **interested parties**

Circularity Indicators – Methods & Challenges



Data acquisition for calculation of circularity indicators:

Primary data: measurement, design specifications, statistical treatment & combination

Secondary data: literature, statistics, databases, modelling

Data effectiveness
Data efficiency

Missing data → Assessment of consequences

If consequences are severe:

- alternative acquisition approaches, e.g. modelling
- alternative ways to measure the indicator
- chose other indicators

For **full-scale** implementation:

✓ **Availability** of primary **data**

Data reliance for:

- ***Benchmark assessment*** (i.e. comparison with baseline)
- ***Dynamic assessment*** (i.e. optimization of system's operation)

For **pilot scale** or **new technologies**:

× Primary **data not** always **available**

✓ **Modelling** procedures

Modelling & data reliance for:

- Future behaviour (***ex ante / prospective*** assessment) – changes in foreground and/or background system

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Circularity Measurement & Assessment in Water – Challenges

Examples from H2020 Projects

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DEEP PURPLE

water mining

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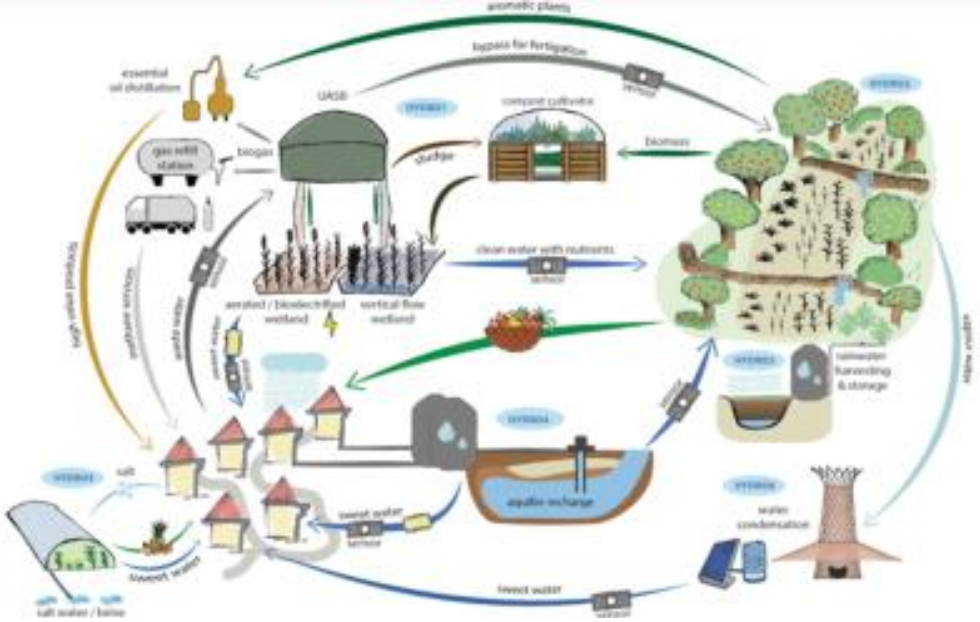


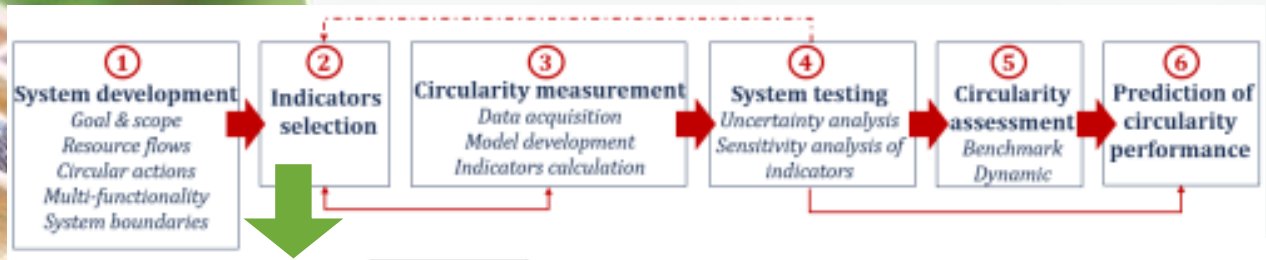
Numerous anthropogenic & semi-natural sub-systems
Water-Energy-Food-Ecosystems nexus

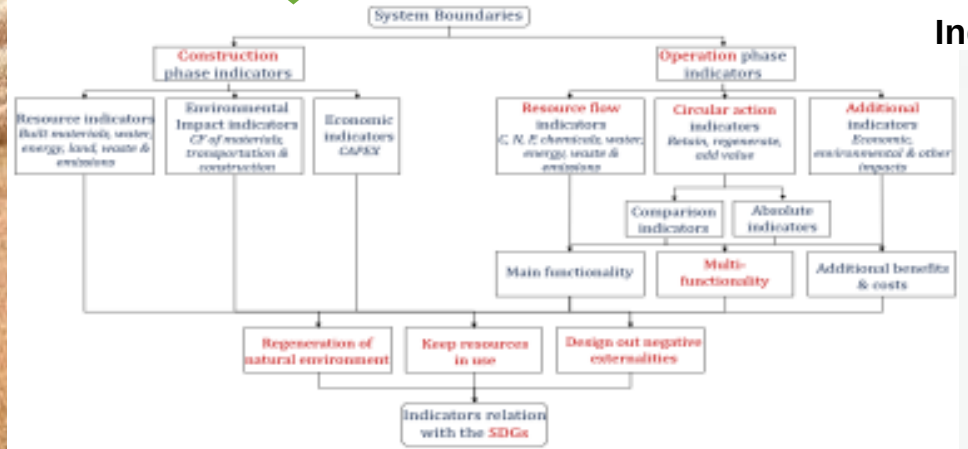
Circularity focused on manufacturing sector → **lack** of guidance on **circularity** measurement & **assessment** in **water sector & nexus**
Lack of **circularity indicators** for water sector & nexus

The *Multi-Sectoral Water Circularity Assessment (MSWCA)* framework

1. 3 CE principles
2. Socio-economic & non-economic sectors
3. Symbiotic management of resources
4. Value in and of water
5. Feedback loops & interdependencies
6. Synergies & antagonisms
7. Socio-economic activities & environmental resilience

The application of the MSWCA to HYDROUSA:

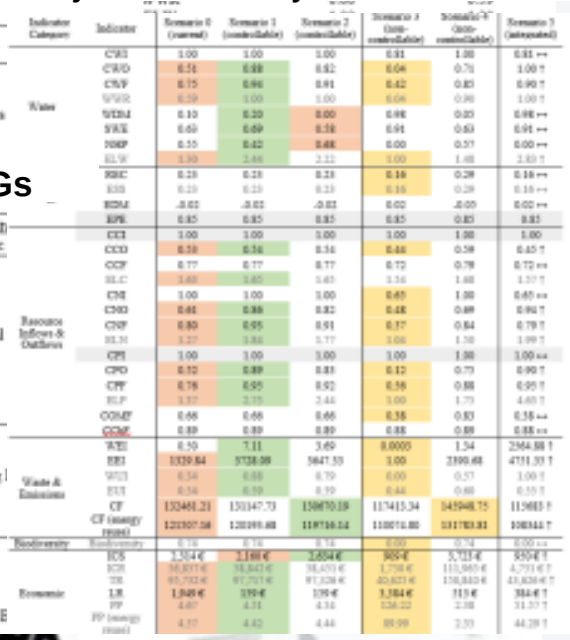




The developed methodological approach for circularity measurement & assessment and for circularity indicators selection

