

Digital environment: the role of data analytics and AI



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**The Smart Water Industry
is no longer a choice....it's
a must**



Powered by

xylem
Let's Solve Water

A Green Future: Our 25 Year Plan to
Improve the Environment



Constructing a digital environment

Vision: To utilise **emerging technologies**, techniques and tools, to more accurately monitor the environment, **enabling** cutting edge research.

NERC-led initiative, with EPSRC and Defra

To provide end-users with more **integrated information** at improved temporal and spatial resolutions to deliver **solutions** to environmental challenges (both acute and long-term)

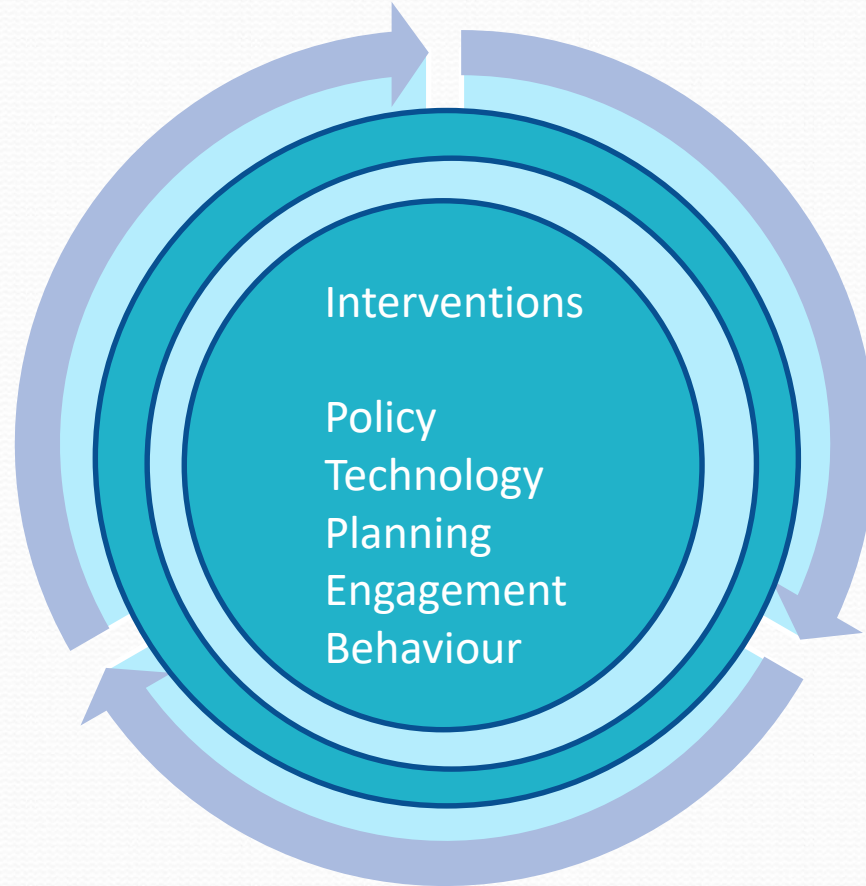
Investment of £10.4 million over the financial years 2018-2019 to 2021-2022

NERC

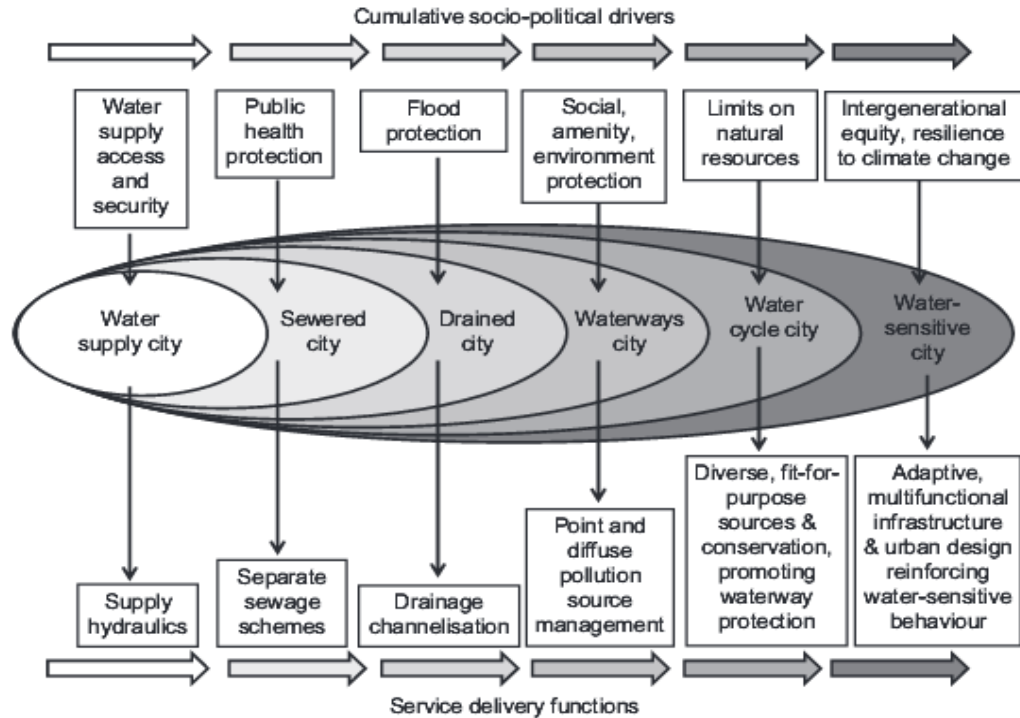
SCIENCE OF THE
ENVIRONMENT

UKRI Strategic Priorities Fund:
Constructing a Digital Environment

Environmental intelligence



Evolution of Urban Water Systems



Water wise city?

Smart city?

Resilient city?

Sponge City?

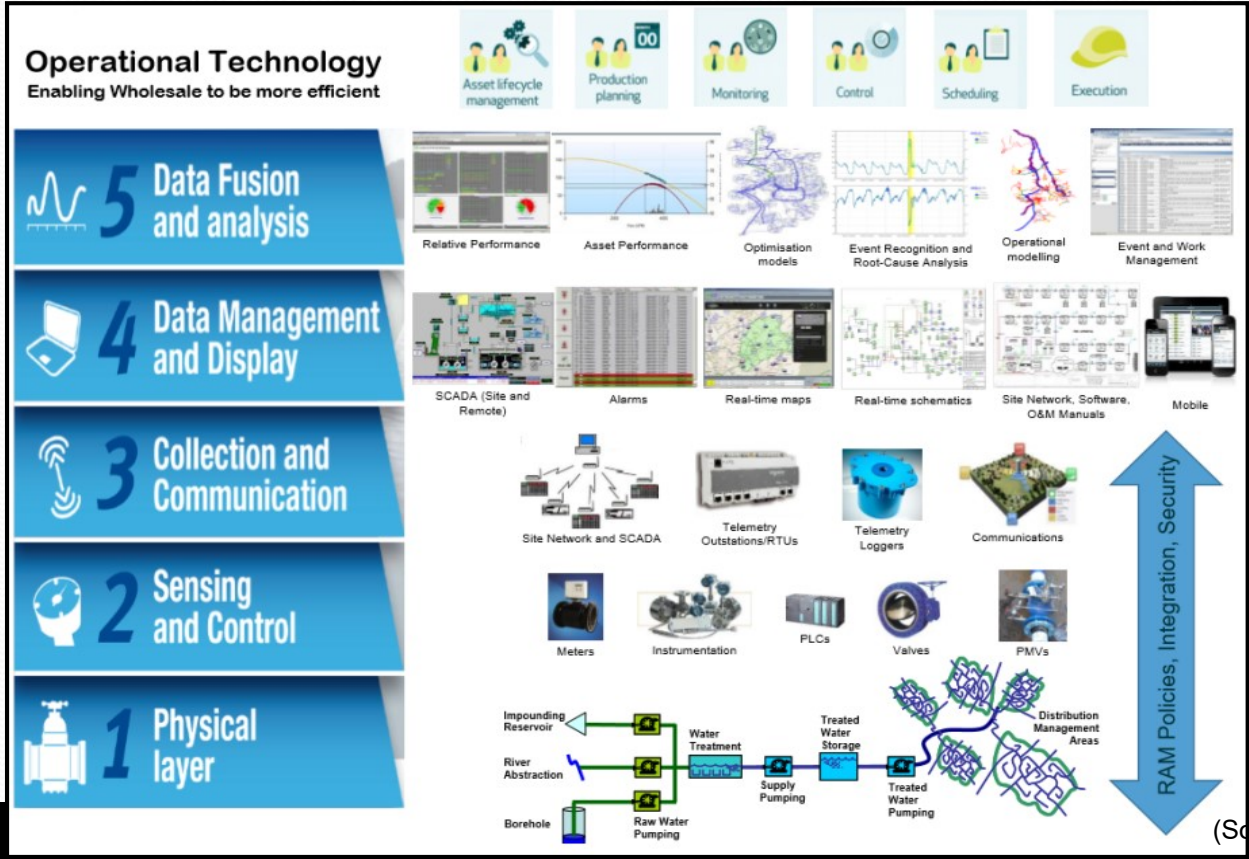
Blue-green city?

