

Sustainability and AI: The Environment

18th Singapore Economic Policy Forum, 2026

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SUSTAINABLE DEVELOPMENT GOALS



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Source: Blogs@NTU

Some common themes...



Source: PUB

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Pollution presents a significant obstacle to achieving these goals

- Pollution: presence of undesirable material in air, water, in quantities large enough to produce harmful effects



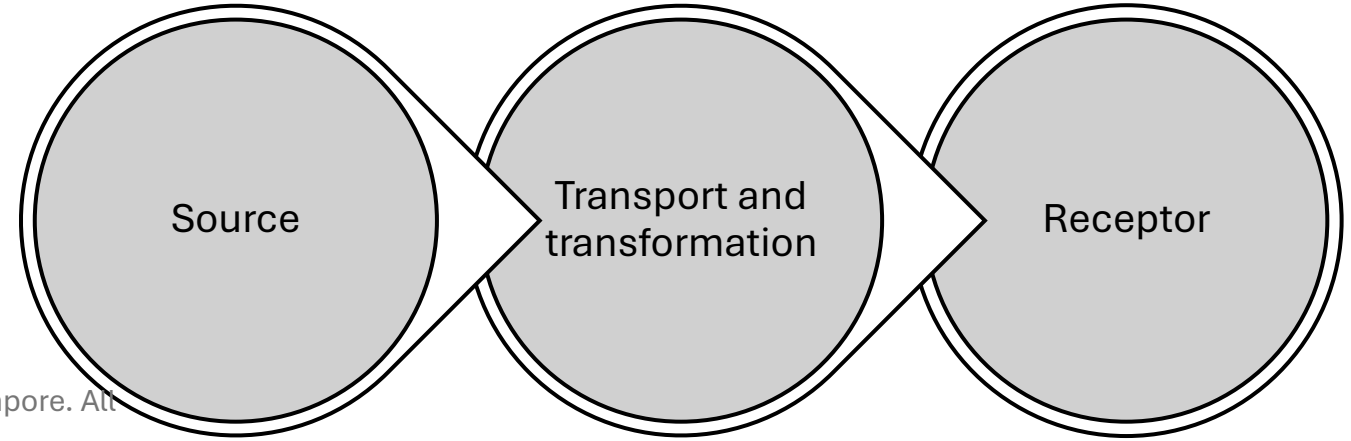


Source: The Atlantic, BBC

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Pollution control

- To effectively implement pollution control measures
  - Need to be guided by rigorous analysis of pollution problem
- If we look at the pollution process, we can break it down into the following:



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Pollution control

- To put in place effective measures to control pollution from the source, we need to know:
  - How much pollutants are going to be released?
  - Where are these pollutants going to go, once they are emitted?
  - What is the projected impact on sensitive receptors due to these pollutants?
  - How effective will measures aimed at reducing emissions be, and how much should be reduced?

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Pollution control

- It is often impossible and seldom practical to address such questions by experimentation
- Models therefore have to be developed and applied to interpret observations or to make predictions
- To help inform decisions on measures to safeguard human health and to ensure a clean and green environment

