

類神經網路動態供水資訊

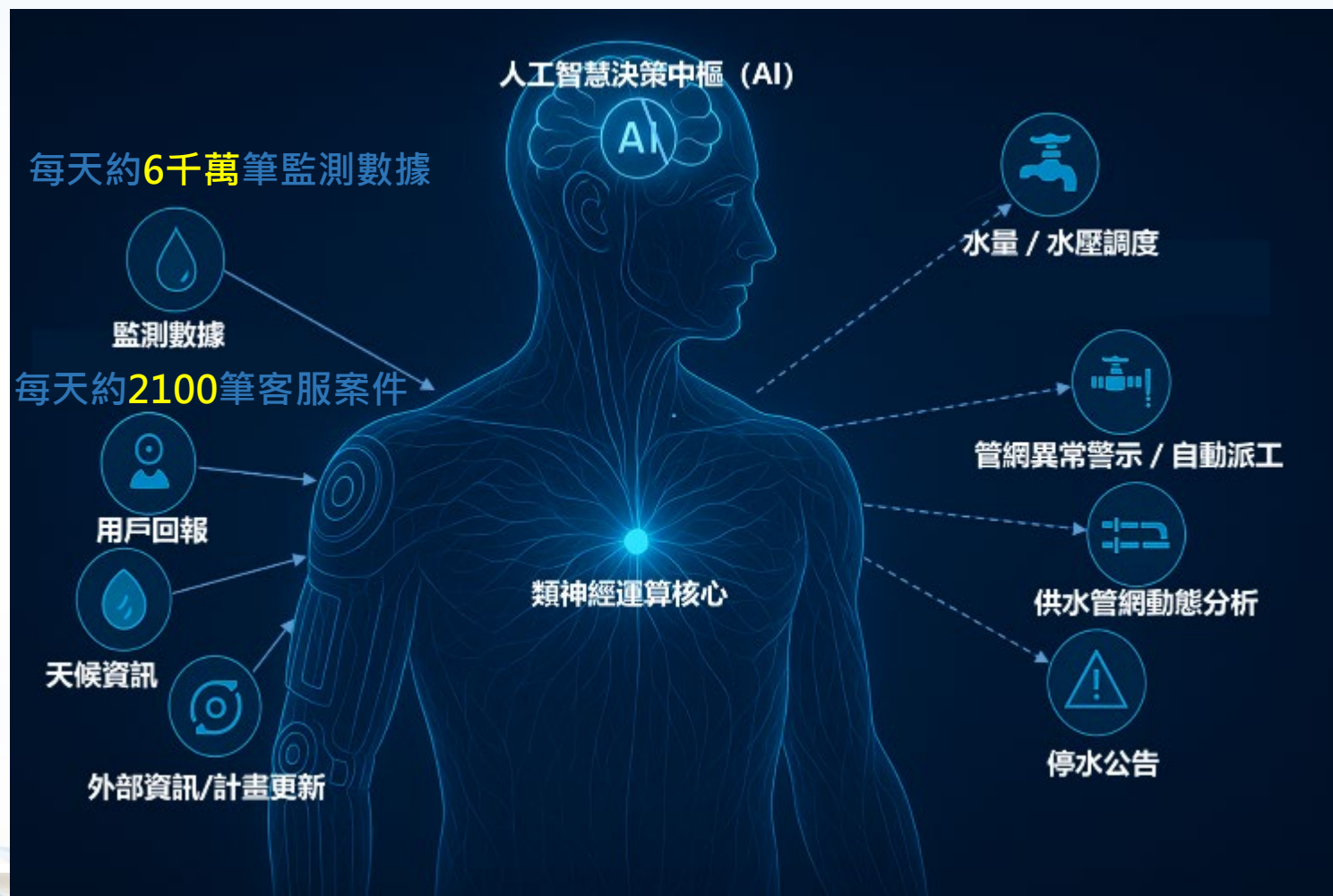
- AI在台水公司的運用

台灣自來水公司 武經文 副總經理
中華民國114年10月28日

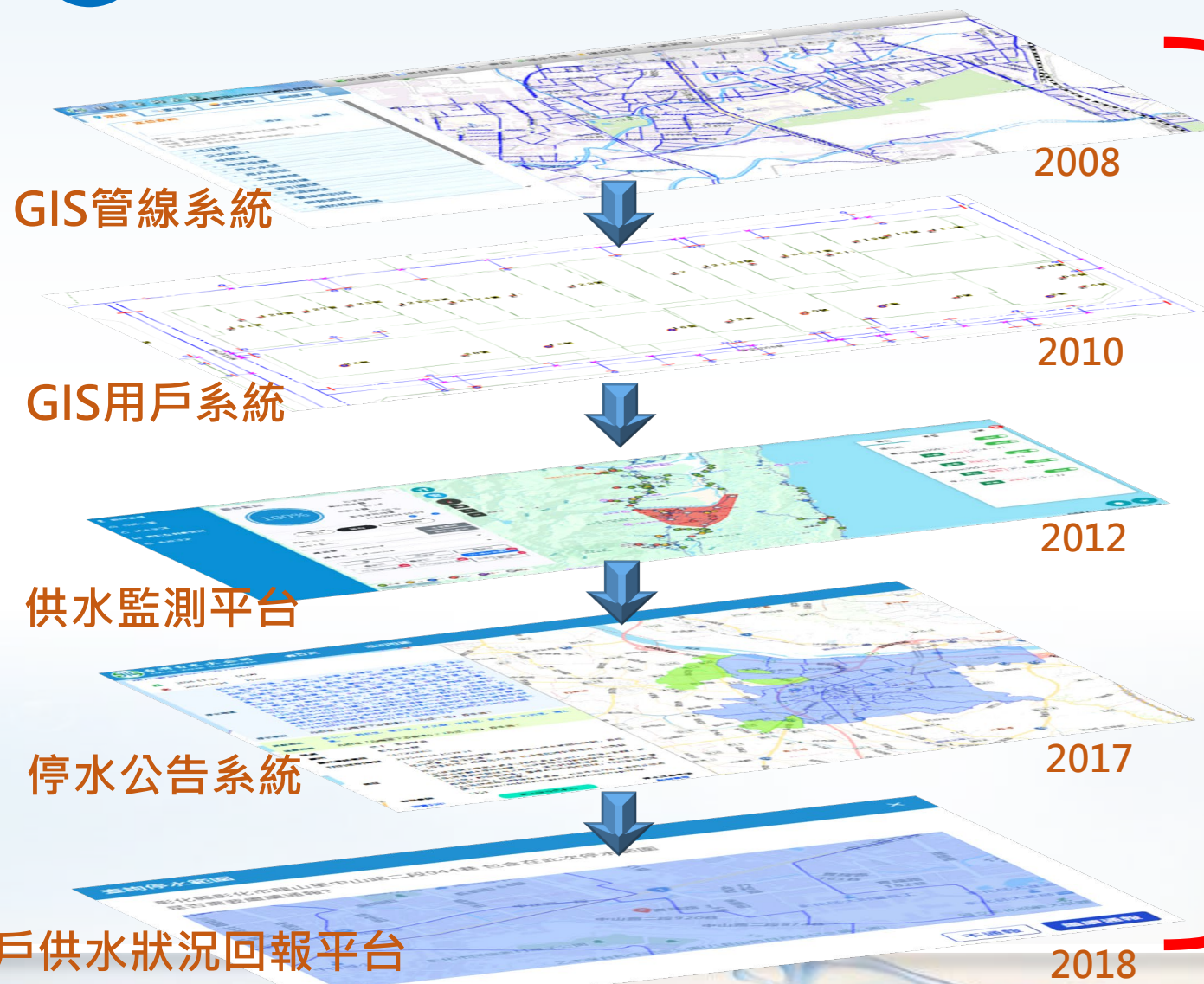
01 TWC 動態供水資訊願景

Current Situation Overview

用戶數	786萬戶
供水量	939萬CMD
輸配水管線長度	6.7萬公里
用戶外線長度	4.2萬公里
淨水場	486個
監控站	33,756個
分區管網	3,971個 (配合降漏計畫再 +716個)