... ..

Water sensitive city?

(Ashley et al., 2013)

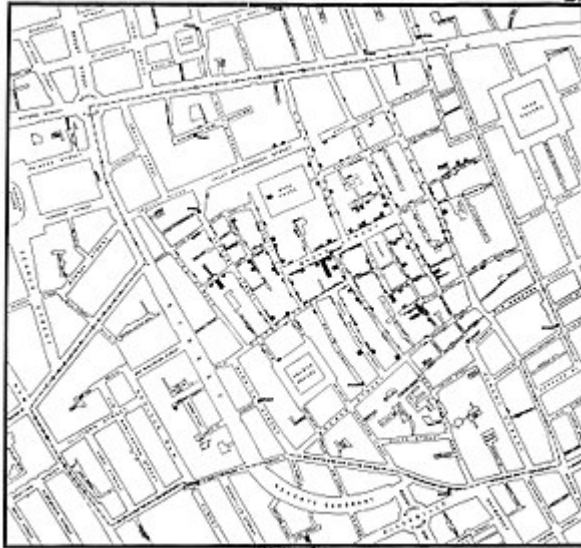
ICT and Data analytics



(Source: United Utilities)

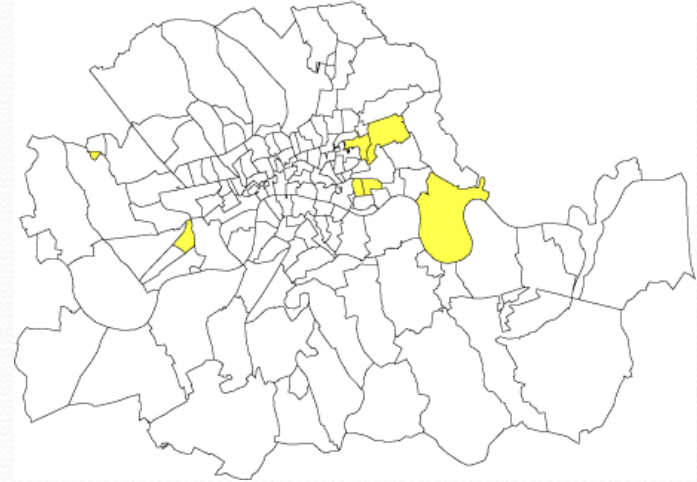
Data Driven Approach

John Snow (1813 – 1858)



Soho cholera outbreaks in 1854

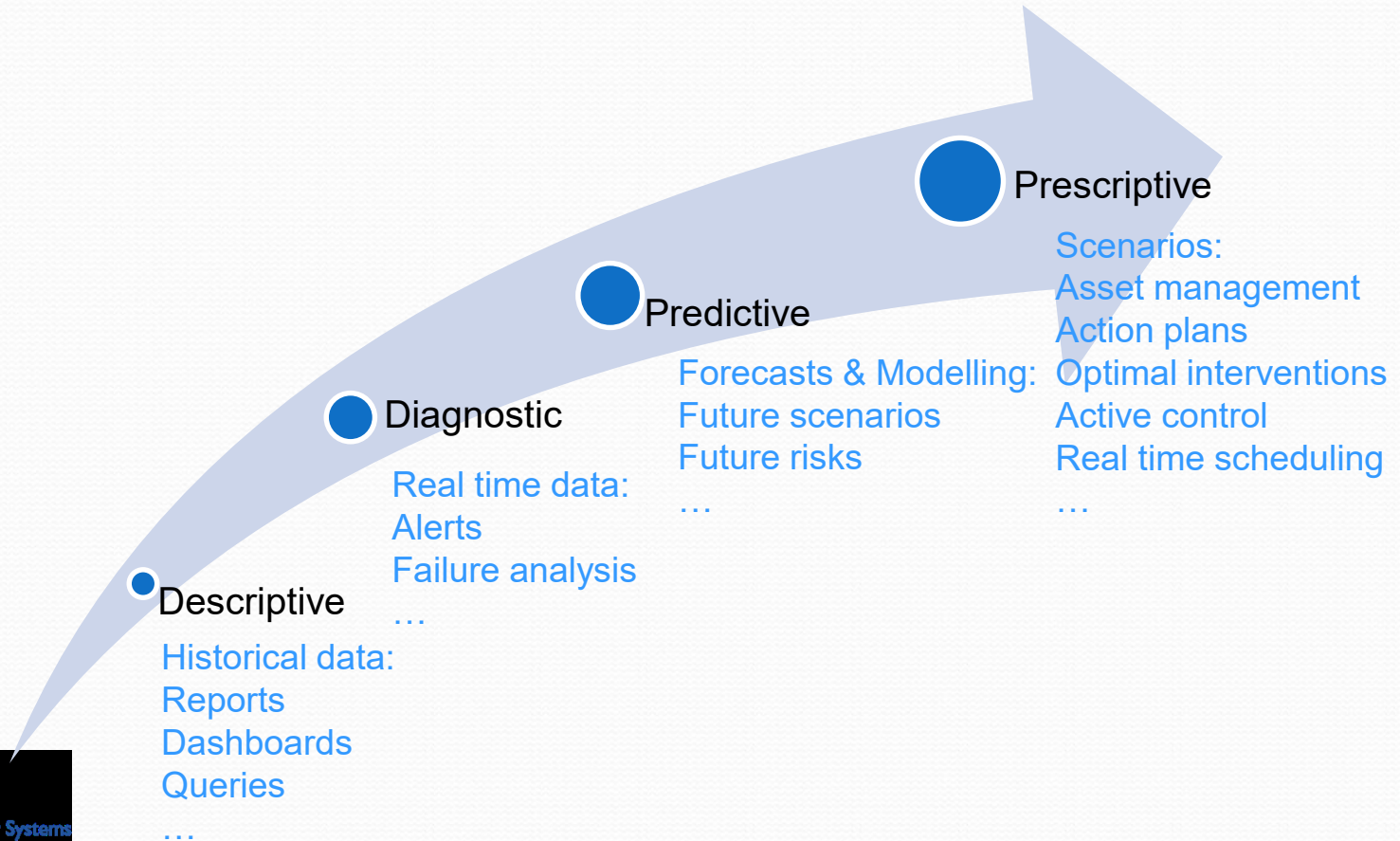
19/7 to 26/7



Bromley cholera outbreak in London in 1866

(Wikipedia)

Data and Decision Analytics



Algorithms

Signal analysis

- Filtering
- Outlier detection
- Statistical process control
- Auto-correlation
- Spectrum analysis
- ...