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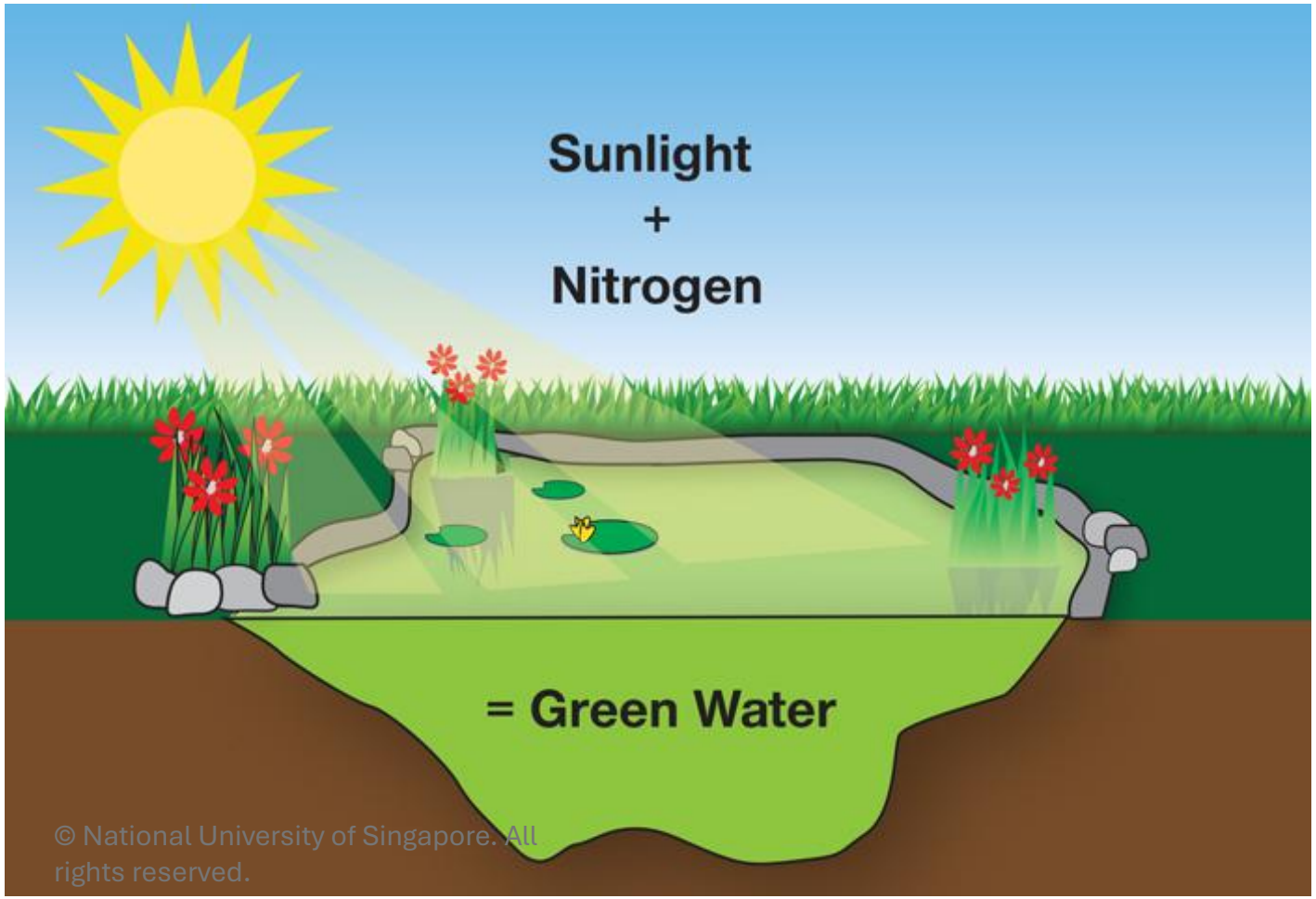
This is where models can play an important role

What are models?

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Model types

- Empirical models



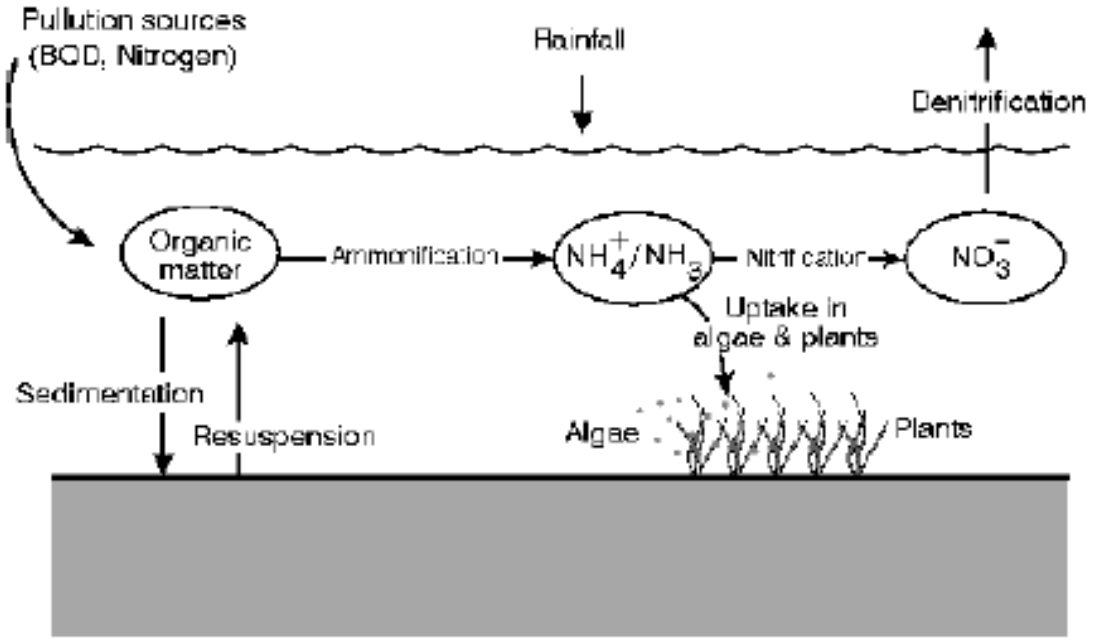
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$$algae = \beta_0 + \beta_1(nutrients) + \beta_2(sunlight)$$