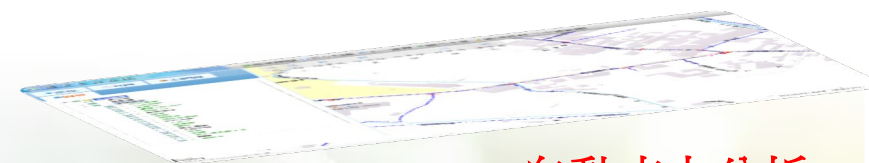
02 各系統結合使用情形



自動生成停水公告

未來趨勢

大數據分析、人工智慧



自動水力分析

02 現況系統介紹-GIS圖資系統

依據不同屬性或條件查詢

勾選不同物件之圖層

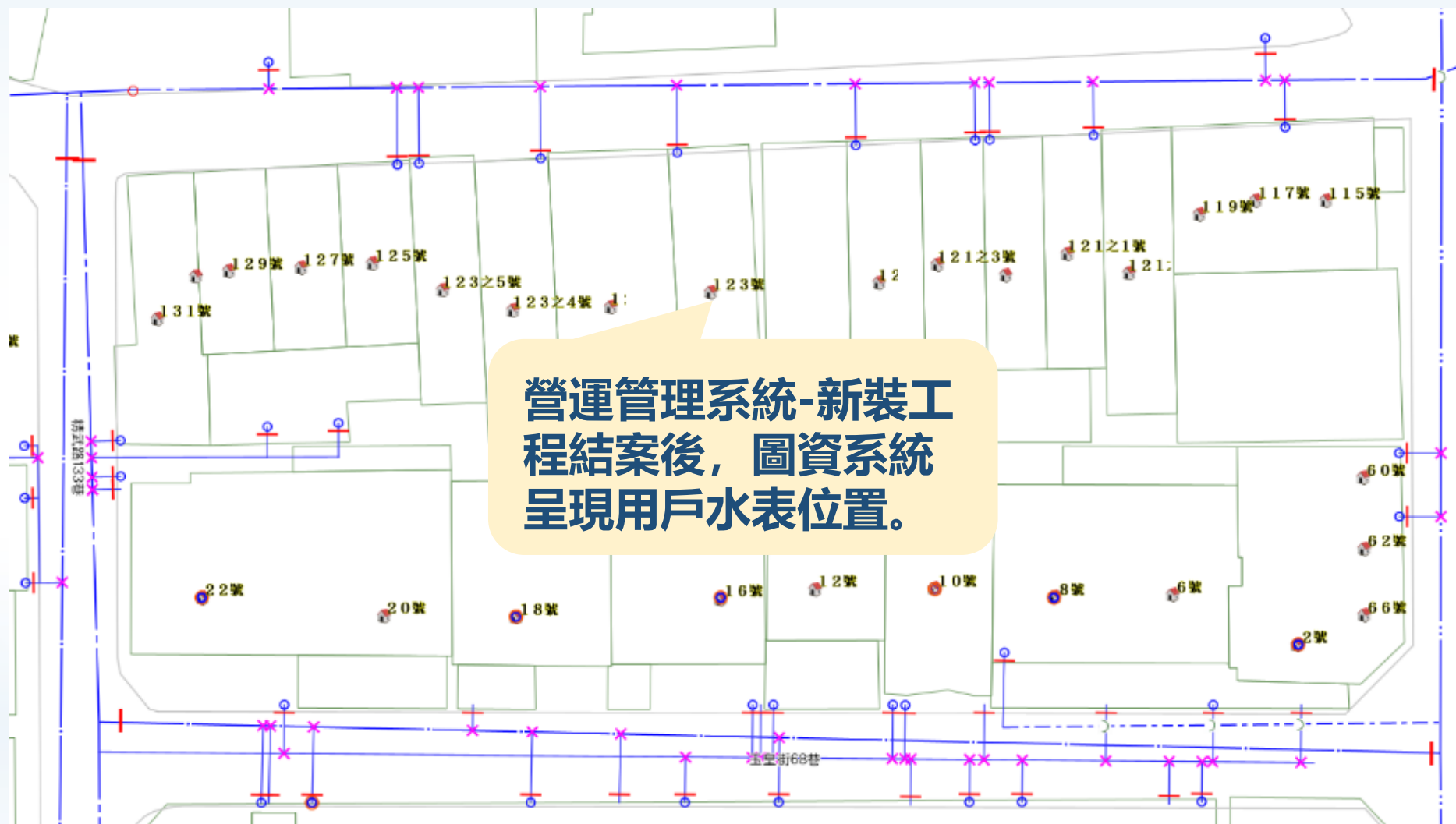
以座標、地址、水號、
工程編號等查詢

The screenshot displays the GIS system interface with several key components:

- Search Bar:** Located at the top, it includes fields for "定位查詢" (Location Search) and "主題圖" (Theme Map), both highlighted with red circles. Below the search bar, there are tabs for "定位", "查詢", "主題圖", and "圖層".
- Search Results:** A list of search results is shown, including "地址門牌" (Address/Doorplate), "交叉路口" (Intersection), "地號查詢" (Land Number Query), "地理座標" (Geographic Coordinates), "用戶水號" (User Water Number), "用戶表號" (User Meter Number), "工程編號" (Project Number), "管線財編" (Pipe Line Asset Number), "索引圖號" (Index Map Number), "修漏案號" (Leak Repair Case Number), "管線識別碼" (Pipe Line Identification Code), "閘類識別碼" (Gate Identification Code), and "消防柱識別碼" (Fire Hydrant Identification Code).
- Layer Selection:** A list of map layers is displayed on the left, including "全部圖層" (All Layers), "地形圖" (Topographic Map), "管線圖資" (Pipe Line Data), "分區管網" (District Network), "分區計量管網水量計" (District Metering Network Water Meter), "管線開閉管段" (Pipe Line Open/Closed Segment), "管線" (Pipe Line), "廢棄管線" (Abandoned Pipe Line), "路管" (Road Pipe), "閘閘" (Gate/Gate), "分區計量管網" (District Metering Network), "分區計量管網地界圖" (District Metering Network Boundary Map), "消防栓" (Fire Hydrant), "消防栓管線" (Fire Hydrant Pipe Line), "用戶水表" (User Water Meter), "人手孔" (Manhole), "修漏點" (Leak Point), "場站" (Station), "水質監測站" (Water Quality Monitoring Station), "水壓監測站" (Water Pressure Monitoring Station), "取水口" (Intake Point), "配水池" (Distribution Tank), "儲水罐" (Storage Tank), "工程財產" (Project Property), and "資產" (Assets).
- Map View:** A map view is shown on the right, displaying a street network and various infrastructure elements. The map includes labels for "放大" (Zoom In), "縮小" (Zoom Out), "恢復縮放" (Reset Zoom), "取消縮放" (Cancel Zoom), "計算距離" (Calculate Distance), "計算面積" (Calculate Area), and "清除結果" (Clear Results).