Statistical analysis

- Multivariate regression
- Principle component analysis
- ANOVA
- ...

AI

- Artificial Neural networks
- Evolutionary algorithms
- Genetic programming
- ...



Seconds

Minutes

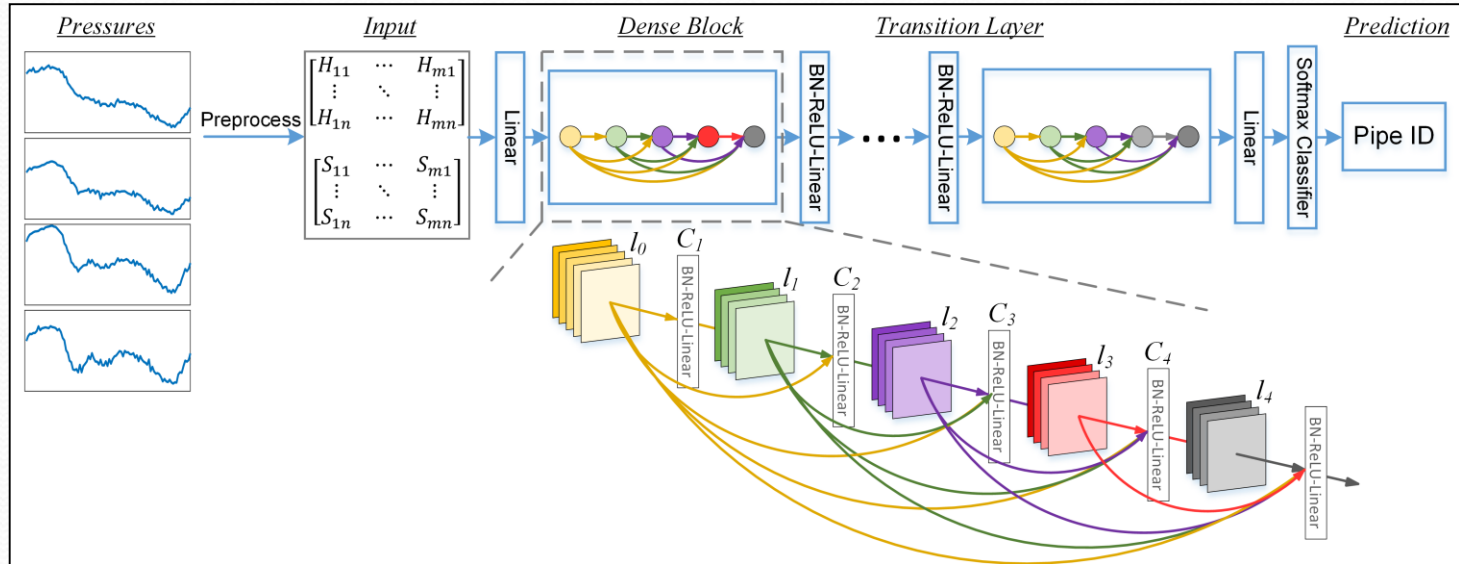
Hours

Days

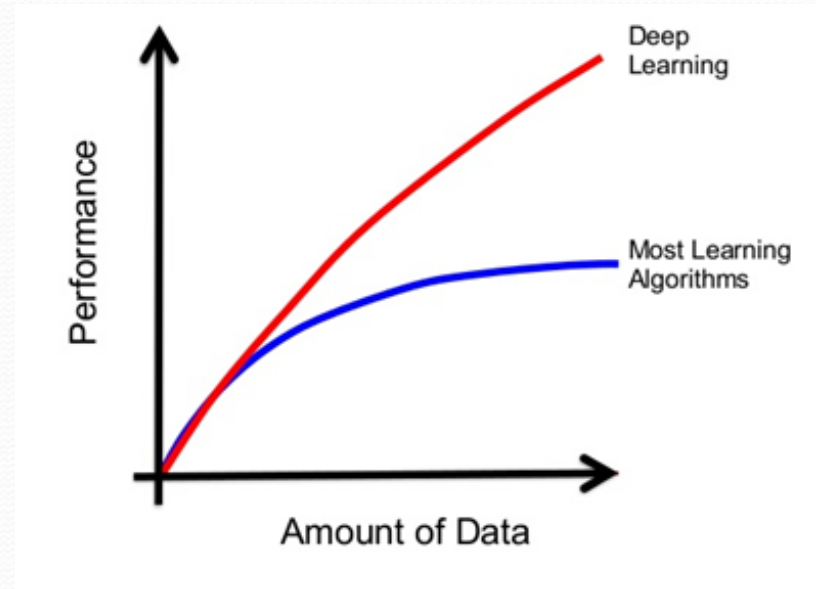
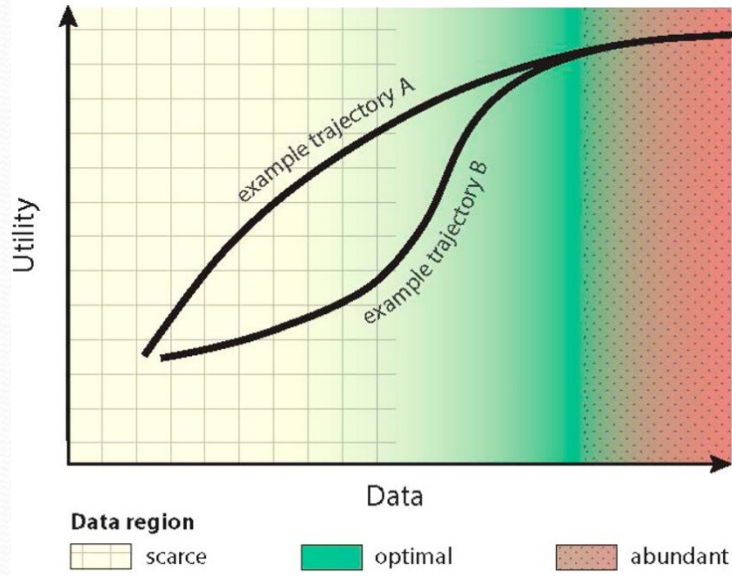
Months