Source: R2K ponds

Model types

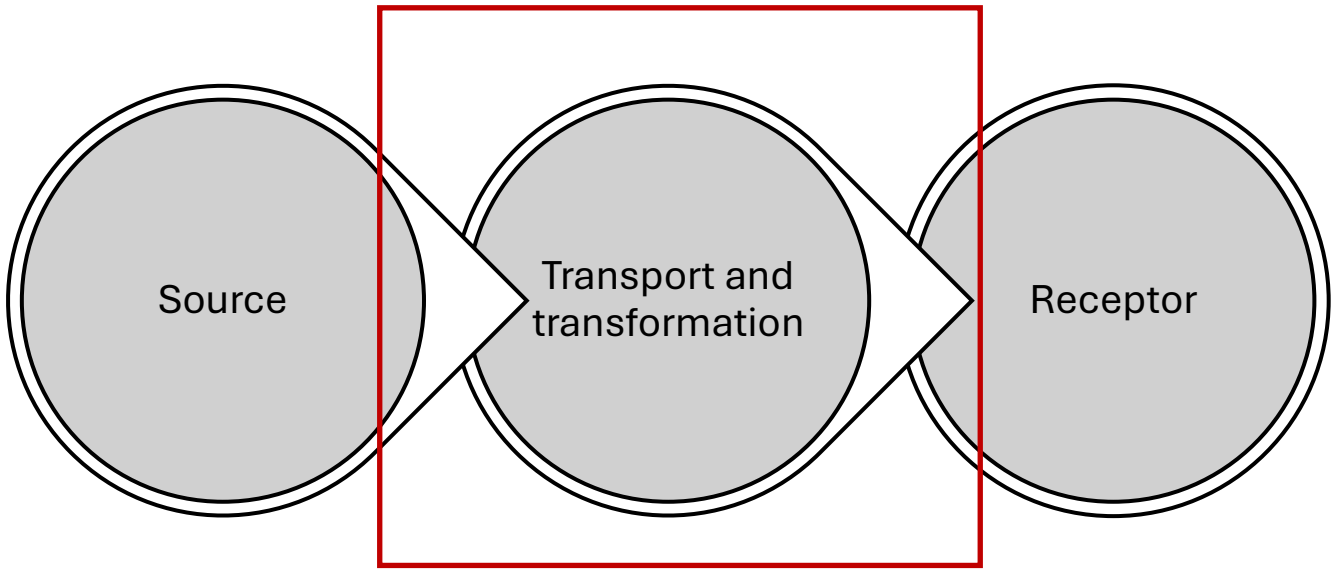
- Mechanistic models



Source: DHI

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Mechanistic vs empirical



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Data requirements

- Models require data for
  - Estimation of model parameters, e.g. regression coefficients, rate constants
  - Validation against experimental observations, i.e. is this model producing results that comport with the actual situation in the field?