依據使用者特定條件需求產出資料

02 現況系統介紹-營運管理系統



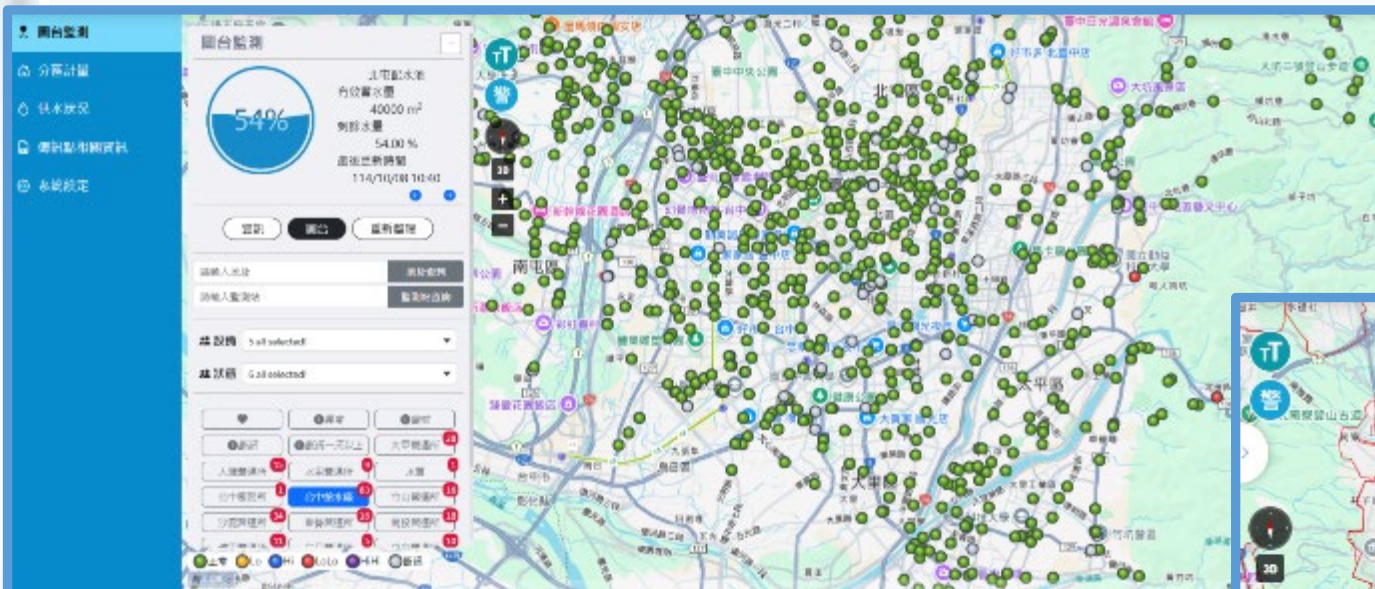
02 現況系統介紹-供水監測平台

EX:馬太鞍溪堰塞湖災害事件



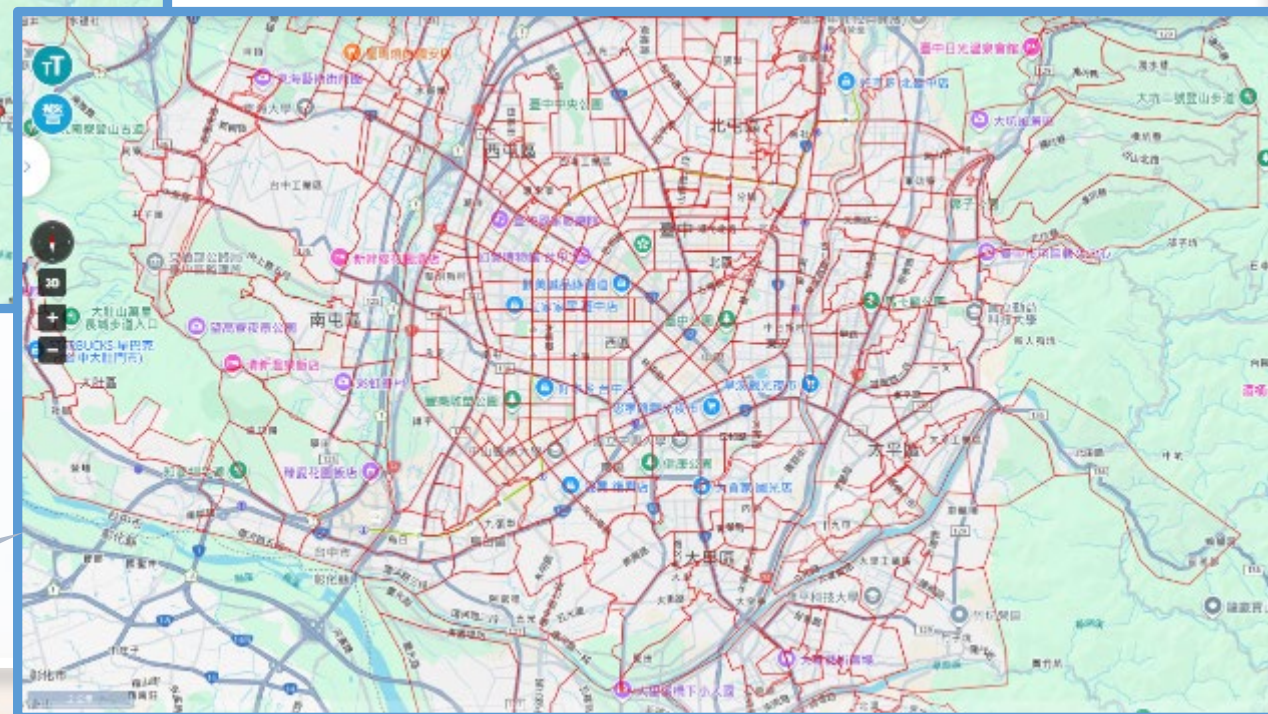
02 現況系統介紹-供水監測平台

EX:第四區管理處台中給水廠



約1500個監測點位

126個供水小區



02 現況系統介紹-澎湖智慧水網系統



02 現況系統介紹-停水公告系統

使用行政區查詢

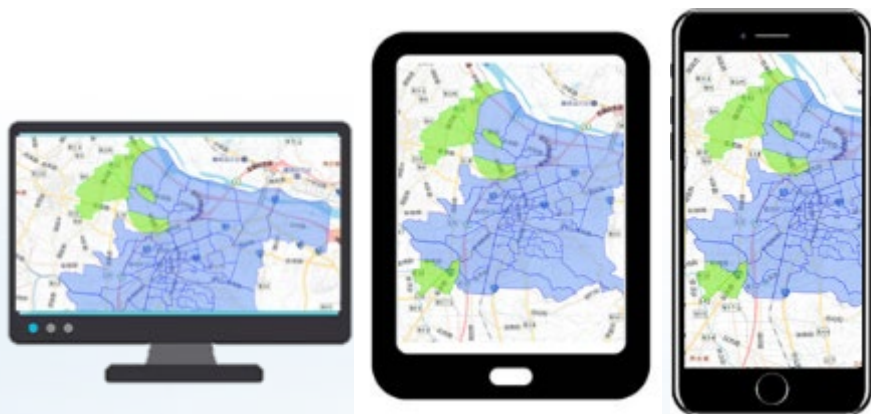
彰化縣 ▾ 彰化市 ▾ 請選擇鄉里 ▾

使用地址路段查詢

長順街64巷

查詢 清除

電腦、平版、手機皆可查詢



台灣自來水公司 TAIWAN WATER CORPORATION

停水時間

起 2025-09-03 00:00
迄 2025-09-04 15:00

停水地區

彰化市：中央里、中山里、下寮里、長福里、富貴里、中正里、龍山里、萬壽里、光華里、光復里、永福里、南英里、忠孝里、忠孝里、西勢里、西勢里、泰芳里、長泰里、五福里、南英里、南英里、泰山里、桃樹里、平和里、華北里、華南里、永生里、大同里、崎頂里、光南里、彰安里、西安里、南興里、福安里、建興里、延平里、介壽里、延和里、成功里、中庄里、德山里、寶福里、國聖里、三村里、和訓里、復興里、古美里、同美里、南南里、南南里、向陽里、南平里、新華里、新興里、萬安里、福明里、文化里、民生里、信義里、興北里、和美鎮：和美里、中國里、中興里、翠盛里、花壇鄉：近竹村、無停水範圍：彰化市(三村里)：彰興路一段6至165號含巷弄以外無停水 彰化市(梧山里)：竹和路部分區域以外無停水 彰化市(華南里)：南興路一段383-515號 彰化市(華陽里)：一心路 彰化市(延平里)：寶山路 彰化市(延平里)：南興路 彰化市(延平里)：南興路 彰化市(延平里)：延平路 彰化市(介壽里)：中興路71巷 彰化市(介壽里)：介壽北路108巷 彰化市(介壽里)：延興路 彰化市(介壽里)：介壽新村 花壇鄉(近竹村)：環山路5-405號停水(以外無停水) 以上區域詳見

停水原因 為辦理「烏嘴潭下游管線A-2-1改接工程」停水施工

降壓區域

降壓範圍

彰化市：新華里、南安里、和美鎮：和美里、新莊里、竹園里、建興里、

降壓原因 為辦理「烏嘴潭下游管線A-2-1改接工程」停水施工

聯繫單位及備註

備註

客服專線 1910

顯示即時供水站 停水注意事項

02 現況系統介紹-停水公告系統

**用Line接收
停水通知**

1. 搜尋「停水公告系統」
或掃QR code 加入

2. 點選「訂閱停水訊息」 3. 新增「用水地址」



The image illustrates the process of subscribing to water outage notifications via Line. It consists of three smartphone screens showing the steps:

- Step 1:** Searching for the 'Water Outage System' or scanning the QR code to join. The screen shows the Taiwan Water Corporation logo, a QR code, and a 'Subscribe' button.
- Step 2:** Selecting 'Subscribe to Water Outage Messages'. The screen shows a confirmation message and a 'Subscribe' button.
- Step 3:** Adding a 'Water Address'. The screen shows a form to add a new address, including fields for name, address, and contact information.