Years

Leakage detection and localisation



The Utility of Data

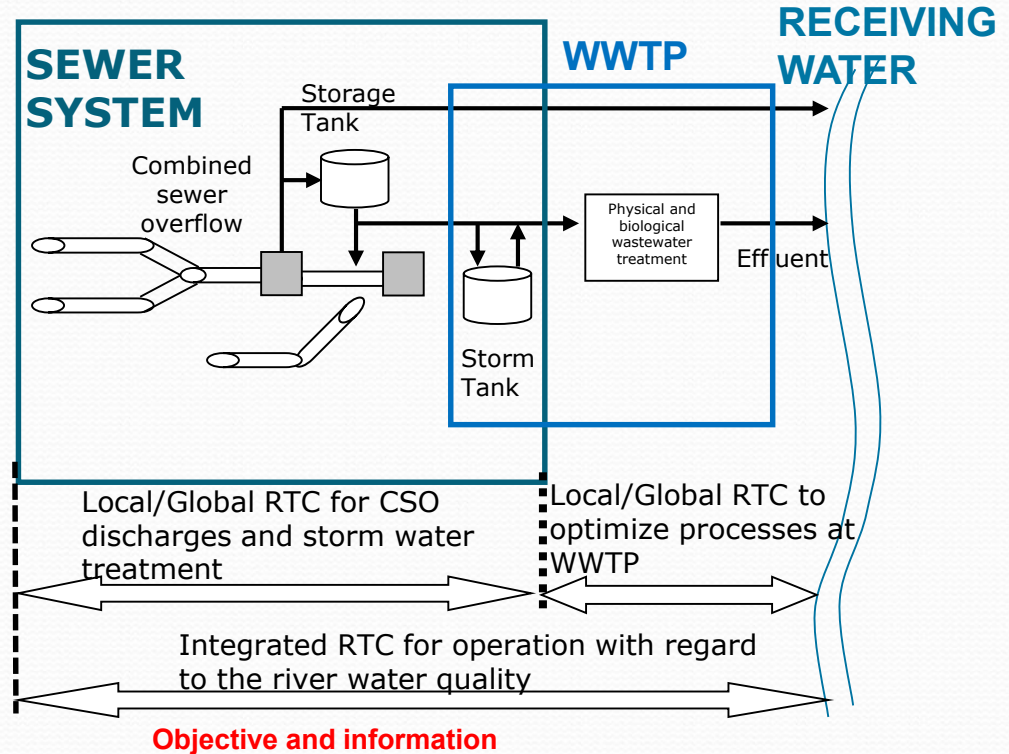


(Eggimann et al., ES&T, 2017)

Integrated control

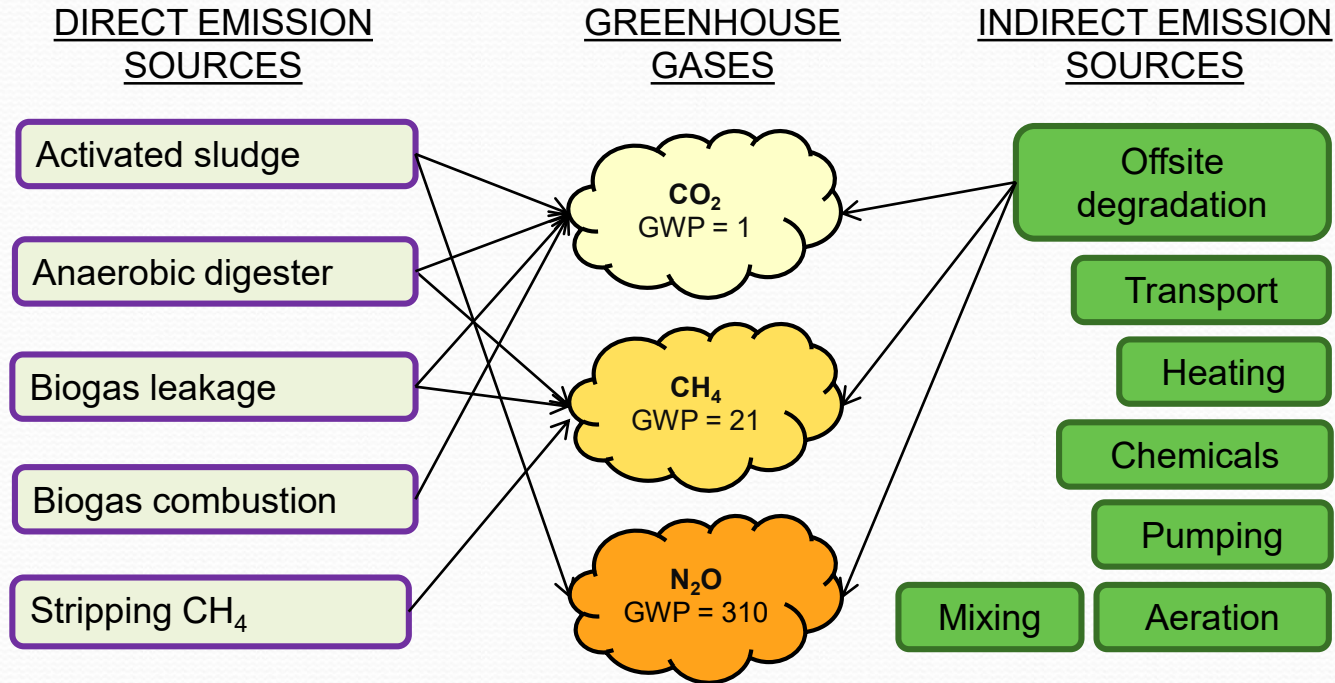
Previous work:

- **Chris Sweetapple:** GHG emissions; resilience analysis
- **Fanlin Meng:** operational permits; real time control; cost-benefit analysis
- **Maryam Astaraiie-Imani:** Combined impacts of urbanisation and climate change
- **Arturo Casal-Campos:** grey vs. green; reliability, resilience and sustainability; robust adaptation pathways
- **Biniam Arshagre:** Integrated & case studies