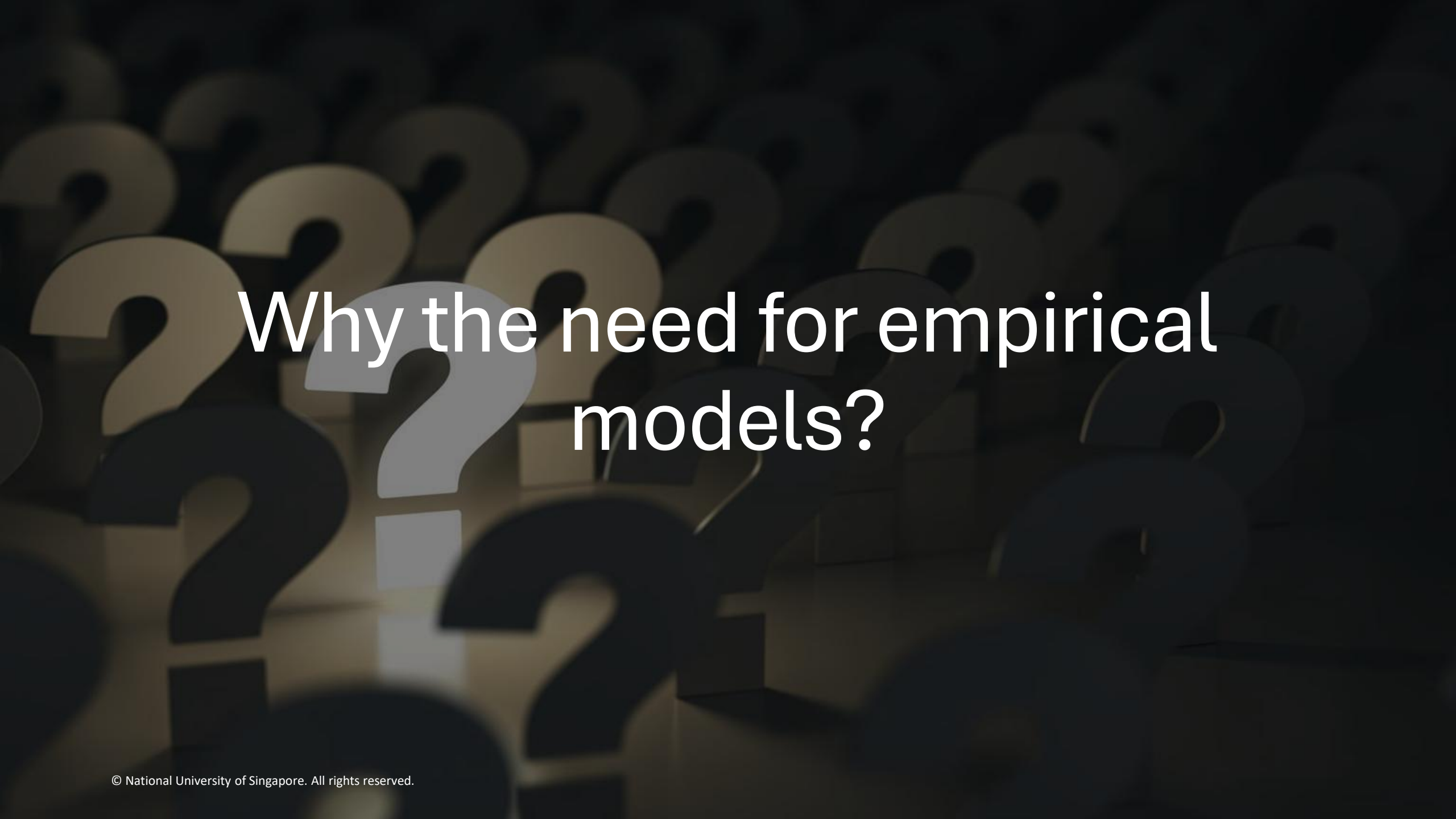
- Therefore, data is also critical, when it comes to modelling for sustainability, e.g. pollution control

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Mechanistic – be all and end all?

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Why the need for empirical models?

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Data requirements

The proliferation of data due to the advent of the internet might make it seem that data required for models are “easy to come by”

However, there is disparity in the types of data that are available (Jimeno-Saez et al, 2018)

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Empirical models

Just because they are empirical doesn't necessarily mean that they are inferior

These models can still give useful predictions

Provide *some* insight into the phenomenon, e.g. main players

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AI models

- And that's where AI empirical models come in
- These days, when AI is mentioned, attention is invariably centred on generative AI, Large Language Models (LLMs)
- But AI goes beyond LLMs, and machine learning (deep learning) models can yield predictive benefits for environmental problems