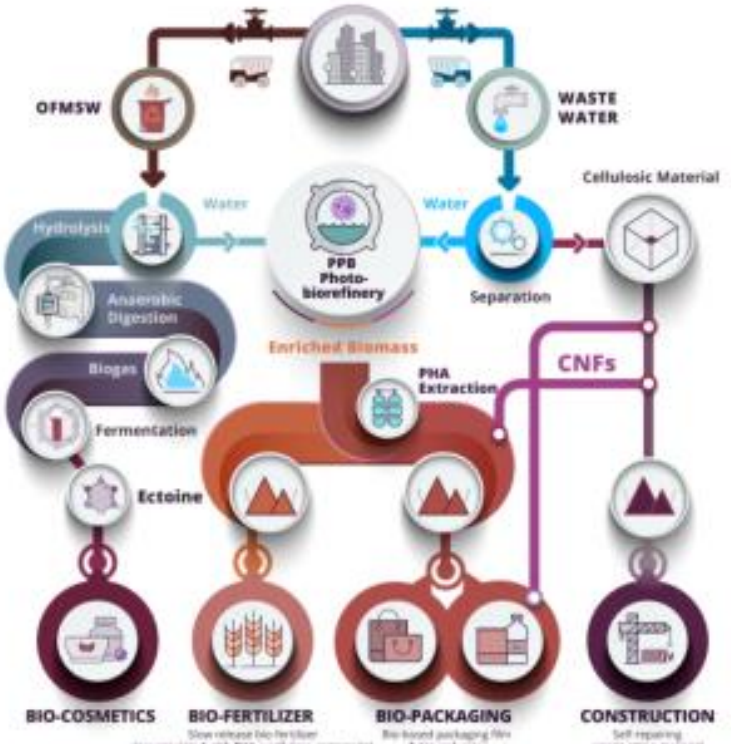
Benchmark circularity assessment

Dynamic circularity assessment

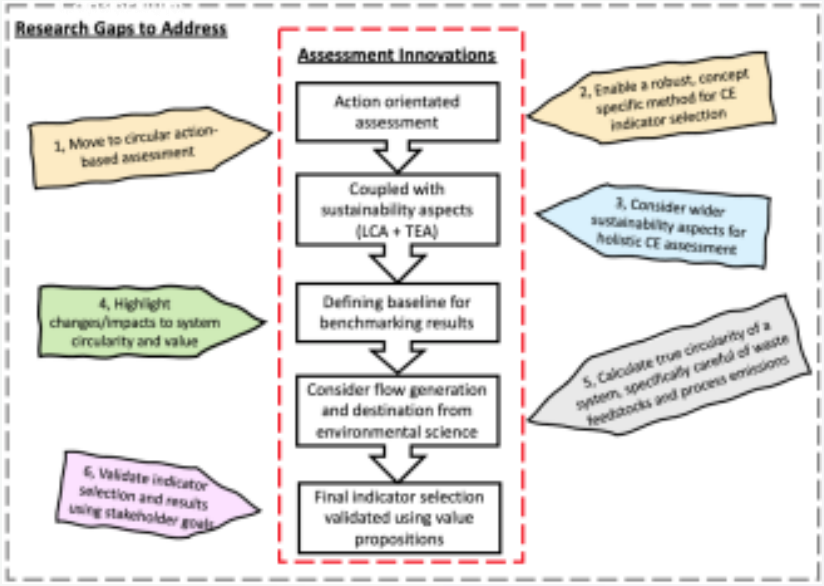


Indicators relation with SDGs

Deep Purple H2020



Multi-platform, multi-product process impact allocation
Product pathway depending on climate conditions



Construction of conventional and integrated system models for technology benchmarking, and integration within process DSS for dynamic assessment

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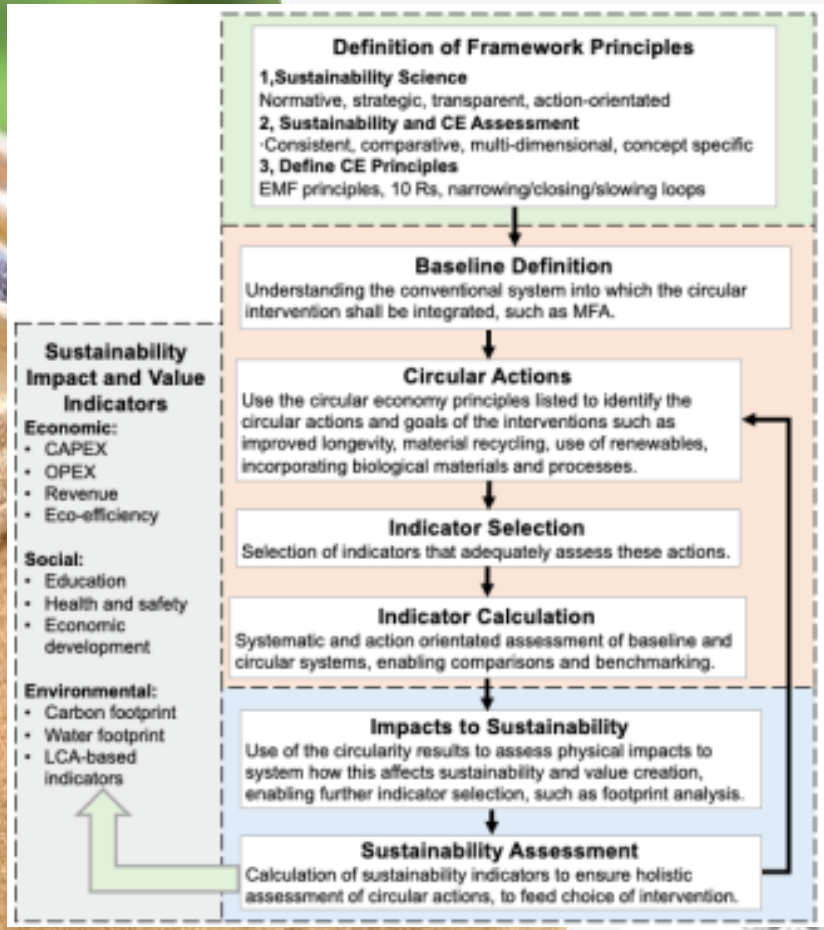
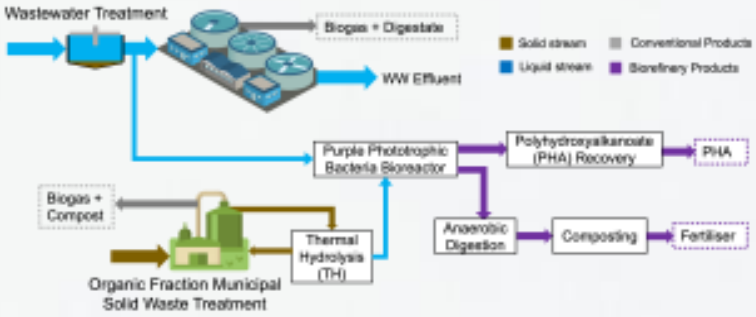


Need for concept specific assessment and holistic sustainability analysis of impacts

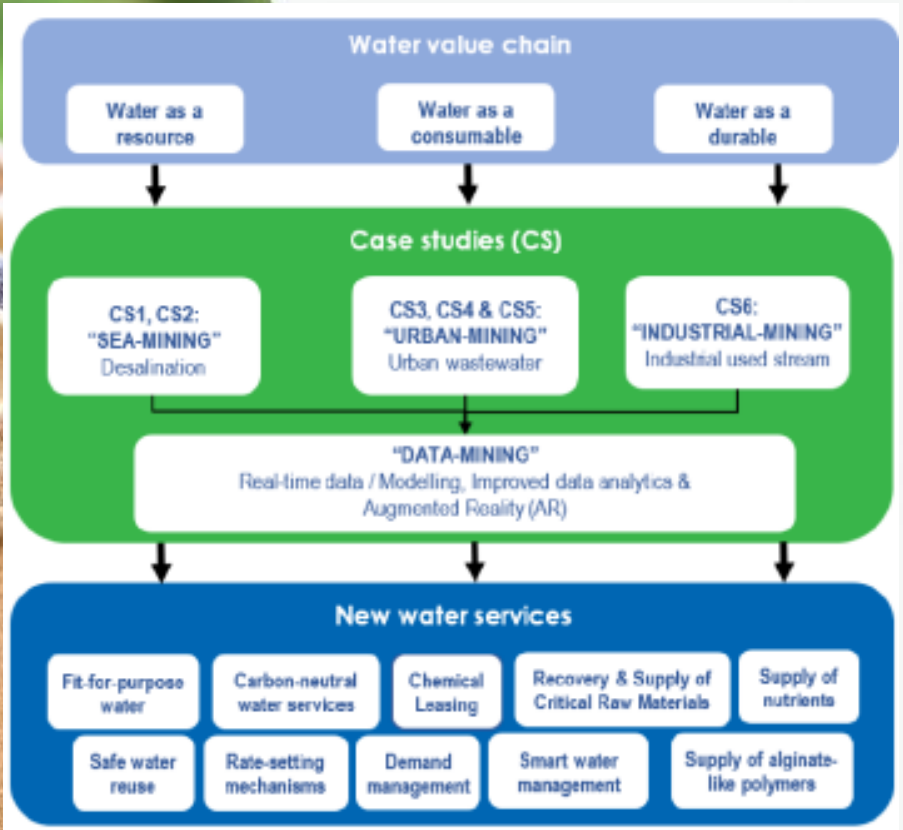
Actions to guide indicator selection and LCA for sustainability aspects

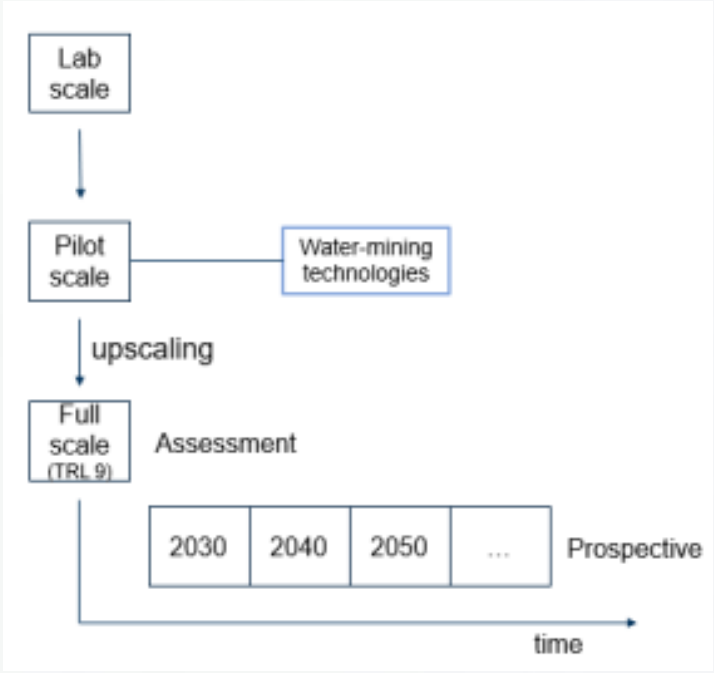
Holistic, action-oriented assessment for benchmarking circular interventions