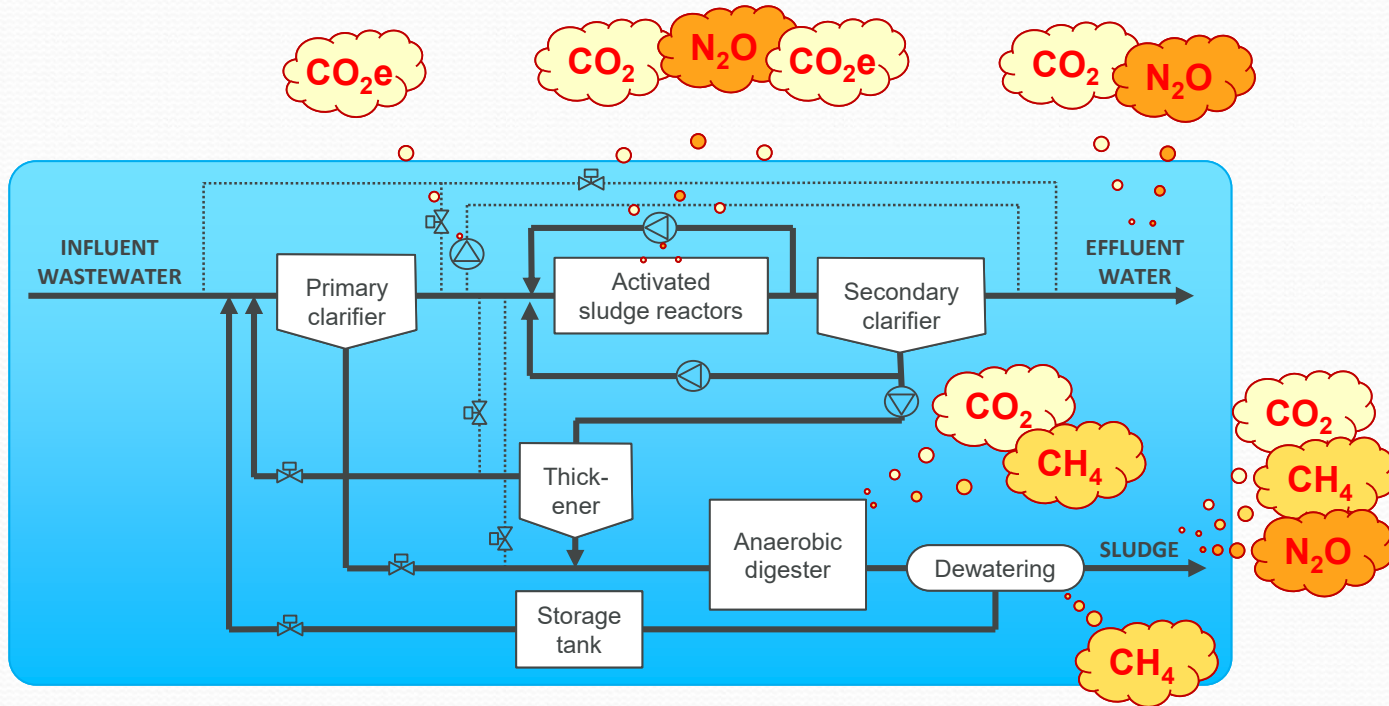


Global Control - WWTP

Sources of GHG emissions



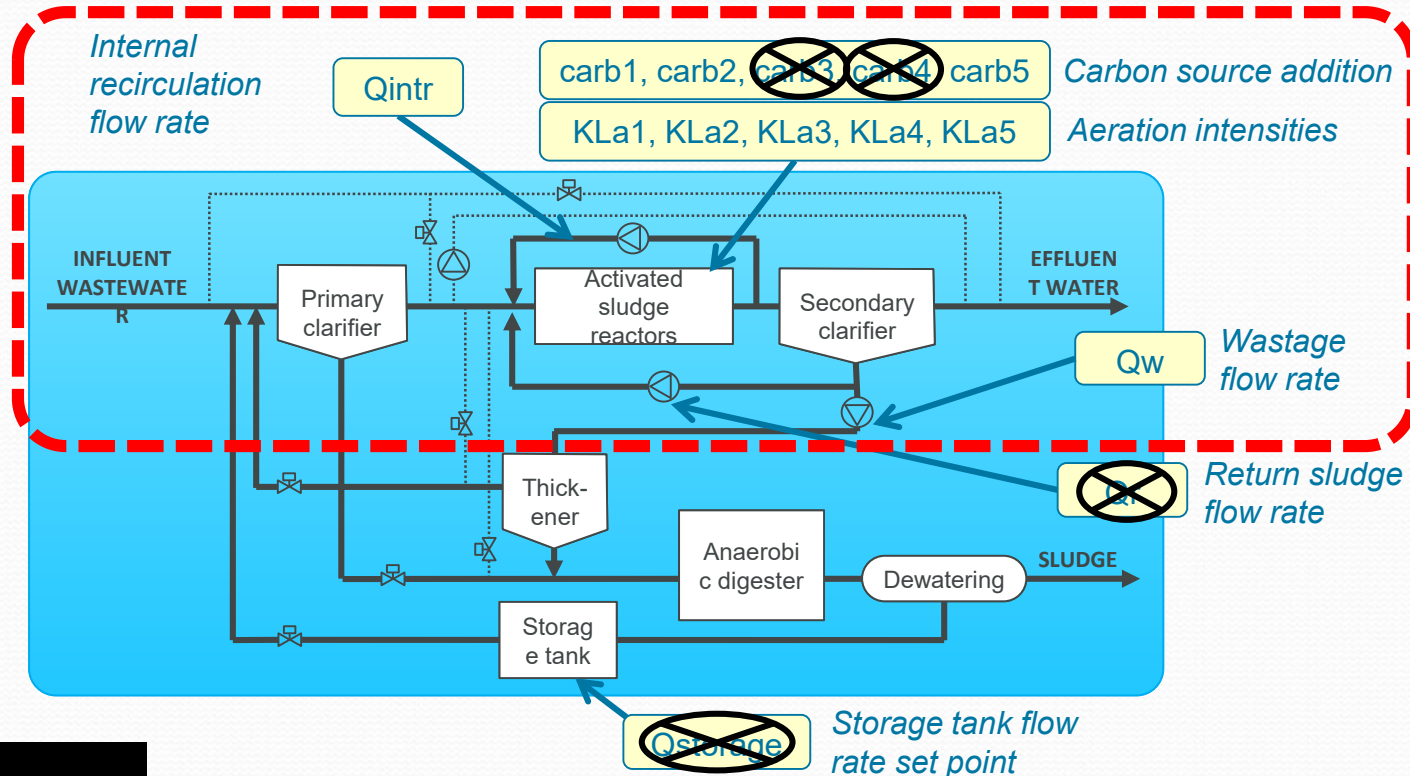
BSM



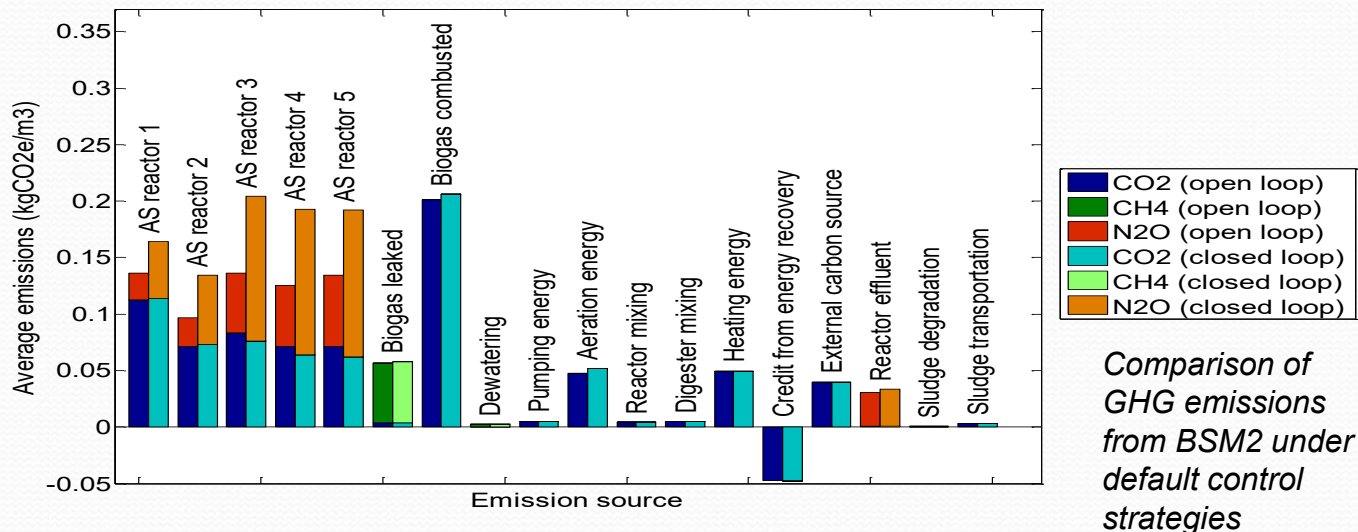
Modelled WWTP layout and sources of GHG emissions

Area containing key operational parameters and with greatest potential for improvement with regard to emissions