02 現況系統介紹-用戶供水狀況回報平台

Who's Water Off

自檢表

進水處是否有水	☐ 是	☐ 否
止水栓是否全開	☐ 是	☐ 否
水表是否還在	☐ 是	☐ 否
鄰居是否無水	☐ 是	☐ 否
最近一期水費是否已繳	☐ 是	☐ 否

1 請先輸入地址查詢是否為停水範圍

縣市 彰化縣

行政區 彰化市

村里 龍山里

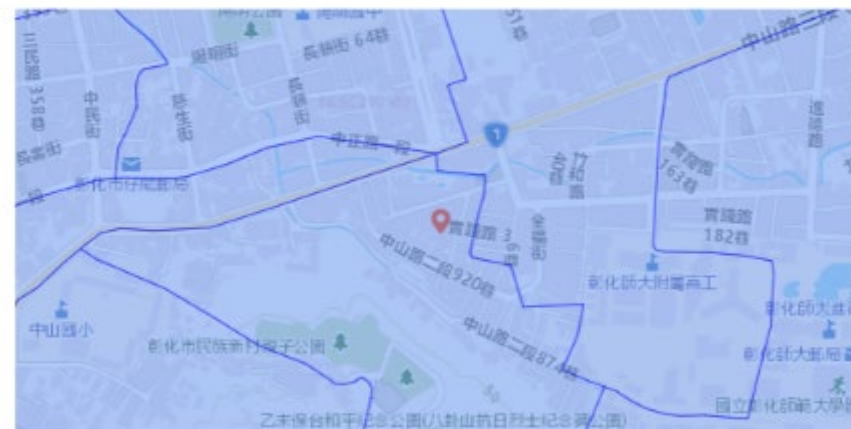
路名 中山路二段

鄰巷弄號 944巷

查詢

查詢停水範圍

彰化縣彰化市龍山里中山路二段944巷 包含在此次停水範圍
是否需要繼續通報?