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Source: Wikipedia

Terminology



AI

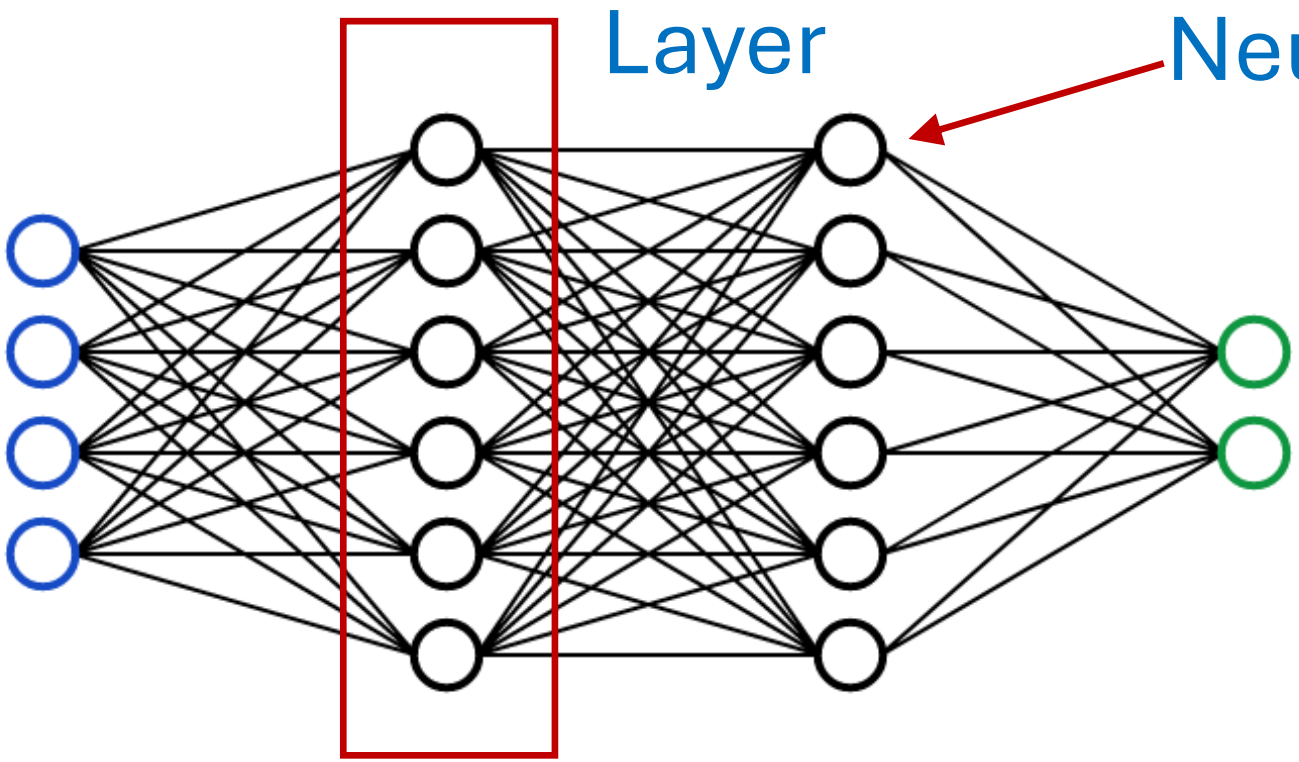


MACHINE LEARNING



DEEP LEARNING

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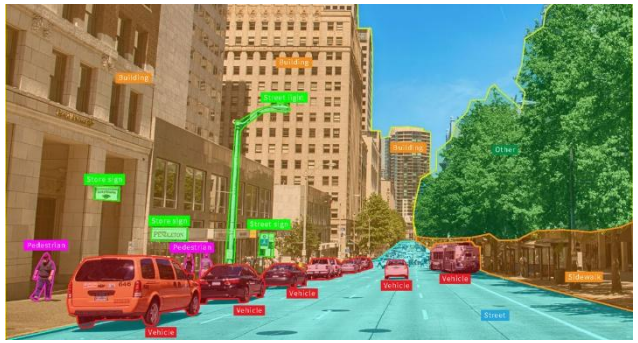


- We can think of each neuron as a worker, working to make sense of the inputs coming in, and passing along what it has learned to other workers
- So that ultimately, we can predict what our desired outputs are

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Achievements of deep learning…

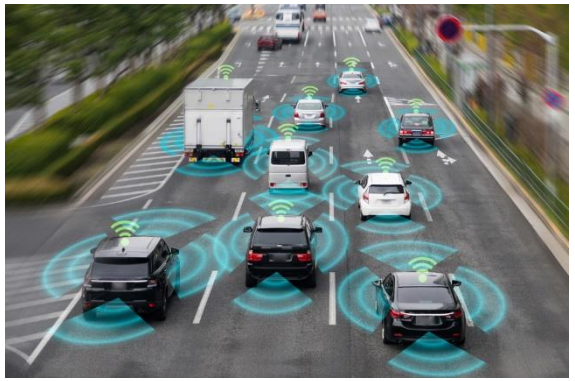
Digital assistants,
e.g. Google Assistant,
Amazon Alexa



Near human-like
image classification

ChatGPT

Ability to answer natural
language questions



Autonomous cars

Improved ad targeting

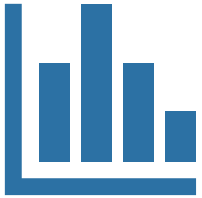
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Sources: KrAsia, Amazon, Bing, TSVC, Appen