Available control handles



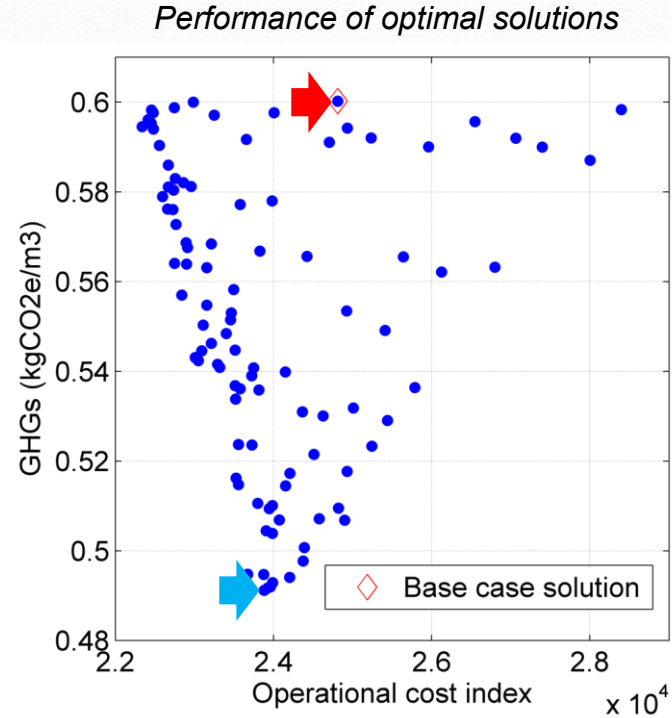
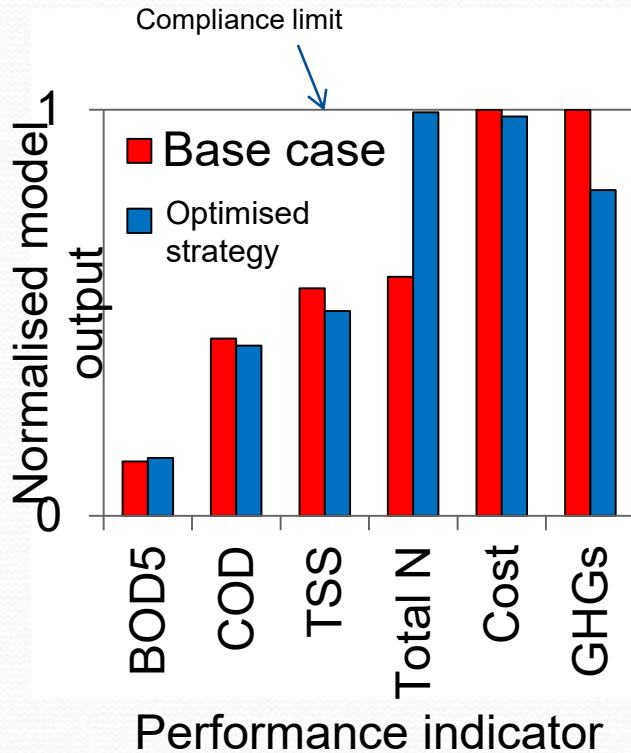
GHG emissions



Control strategy	EQI (-)	OCI (-)	GHGs (kg CO ₂ e/m ³)
Open loop	6366	9102	1.077
Closed loop	5722	9472	1.350

(Sweetapple et al. 2013, Water Research)

Legislative compliance

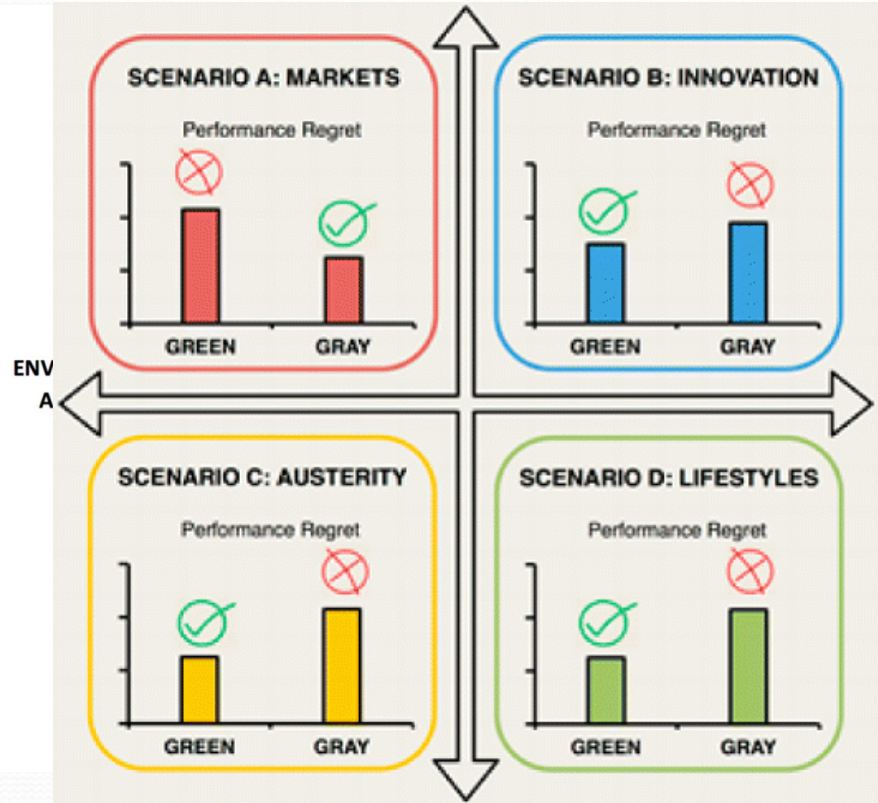
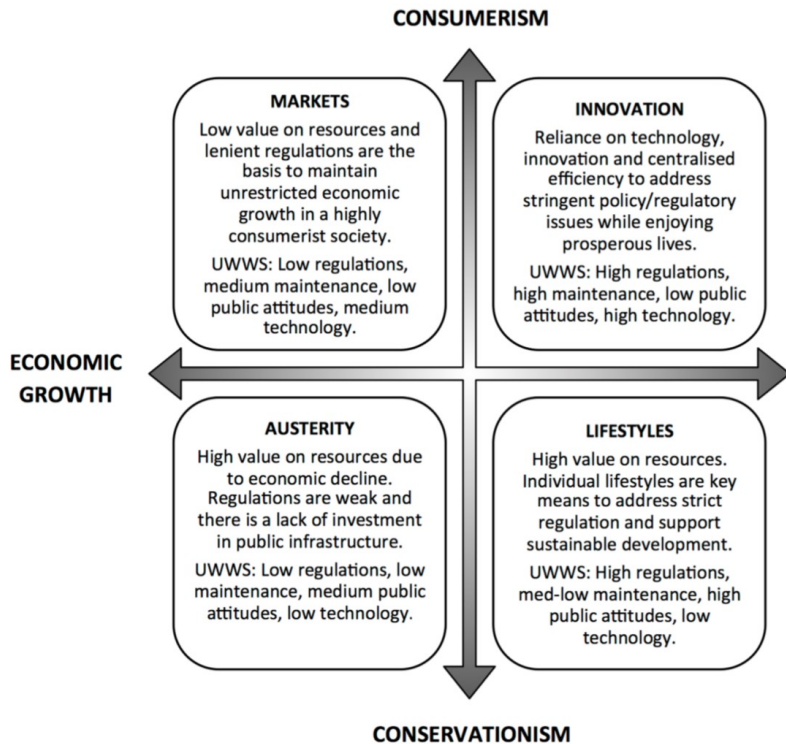


Integrated management: GI



*There is an **established technical understanding** of many new and existing technologies, particularly **at a site scale**.*