Selected indicators to be integrated within process DSS for dynamic calculation

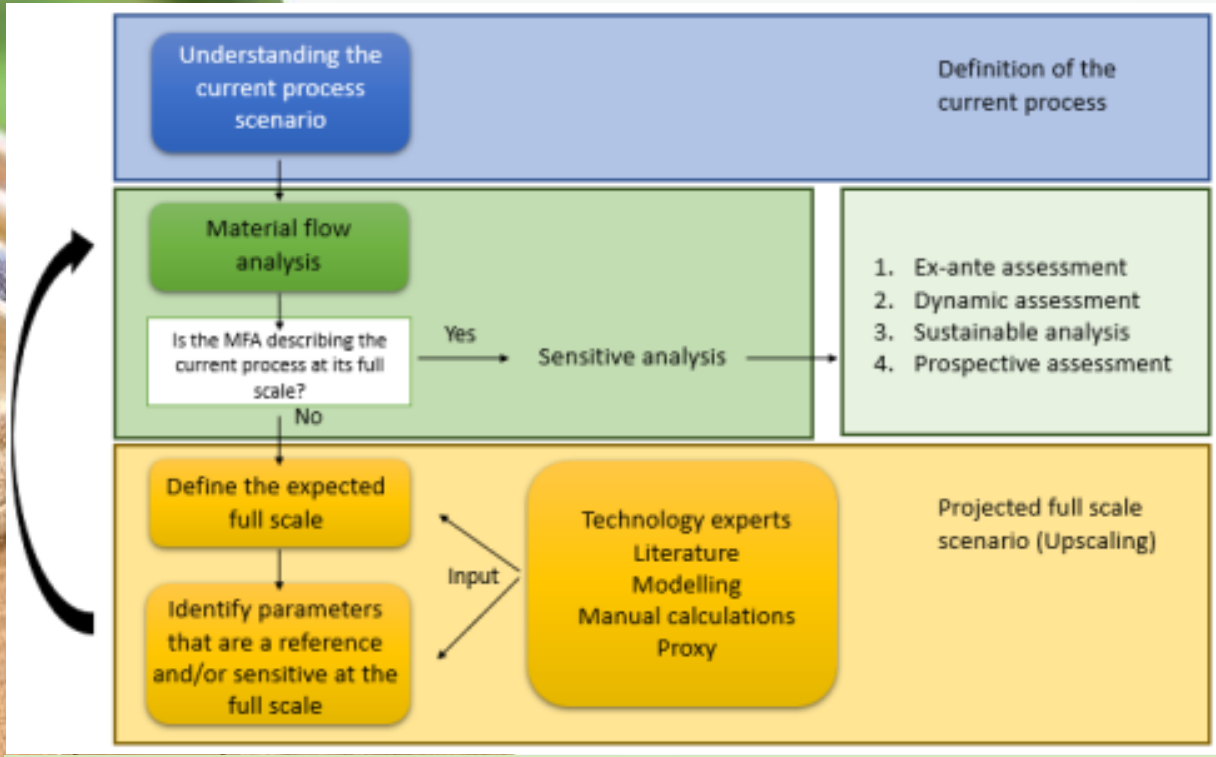


Water Mining H2020





WM technologies at pilot-scale (5-7 TRL)
Multi-functionality
Several types of products and by-products



The developed methodological approach for upscaling

<u>In progress:</u>
Assessment of the projected full scale
Assessment of the value of circular actions in short and/or long term (future scenarios)

Challenges of Circularity Assessment – Lessons learnt from projects

Challenges

Characterisation of resource flows in water systems

Water systems coupled with NBS, requiring a nexus approach

Water & WW management systems/technologies for multi-product generation

Low TRL of technologies & projection of system behaviour & circularity performance

Lack / Delay of primary data availability

Appropriate & case-specific circularity indicators

Meaningful outcome & usability of circularity indicators

Solutions to overcome those challenges

Guidance on the true circularity of water & water-related resource (incl. waste & emissions) streams from environmental science perspective ***(Deep Purple)***

Development of the MSWCA framework ***(HYDROUSA)***

Targeted circularity measurement & assessment methodologies, following the new ISO ***(Deep Purple, Water Mining)***

Upscaled & prospective circularity & sustainability assessment ***(Water Mining)***

Combination of modelling procedures & operational data ***(HYDROUSA, Deep Purple, Water Mining)***

Guidance on how to select circularity & sustainability indicators ***(HYDROUSA)***

Integrate indicators within DSS for dynamic calculation for process optimisation ***(Deep Purple)***

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What does the new ISO bring and how can be applied to the water systems?

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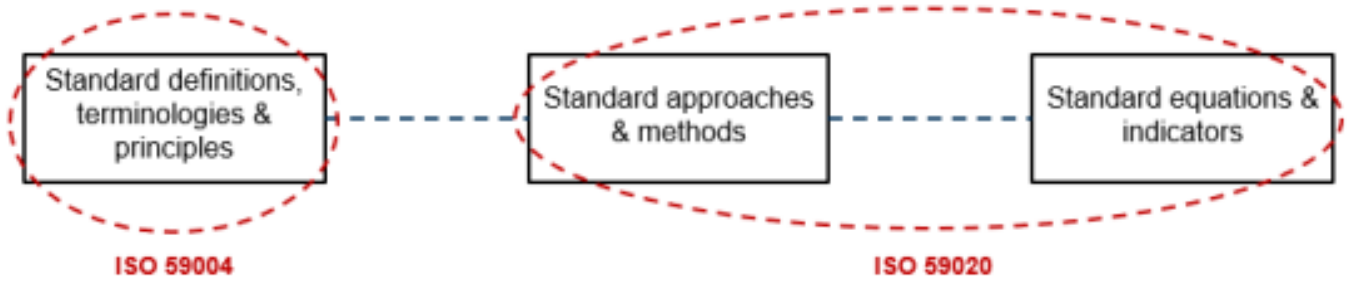
Standardisation of circularity measurement, indicators & assessment

The new ISO family



\+ **ISO 59010:** Business models & value chains
ISO 59014: Environmental management of secondary materials
ISO 59040: Circularity product

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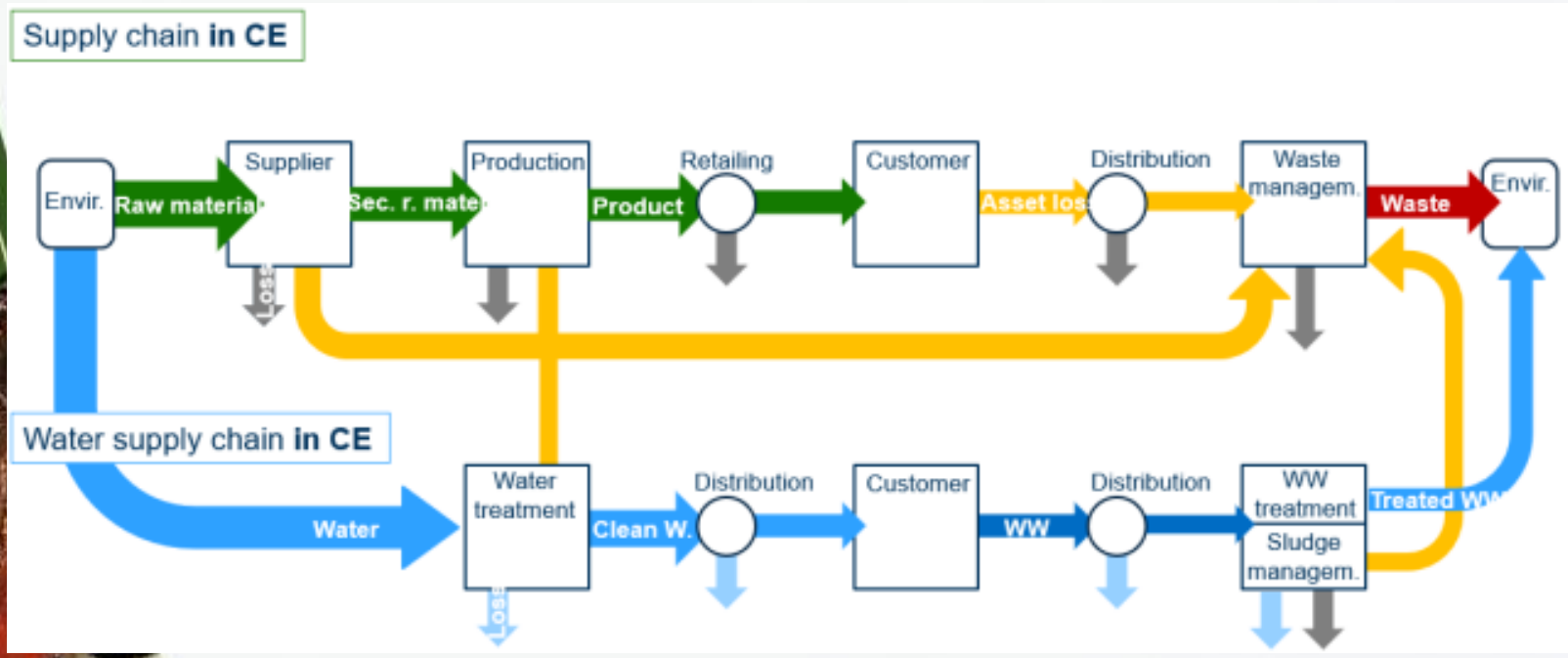
Standardisation of circularity measurement, indicators & assessment