不通報

繼續通報

01

用戶自檢

02

系統查詢

02

供水異常通報

AI未來功能展望-自動產出停水公告功能

01 監測數據異常



04 資料庫修正



02 自動產出停水公告



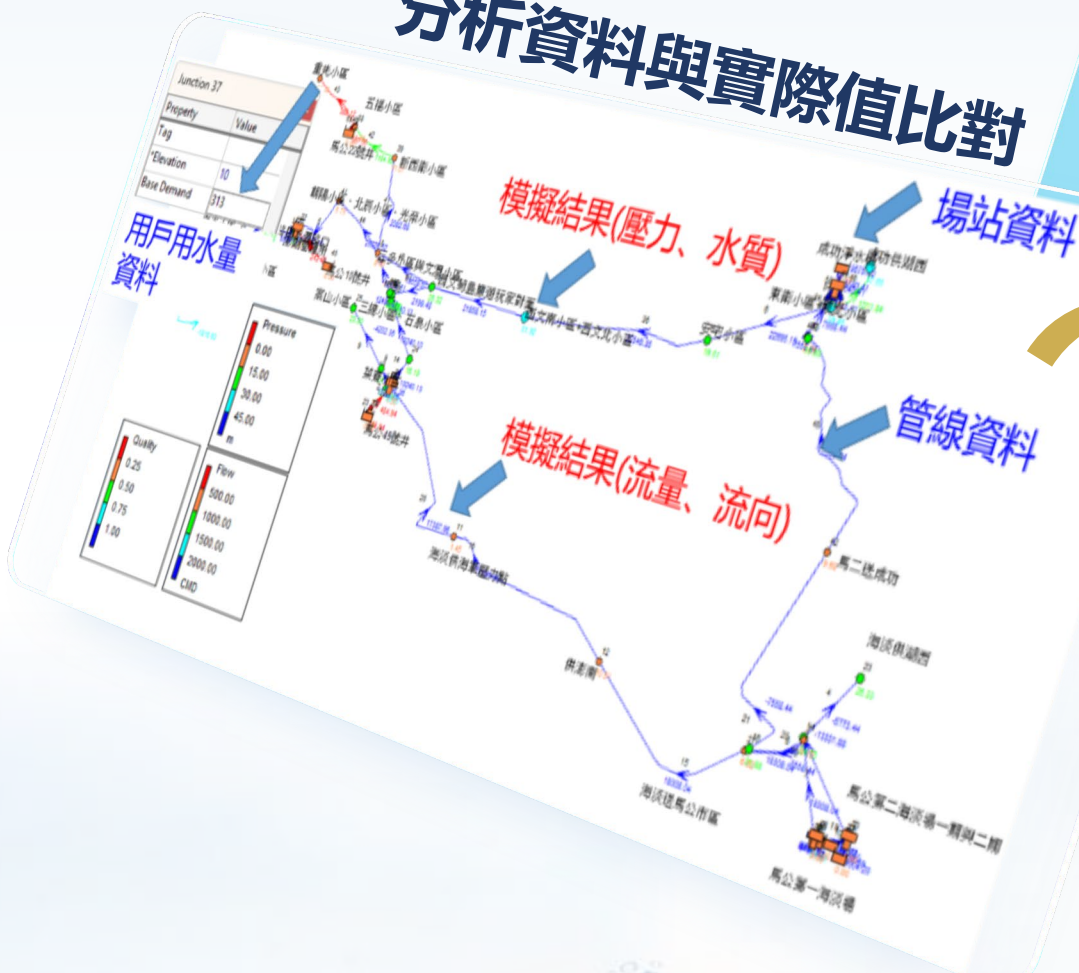
03 用戶及監控回饋資訊



功能模組上線測試中

AI未來功能展望-自動水力分析

分析資料與實際值比對



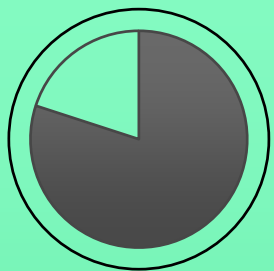
數據異常回饋予分析



功能模組開發中

台水AI輔助檢漏技術-歷程及作業流程

發展歷程



80%

第一階段
109~111年
建置AI模型、
硬體及漏水點
複測為主

初始AI模型在漏
水確認中達到
80%的準確性。



82.35%

第二階段
112年
建立管網漏
水AI快篩模
式

- 開發AI檢測快篩模式
此快篩模式於第三區
達到82.35%。
- 以三區模型擴展其他
區處需持續優化。



87.5%

第三階段
113~114年
強化AI快篩模式
廣度

- 增加北中南東8個區處
300處以上實際漏水點
音訊聲紋作模型訓練
- 此模式66.33公里管線
盲測AI檢出21處與專
業檢漏人員檢出24處
重疊，吻合度87.5%

第二階段研究成果發現

環境因素和訓練數據對其在**不同地區**的有效性有顯著影響。

05 現場開挖修復



04 資深人員聽音確認



作業流程

01 非專業人員配戴物聯網設備(IoT)