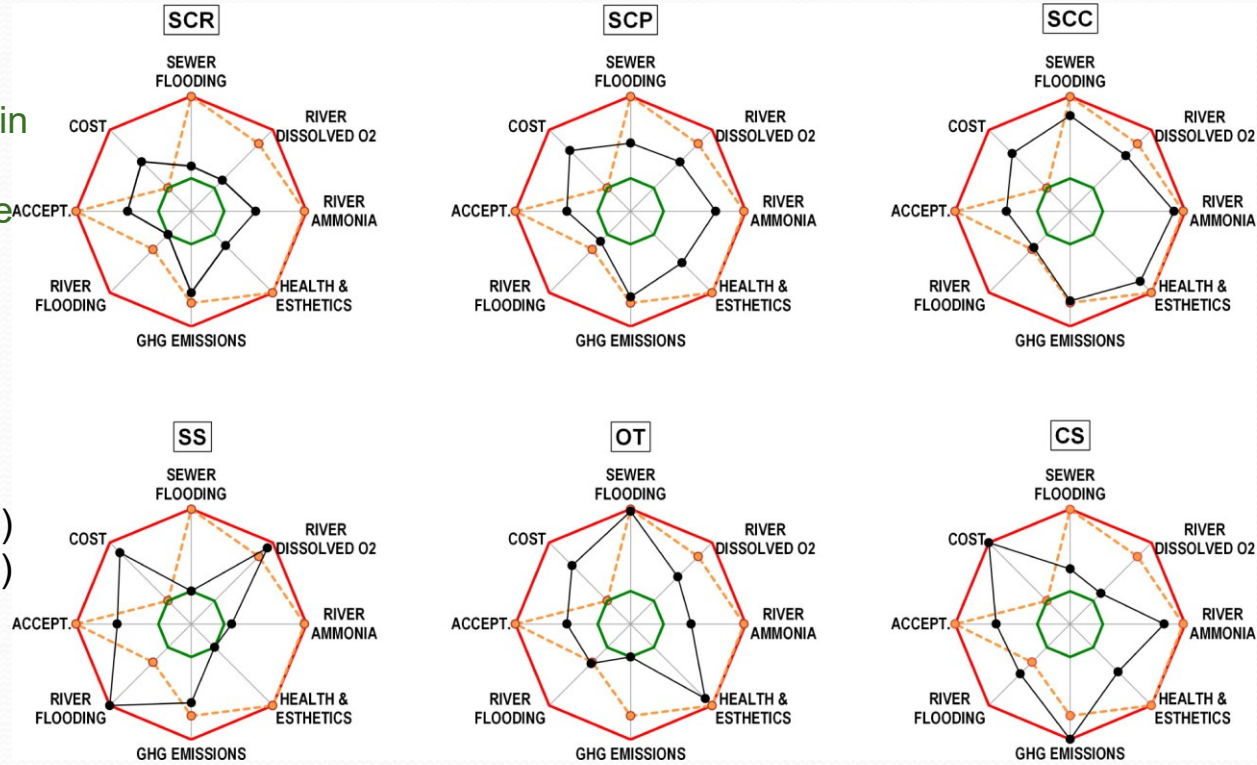
Integrated management: future scenarios



Green vs. grey strategies

Green strategies:

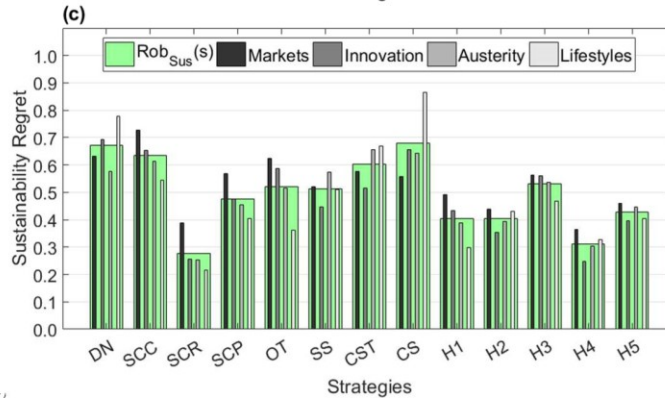
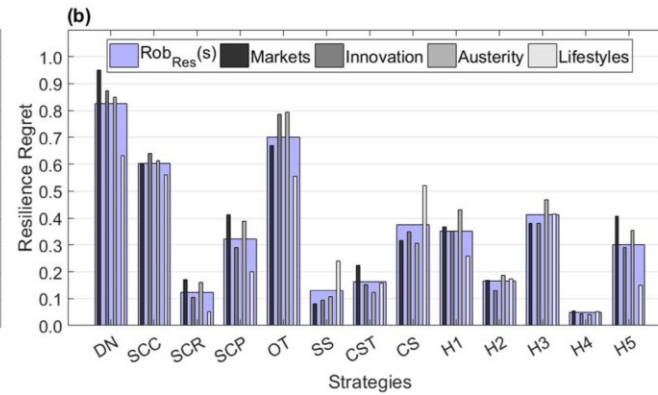
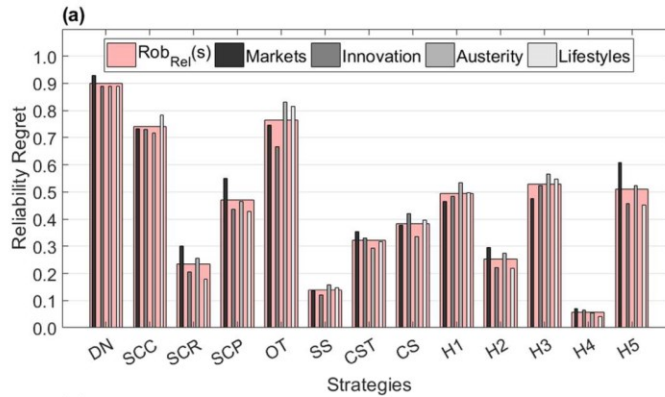
- Roof disconnection/rain gardens (SCR)
- Bioretention for source control of Pavements (SCP)
- Permeable pavement (SCC)



Grey strategies:

- Sewer separation (SS)
- On-site treatment (OT)
- Centralized storage (CS)

Reliability, resilience and sustainability

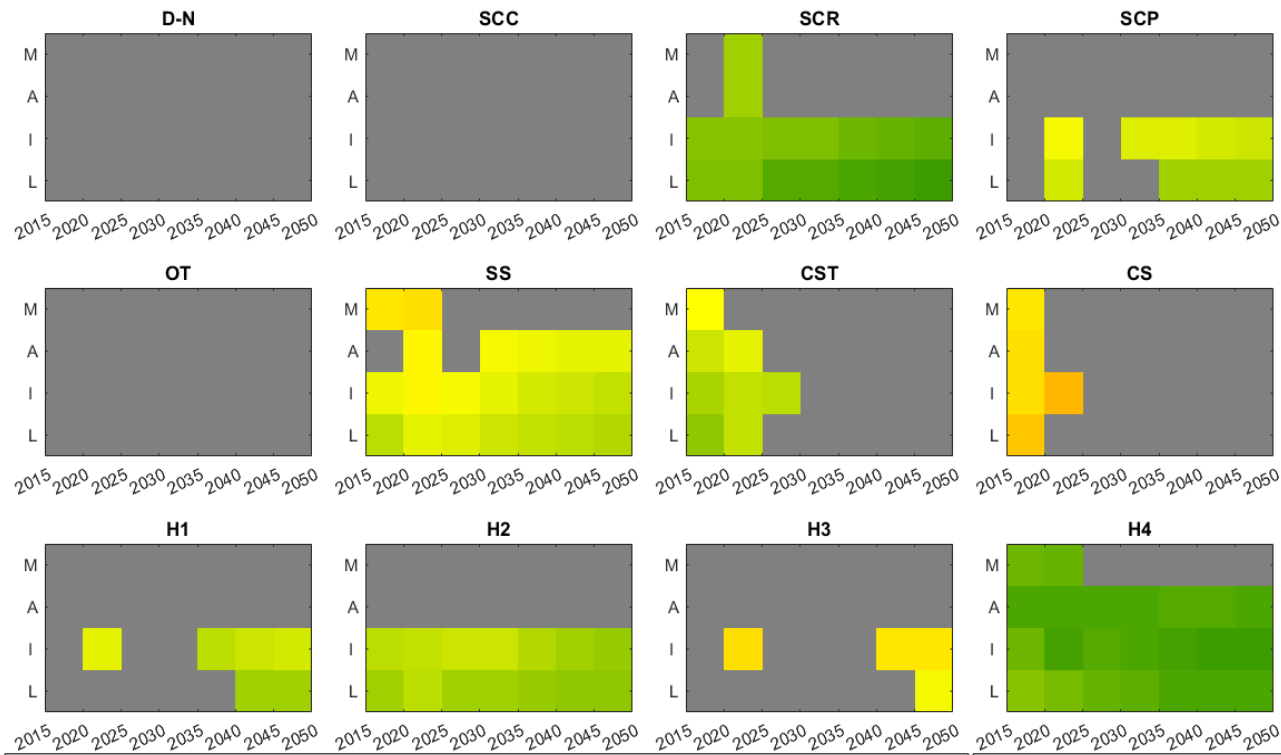


Proposed strategies:

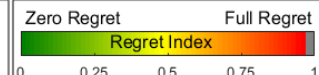
DN: do-nothing; **SCC:** permeable pavement; **SCP:** bio-retention planters; **SCR:** rain gardens; **SS:** sewer separation; **CST:** improved sewer capacity and a new storage tank; **CS:** improved sewer capacity only; **OT:** on-site wastewater treatment; **H1:** SCR + OT; **H2:** SCR + SS; **H3:** SS + OT; **H4:** SCR + CS; **H5:** SCR + CST (strategy without sewer pipe rehabilitation).