The new ISO family and its applicability to water systems



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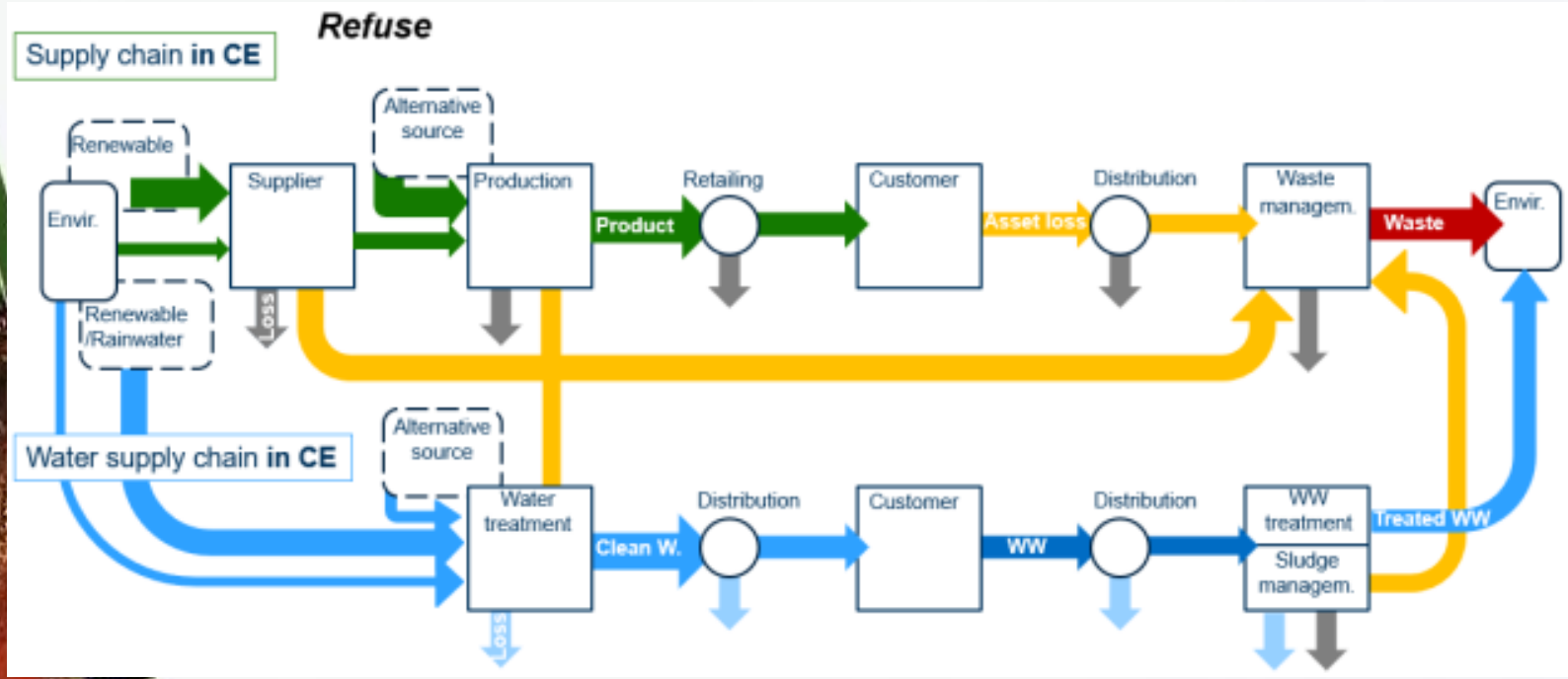

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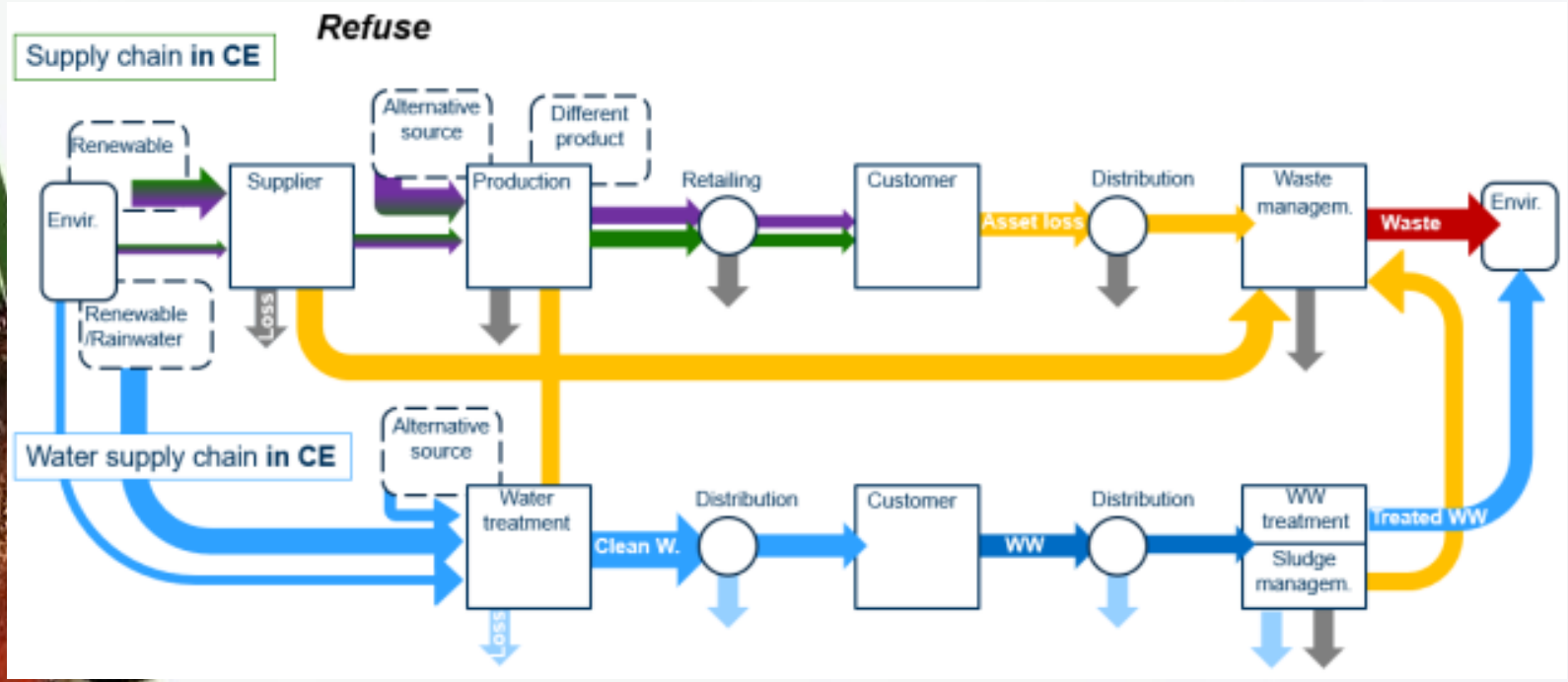

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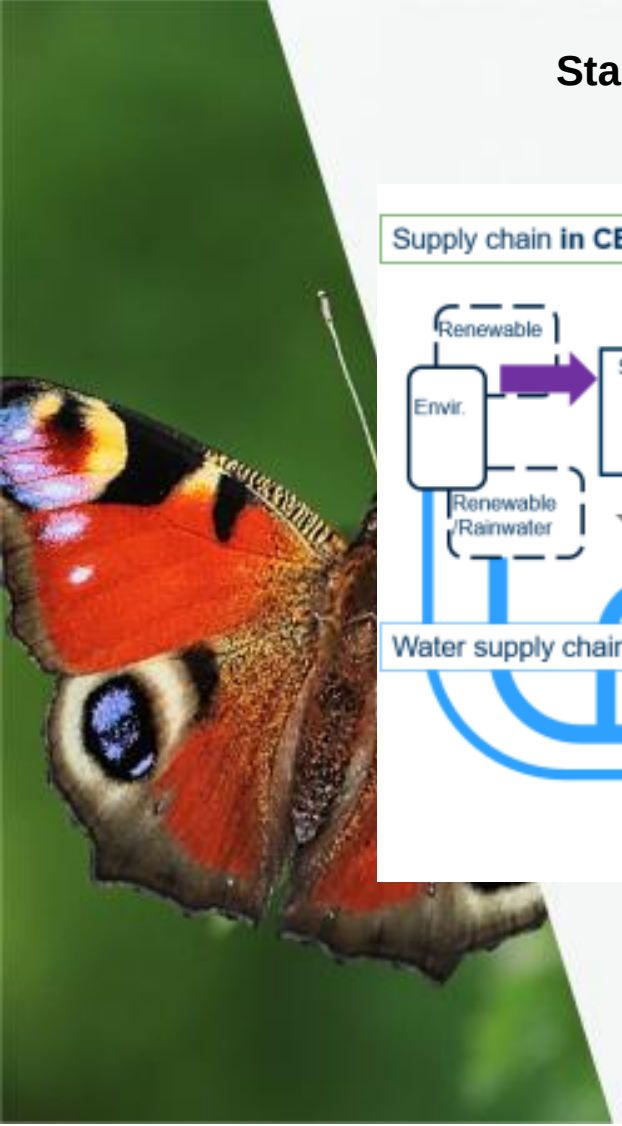