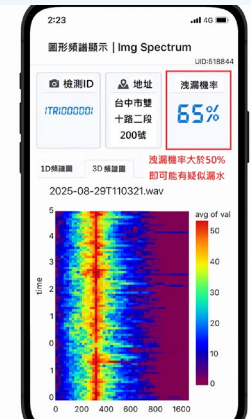


03 巡檢軌跡 漏水預判



洩漏座標: 24.7990291,
120.9936702
AI檢測結果: 洩漏機率: 52.0%,

02 透過工研院 AI- Powered Acoustic Sensing技術



台水AI輔助檢漏技術-114年執行狀況

結合工研院開發「智慧漏水音輔助辨識系統」提升漏水檢測能力

全台場域至2025年7月為止

AI診斷完成距離



2886公里

全台運行AI巡檢設備39套

全台場域至2025年7月為止

AI診斷漏水點驗證數



1570處



阻漏每度水
降0.156公斤CO₂



WIFI



小白盒接收聲音訊號



web系統顯示AI診斷結果



建立管線巡檢歷程資料庫

整合門牌圖資、街景與導航系統

- 複測漏水 快速化
- 漏水位置 視覺化

- 巡檢歷程 數位化
- 人員管理 即時化

數據由由原工研院產業經濟與趨勢研究中心 (IEK) 提供

人力

- 目前AI輔助裝置39套，透過簡易教育訓練，非專業人員即可使用。
- 以台水現況93名專業檢漏人力，等同於增加39名基礎檢漏人力。
- 相當於擴增檢漏人力42%。

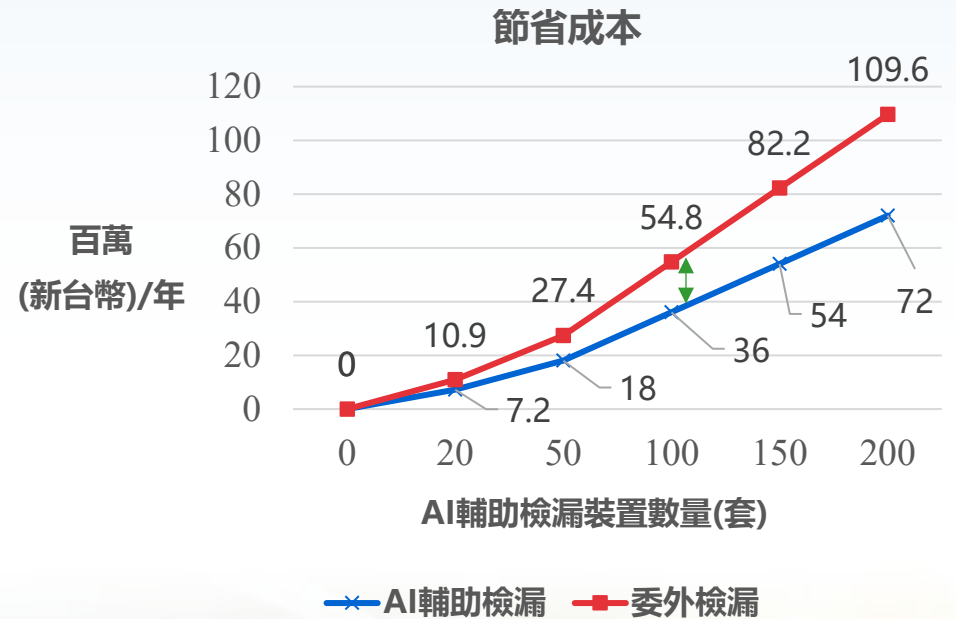
基礎檢漏人力
短時間擴
增42%

時間

- ◆ 管線長度7.5公里的小區。
- ◆ 假設以1人作業，傳統巡檢時間3天。
- ◆ AI快篩模式(專業人力確認漏水熱點)1天。
- ◆ 相當於台水檢漏人員檢測時間可減少約67%。