Adaptation pathways

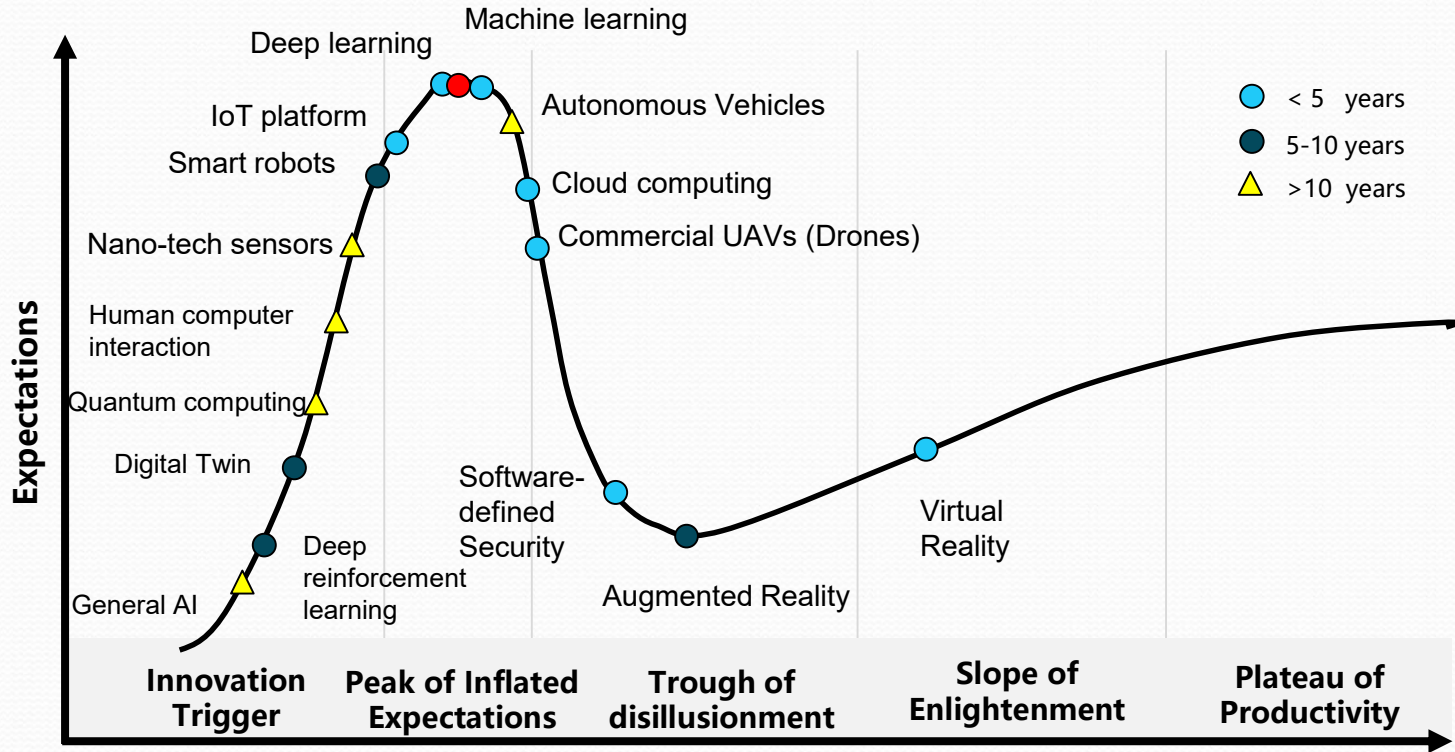
Reliable, resilient and sustainable domains for sewer flooding and CSO adaptation thresholds



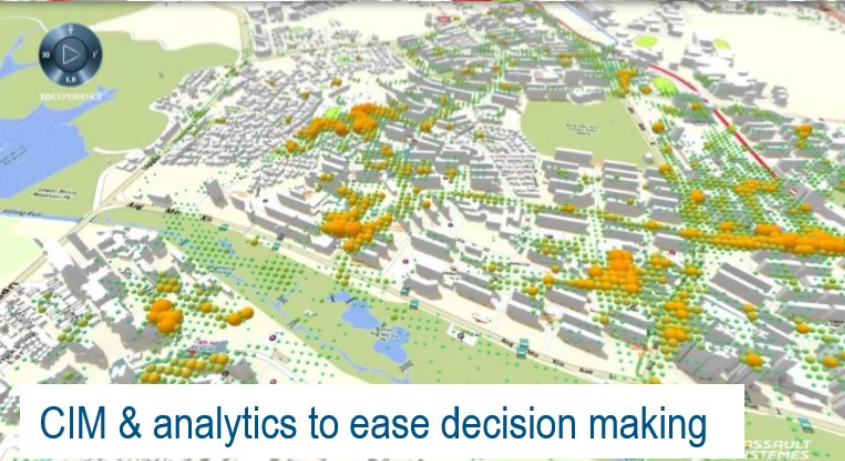
Scenarios [M: Markets; A: Austerity; I: Innovation; L: Lifestyles] - Strategies [D-N: do-nothing; SCR: roof gardens; SCC: permeable pavement; SCP: bio-retention planters; SS: sewer separation; CST: improved sewer capacity & storage tank; CS: improved sewer capacity; OT: on-site treatment; H1: SCR+OT; H2: SCR+SS; H3: SS+OT; H4: SCR+CS]



Gartner Hype Cycle



Digital Twin: Virtual Singapore



CIM & analytics to ease decision making

Level 1 Basic	Level 2 Opportunistic	Level 3 Systematic	Level 4 Differentiating	Level 5 Transformational
<ul style="list-style-type: none"> Data is not exploited, it is used D&A is managed in silos People argue about whose data is correct 	<ul style="list-style-type: none"> IT attempts to formalize information availability requirements Progress is hampered by culture; inconsistent incentives 	<ul style="list-style-type: none"> Different content types are still treated differently Strategy and vision formed (five pages) 	<ul style="list-style-type: none"> Executives champion and communicate best practices 	<ul style="list-style-type: none"> D&A is central to business strategy
<ul style="list-style-type: none"> Analysis is ad hoc Spreadsheet and information firefighting Transactional 	<ul style="list-style-type: none"> Organizational barriers and lack of leadership Strategy is over 100 pages; not business-relevant Data quality and insight efforts, but still in silos 	<ul style="list-style-type: none"> Agile emerges Exogenous data sources are readily integrated Business executives become D&A champions 	<ul style="list-style-type: none"> Business-led/ driven, with CDO D&A is an indispensable fuel for performance and innovation, and linked across programs Program mgmt.. mentality for ongoing synergy Link to outcome and data used for ROI 	<ul style="list-style-type: none"> Data value influences investments Strategy and execution aligned and continually improved Outside-in perspective CDO sits on board

D&A = data and analytics; ROI = return on investment

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Conclusions

- **Digitalization of the environment**
 - Embedded in planning, design, operation and management
 - Links environment, infrastructure, people and decision making
 - Data are useful but should be used with care
 - AI is great...for now remains just a hopeful promise...

Digital environment: the role of data analytics and AI

Thank you!

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