Driving the popularity of deep learning



Hardware



Datasets and benchmarks



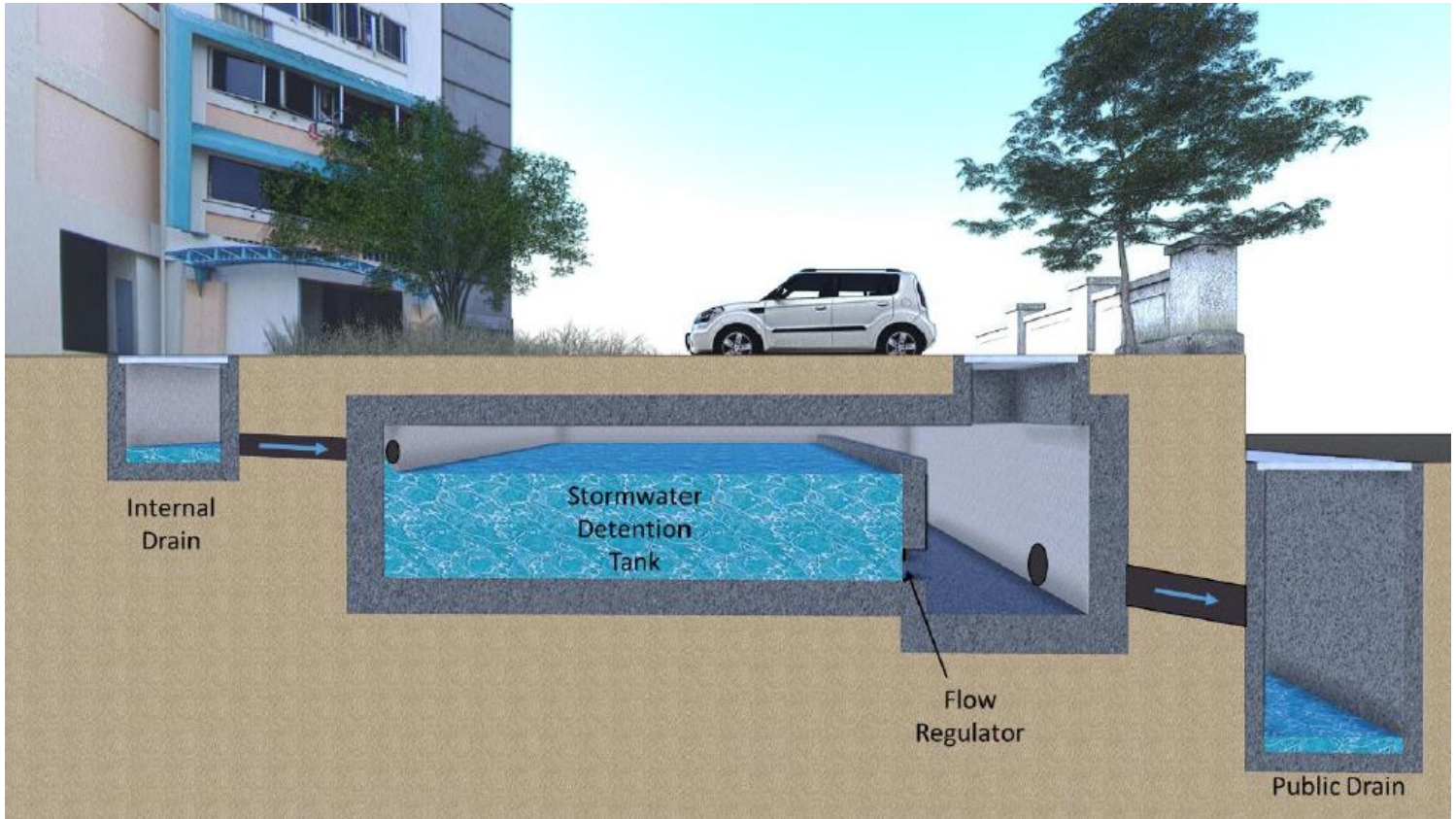
Algorithmic advances

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The possibilities are there…

- When it comes to solving sustainability problems (such as flooding) which are often described by complex non-linear relationships