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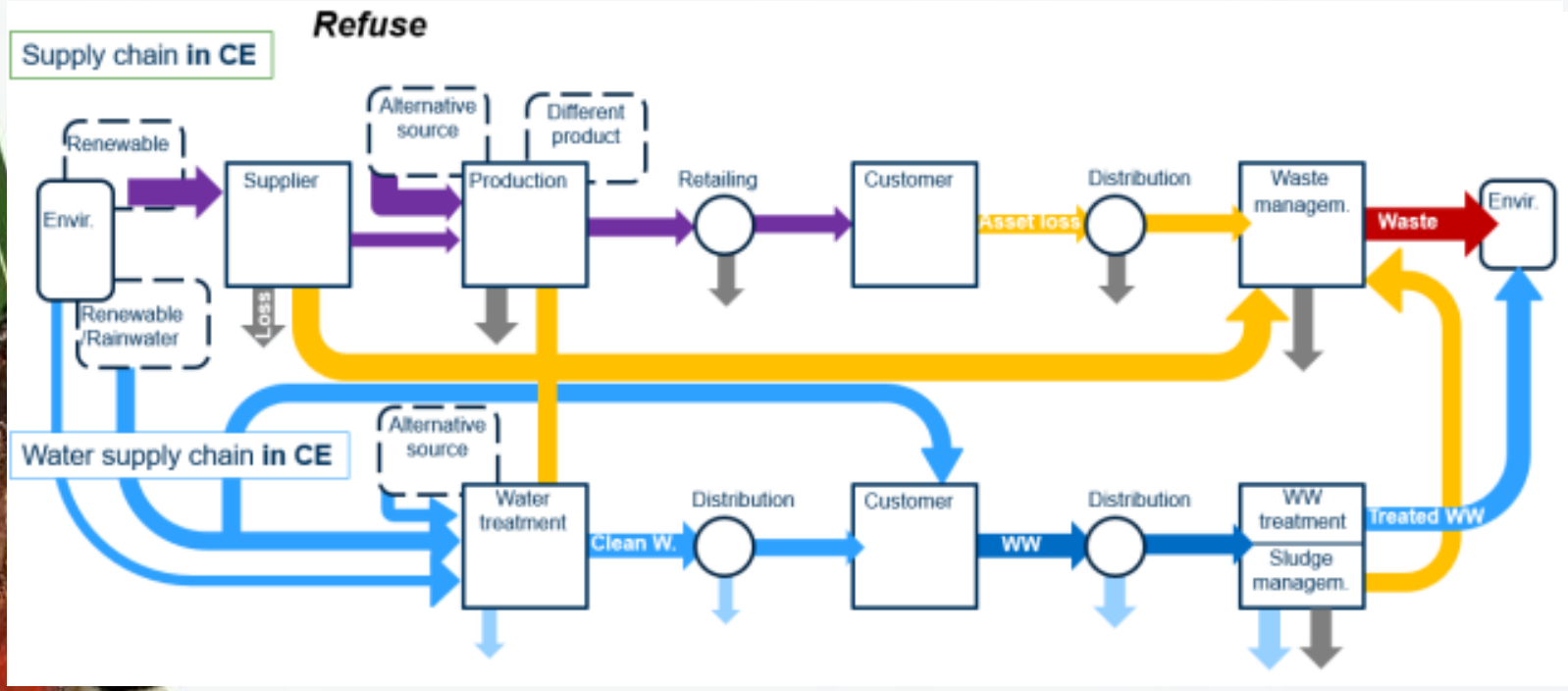

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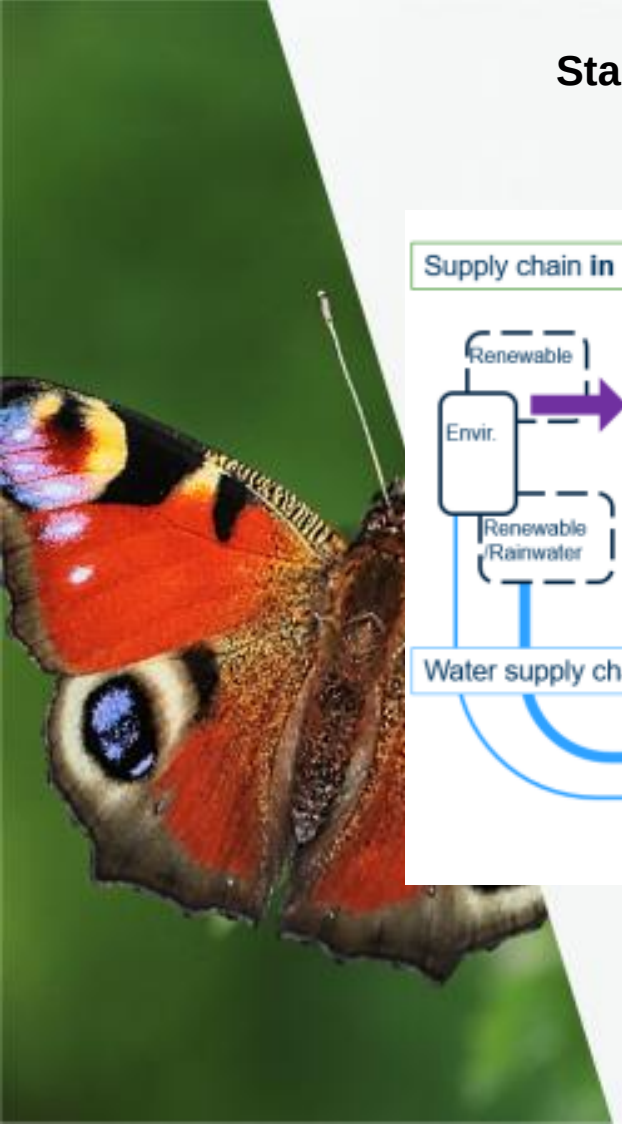

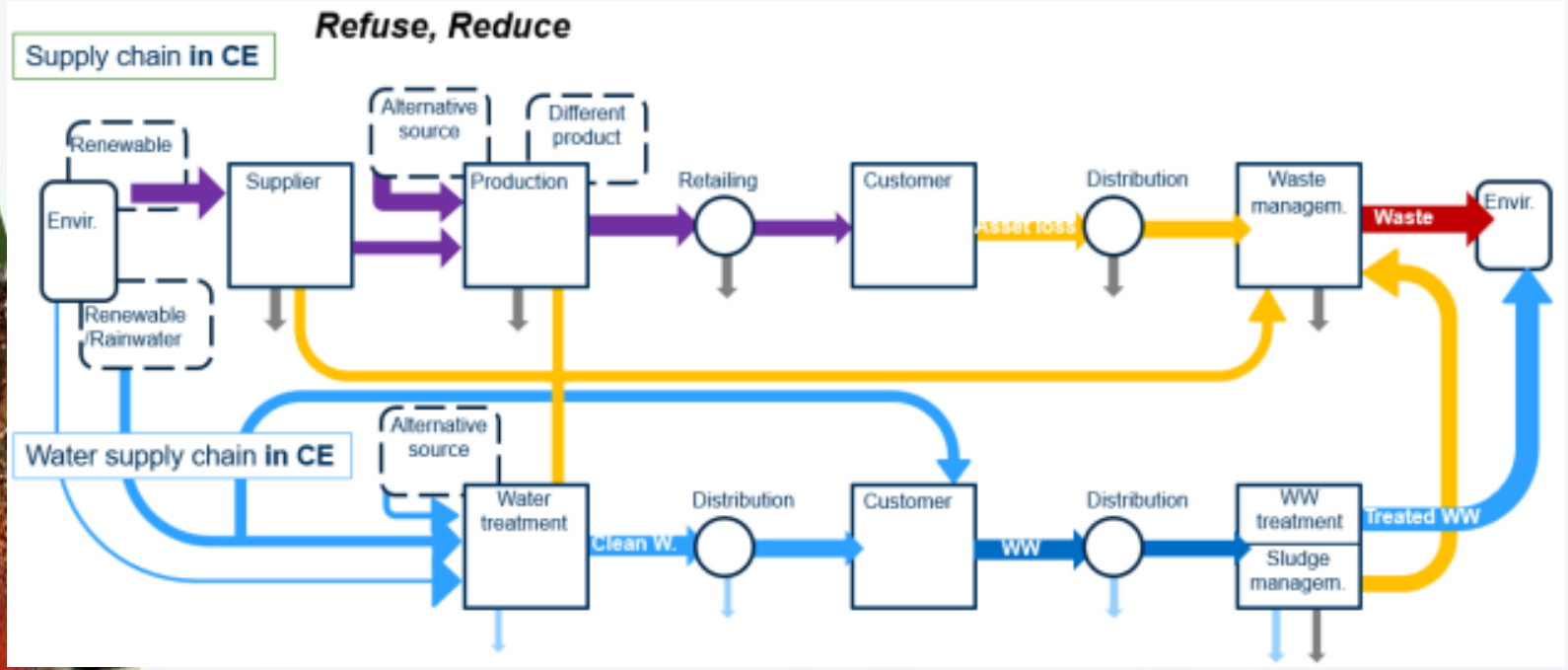

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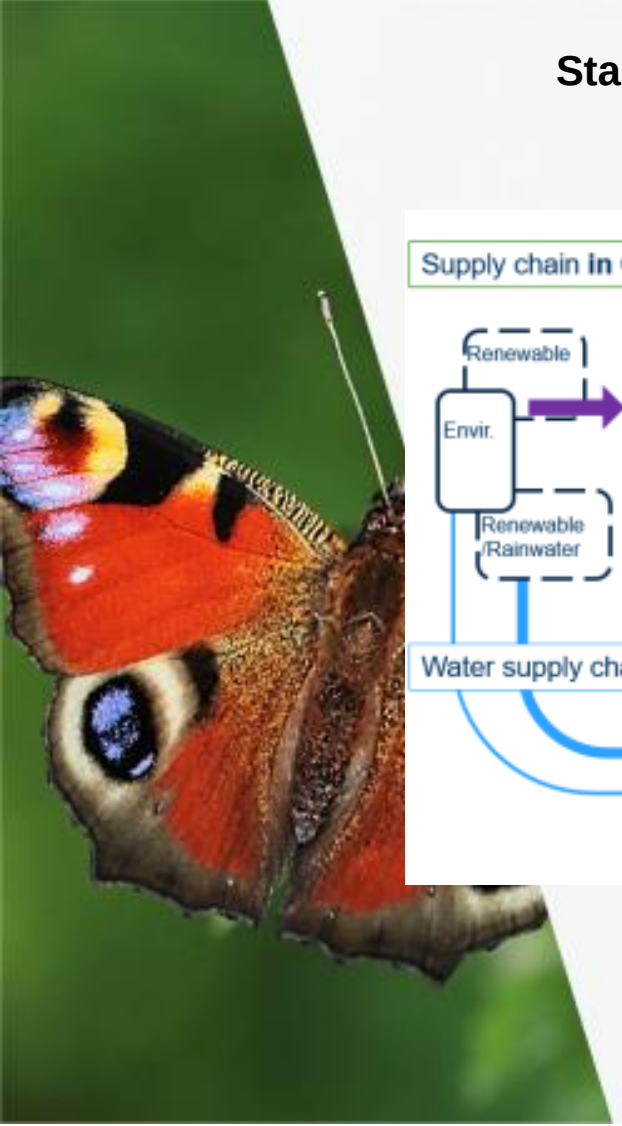

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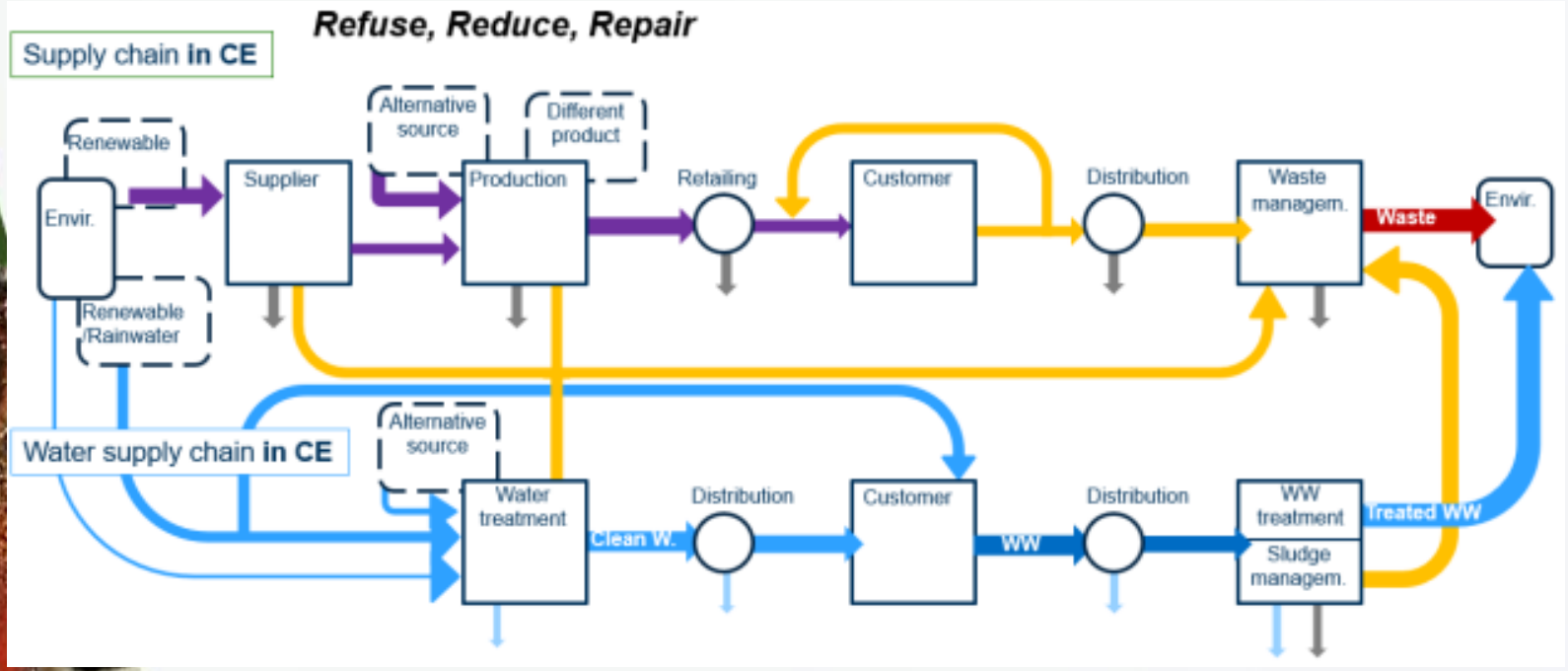

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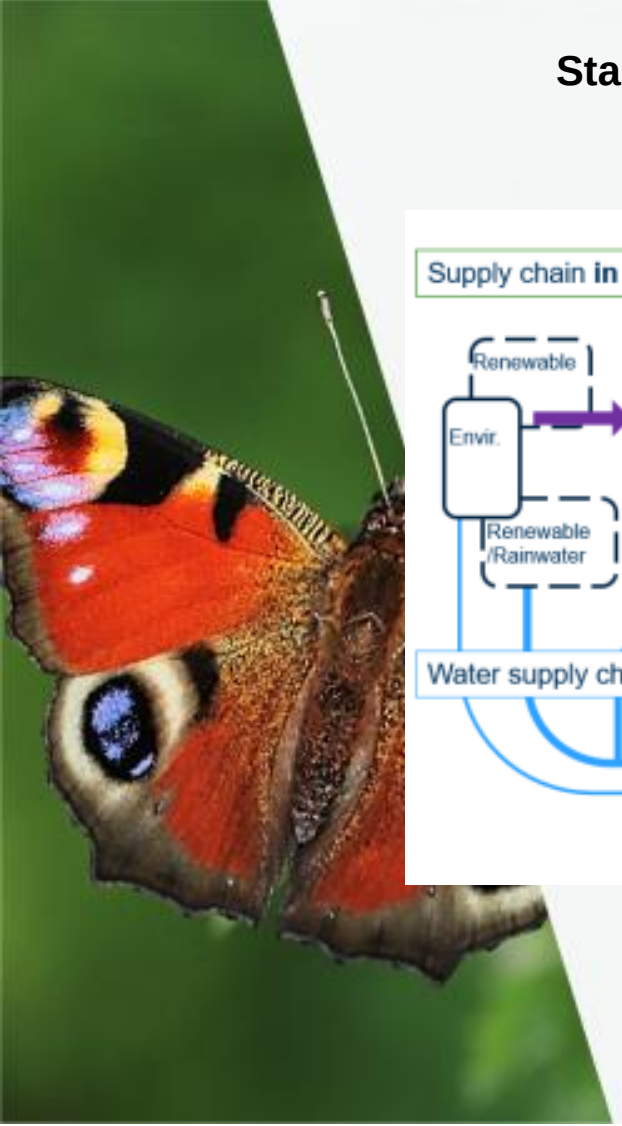