Case study: Detention tank as a source solution to manage runoff

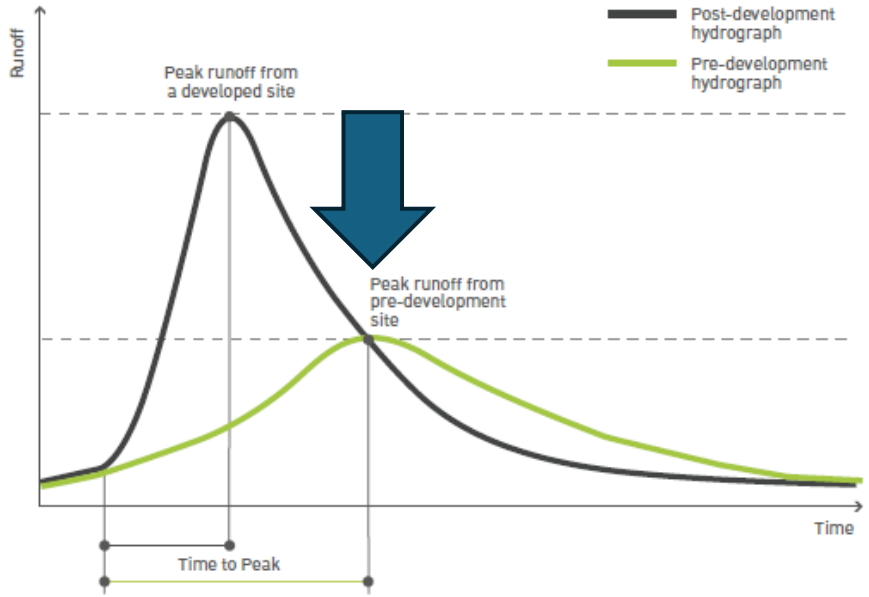


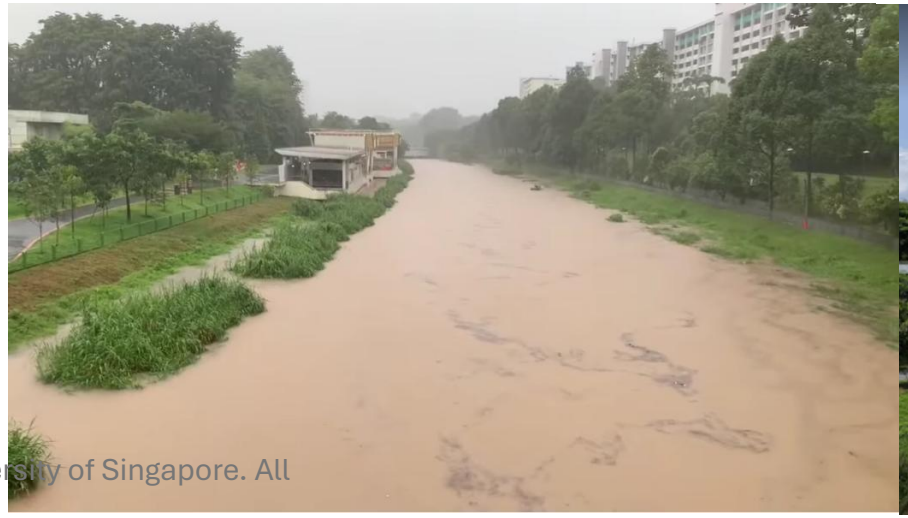
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Through such flow regulation…

- How much are we able to reduce the peak flow in our catchment outlet?