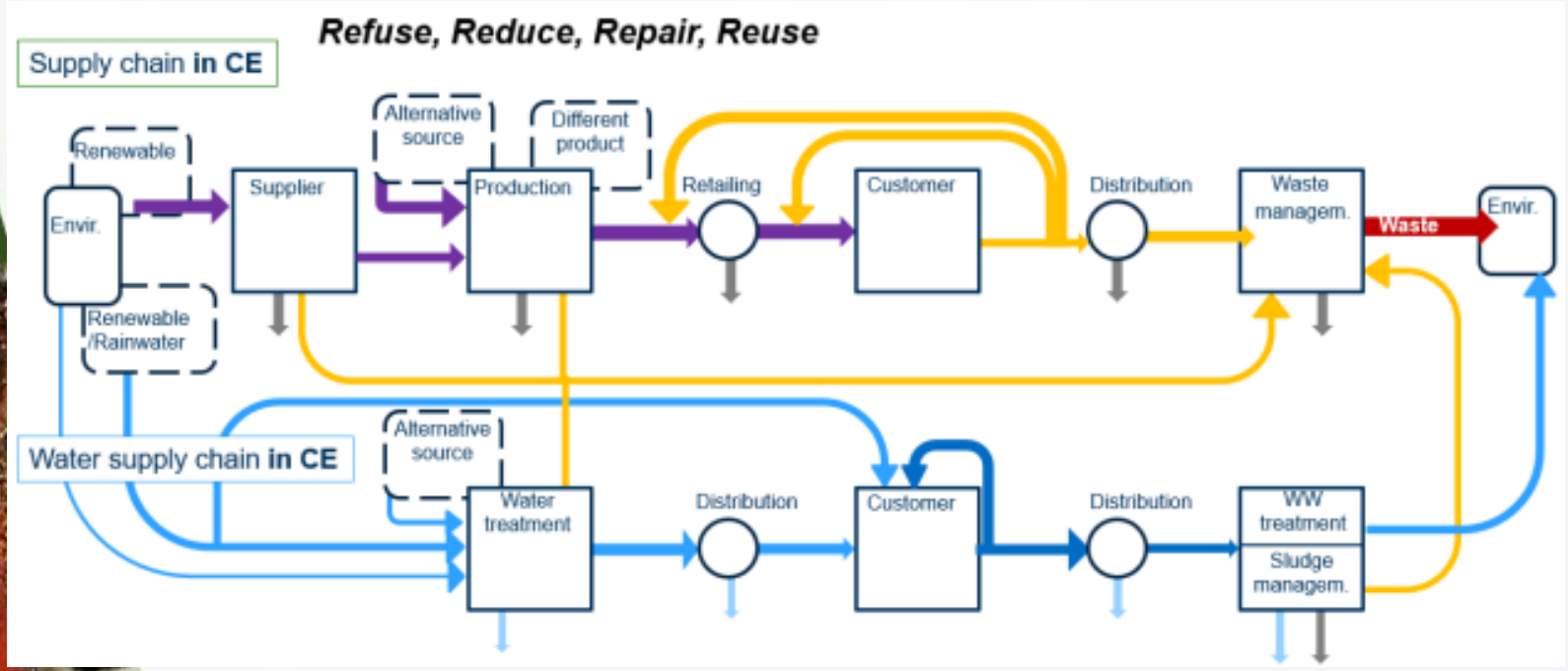

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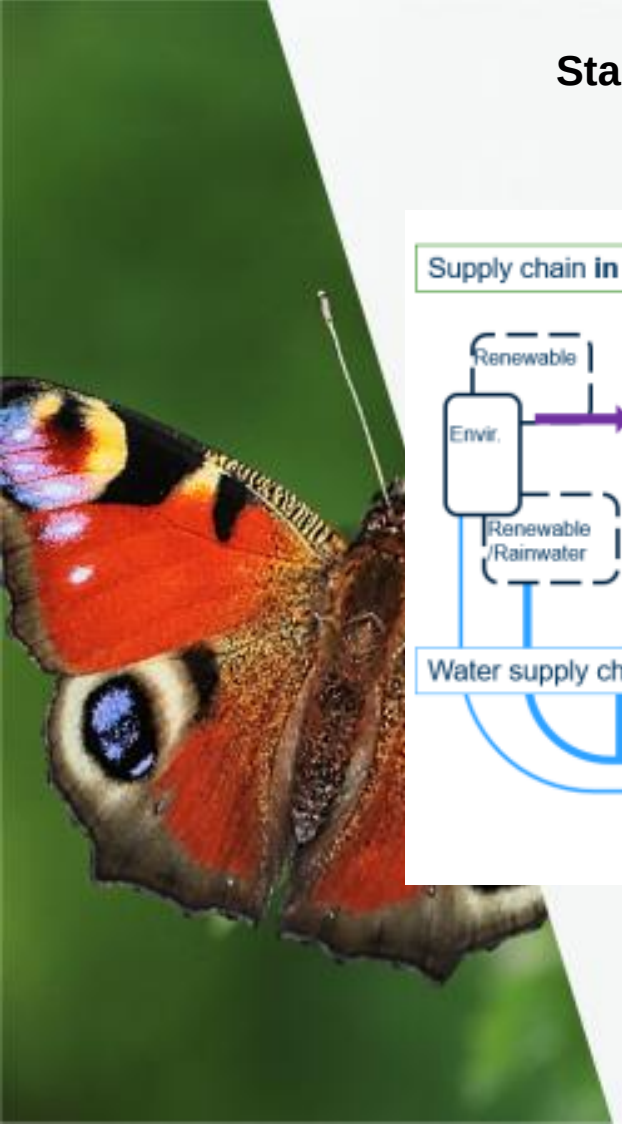

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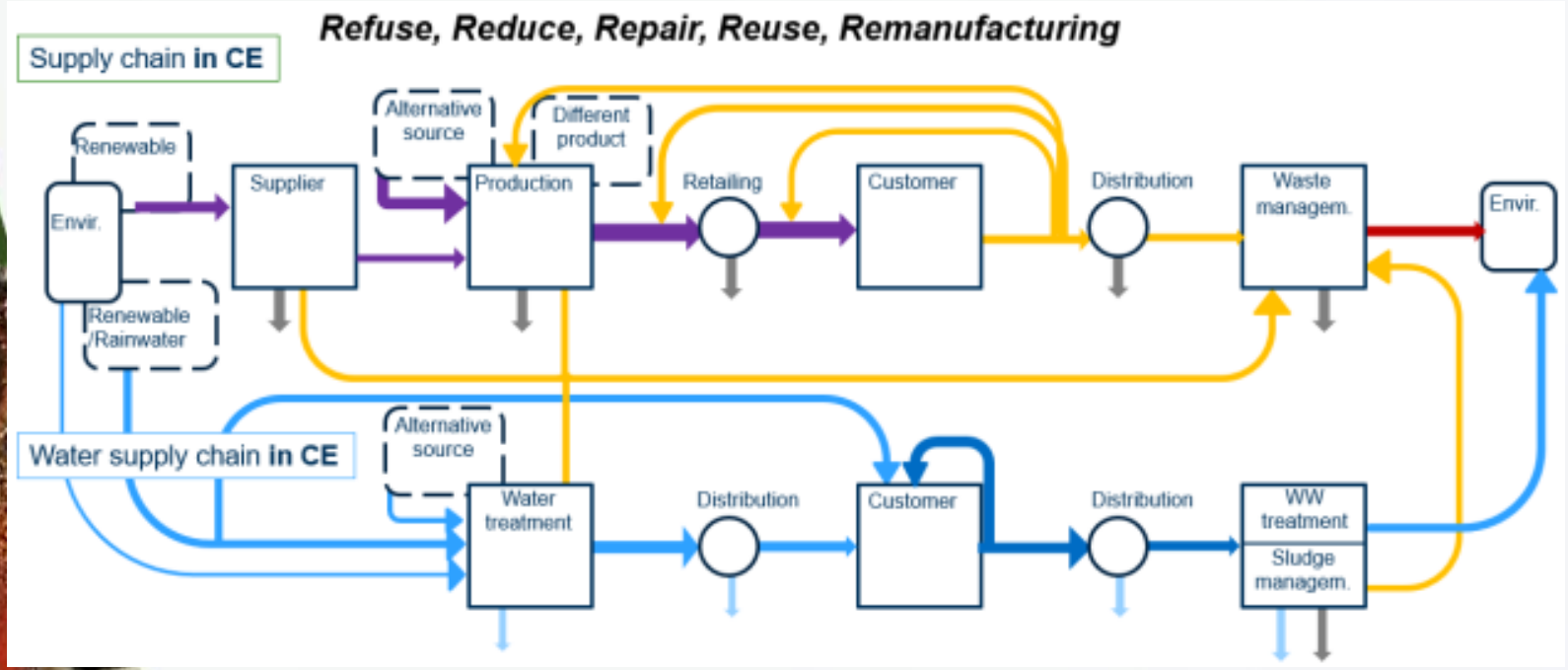

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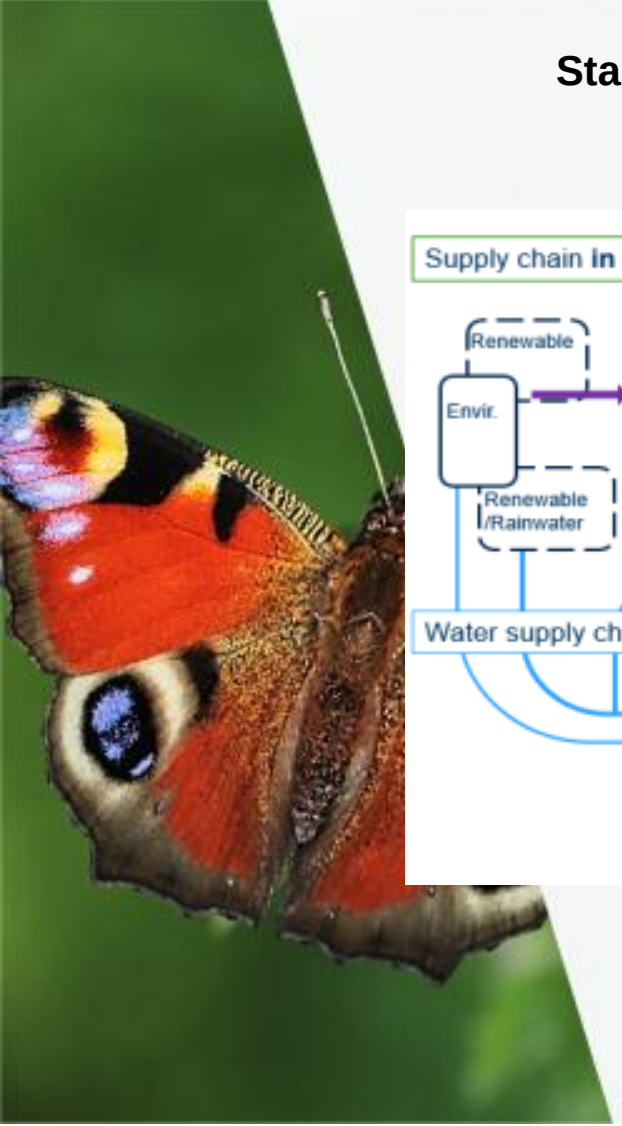