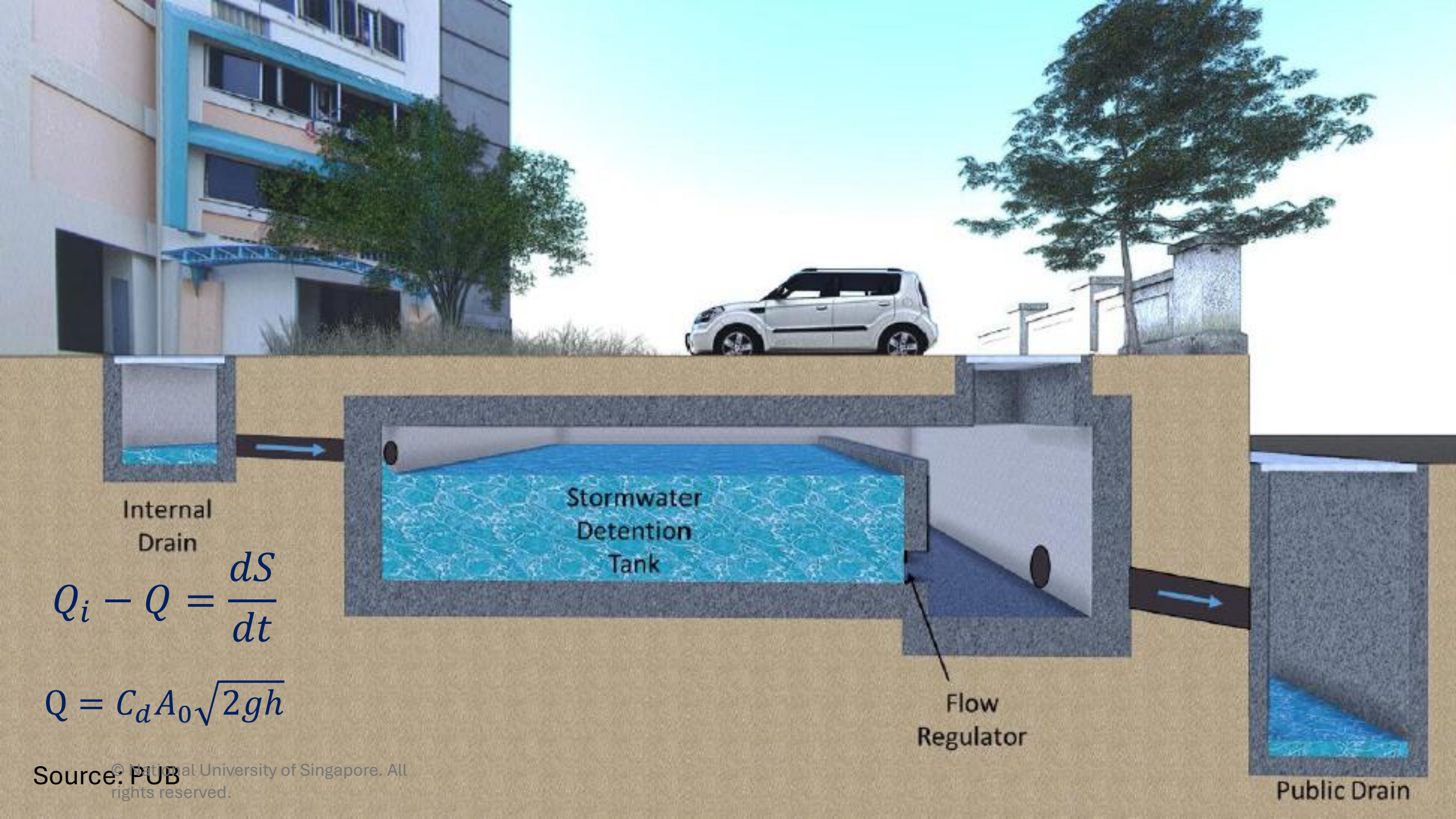






Sources: PUB, Jian Lin Lee, Straits Times

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$$Q_i - Q = \frac{dS}{dt}$$

$$Q = C_d A_0 \sqrt{2gh}$$

Source: PUB

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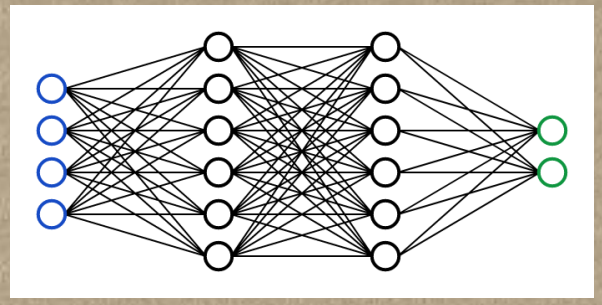
Internal Drain

Stormwater Detention Tank

Flow Regulator

Public Drain

Neural networks can serve as universal function approximators



Source: PUB

So for AI in sustainability…

- Iterative process of experimentation: tuning hyperparameters to help the model train better
- These hyperparameters though, don’t describe the actual “physicality” of the problem
- Ever more important to exercise critical thinking in the use of AI models

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Critical thinking in the age of AI



Promise of AI for sustainability is there



Flip side, thinking can be automated by AI, LLMs, which could erode critical thinking (Kosmyna et al, 2025)



Unstructured, organic learning can play an essential role

Structuring unstructured learning

- Reflective e-portfolios for providing a structured platform for students to make their own connections between classroom learning and learning experiences elsewhere

- Dewey (1933) and Rodgers (2002) – critical reflection in helping to shape the way we think and learn

- Yancey (2009) has demonstrated the promise of e-portfolios in inculcating reflective practices

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Case study

- Using an e-portfolio platform, students in my courses were tasked to upload artifacts of learning from our course and learning experiences elsewhere, make connections between these artifacts and draw insights from such connections

- E.g. students have drawn connections between AI and diverse fields including urban heat risk, dengue and even procurement

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Conclusion



AI can help us model and describe complex environmental systems



AI-generated predictions and responses still require human judgement and critical interpretation



Education has a role in developing that capacity through critical reflection

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