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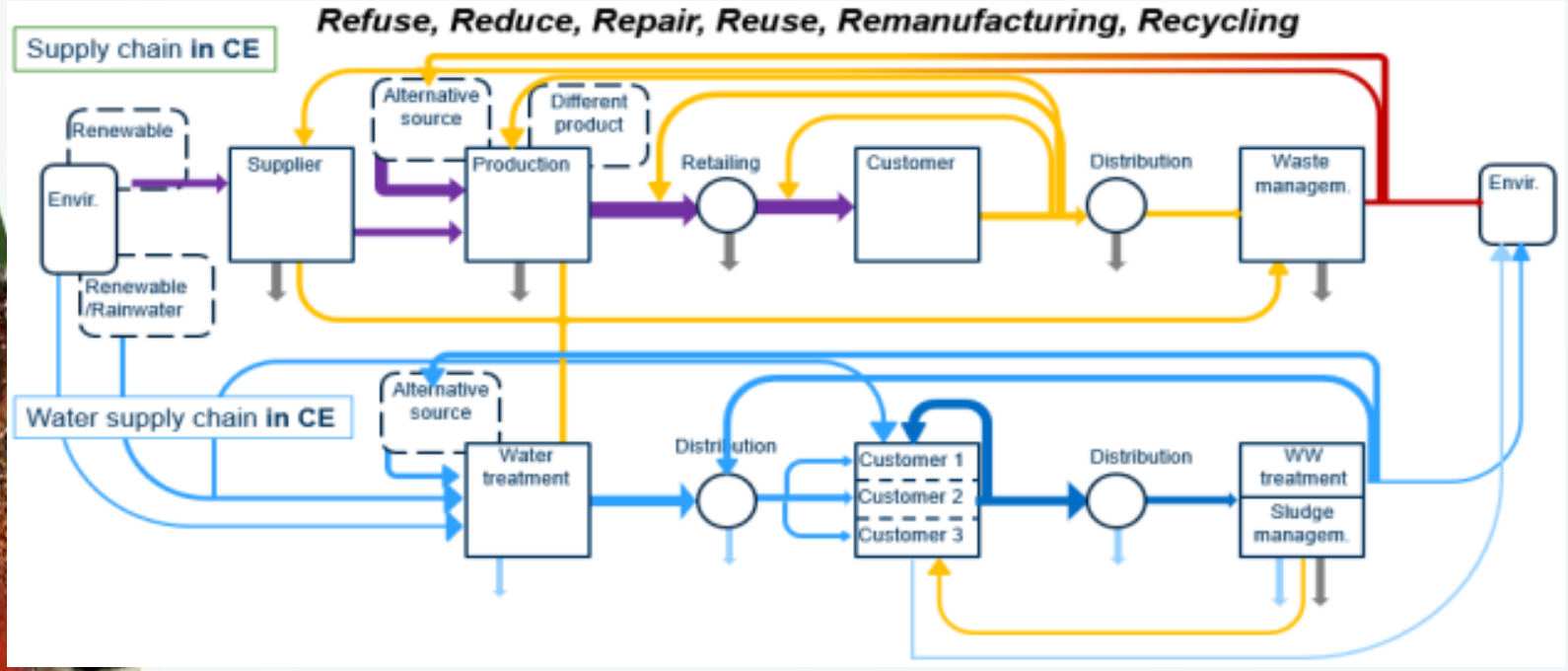

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Standardisation of circularity measurement, indicators & assessment

Summary of findings

Focus of the new ISO

Manufacturing sector & upstream side of the supply chain (suppliers & producers):

Source selection of primary & secondary raw materials

Responsibility & prediction of product fate based on design & specifications

Water Suppliers:

Restricted source selection: natural, physical/local, regulatory issues

Water quality changes with consecutive uses, fate depends on user and/or WWTP

Stress on **infrastructure**, **user awareness**, **WWTPs**

Provided definitions for CE-related terms

Need for flows characterisation to apply the definitions

Importance of natural environment <u>but</u> how to approach it is unclear

Natural environment: inherent to water sector → water is local & watershed needs to be considered

Preliminary list of potential circularity indicators

Not enough for water: water specificities & important aspects are not depicted in the indicators

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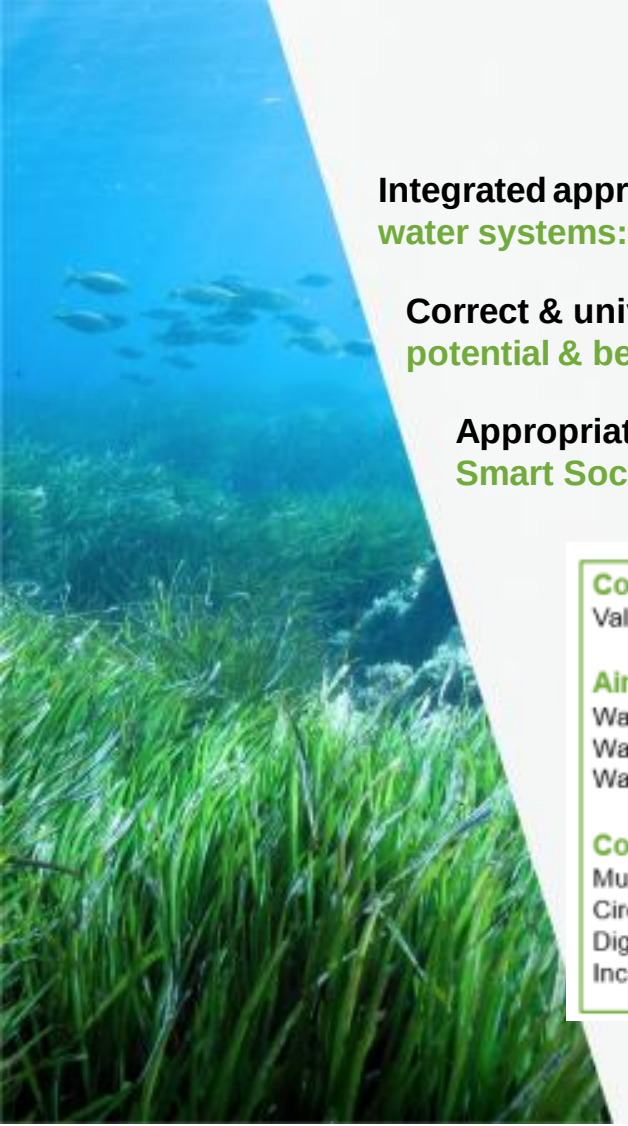

Where do we need to put our focus on water systems?

Integrated approach to circular water management → natural environment & anthropogenic water systems: *how to approach?*

Correct & universal characterisation of water & water-related flows → unlock circularity potential & benchmark

Appropriate indicators in accordance with CE principles & Water Europe's Vision for Water Smart Society:

Core Value:
Value of Water

Aims & Challenges:
Water Security
Water Safety
Water Sustainability

Concepts driving solutions:
Multiple waters (allocation)
Circular water (loops)
Digital water (management)
Inclusive water (governance)

→

UN's standards:
1. Availability
2. Accessibility
3. Affordable
4. Acceptability
5. Quality & safety

+

ISO's CE principles:
1. Systems thinking
2. Value creation
3. Value sharing
4. Resource Availability focus
5. Ecosystem Resilience
6. Resource Traceability

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Conclusions

The new ISO:

- Standardized definitions
  - Appropriate characterization of flows to apply standardised definitions in water systems
- Standardised methods & approaches
  - Issues on local nature of water & watershed consideration for a standardised approach
  - Lack of standardised methods for natural environment & water valuation
- Standardised circularity & sustainability indicators
  - Lack of standardised indicators covering all important aspects of water systems

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Our next actions

Focus on WWTPs & resource recovery facilities:

- ✓ **Characterization of streams:** renewable vs non-renewable; recoverable vs non-recoverable; linear vs circular
- ✓ **Application to conventional WWT processes for benchmarking**
- ✓ **Development of holistic CE assessment methodology, adapting the ISO:** circular actions, resource flow circularity, value propositions, 6 capitals (Yorkshire Water), Water Smart Societies
- ✓ **Selection of meaningful circularity & sustainability indicators**
- ✓ **Full-scale & prospective assessment**

Transferability to DWTPs & Industrial symbiosis (water and resource recovery & reuse)

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Thank you ☺

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