檢測時間
減少67%

成本



節省委外檢漏
費用約34%

AI技術與智慧基礎設施

AI Technology & Smart Infrastructure



WADA(Water Advanced Data Analysis)系統

關鍵功能與應用效益

Key Functions & Benefits

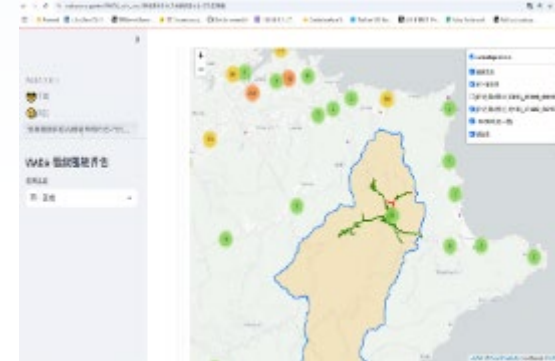


夜間小流檢漏系統 Nighttime Low-Flow Leak Detection System



管線風險評估

Pipeline Risk Assessment



介接圖資系統

Integration with GIS



追蹤與統計(~2025.09)

Tracking & Statistics



✓ 系統擴張

System Expansion

介接小區已達**3,002**
3,002 connected zones

✓ 特殊分析

Special Analysis

無流量
No Flow

無壓力
No Pressure

小流量率 >80%

Low Flow Rate >80%

AI技術與智慧基礎設施

AI Technology & Smart Infrastructure



WADA(Water Advanced Data Analysis)系統

運作流程 Process 模型分析

結果推播

輸入 Input

處理 Process

輸出 Output

SCADA收集流量/壓力資料

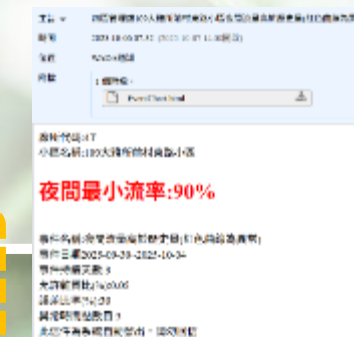
使用機器學習演算法(MA)預測

1.事件報表自動生成



日期	系統	資料編號	小區	檢長度(米)	水壓計算	水壓計	配水站	倒閉值	日最小值	日平均	日最大	日最小
2005-10-01	北所	1006-06-0	水頭小區	21.35	237.000000	P50001	P50002	P50003	1.23	4.1	4.13	3.98
2005-10-01	北所	1006-06-0	雙福小區	41.59	4550.000000	F000347	F000348	F000349	1.71	2.38	2.45	2.57
2005-10-01	北所	1343-01-0	萬州新區	8.83	584.000000	A-A-00054	A-00055	A-00056	0.41	0.49	0.52	0.5
2005-10-01	北所	1006-06-0	萬州新區	1.03	64.000000	D00057	D00058	D00059	4.78	5.42	5.38	5.36
2005-10-01	北所	1006-06-0	萬州新區	4.72	485.000000	K00008	K00009	K00010	1.27	2.38	2.74	2.66
2005-10-01	北所	1006-06-0	萬州新區	10.28	872.000000	SP0100A	SP0100B	SP0100C	2.06	2.79	2.93	2.94
2005-10-01	北所	1006-06-0	萬州新區	13.97	1745.000000	A-00053	A-00054	A-00055	0.91	1.33	1.4	1.81
2005-10-01	北所	1006-06-0	萬州新區	33.83	1267.000000	B-000744	B-000745	B-000746	5.41	5.81	6.1	6.34

2.即時人員通知(郵件或Line)



效益 Benefit

地區水壓異常 → WADA偵測 → 自動通知 → 快速處理 → 減少漏水

感謝聆聽，敬請指教



AI 2.0 新契機：通用人工智慧轉化為工程專家

Turning General Intelligence into Domain Experts in the AI 2.0 Era

2025.10.28

陳俊杉

Chuin-Shan (David) CHEN

dchen@ntu.edu.tw

臺灣大學土木系/臺灣大學材料系 特聘教授

Distinguished Professor, National Taiwan University

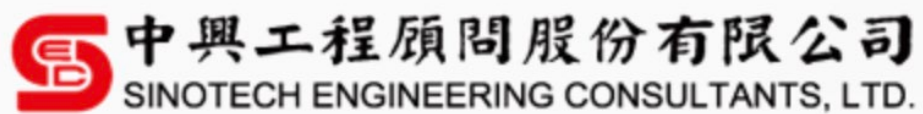
國震中心與臺大土木合設 AI 中心 主任

Director, NCREE-NTUCE AI Center

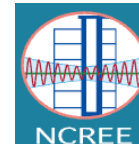
台大智活 執行長

CEO, NTU iNSIGHT Center

The Team



工業技術研究院
Industrial Technology
Research Institute

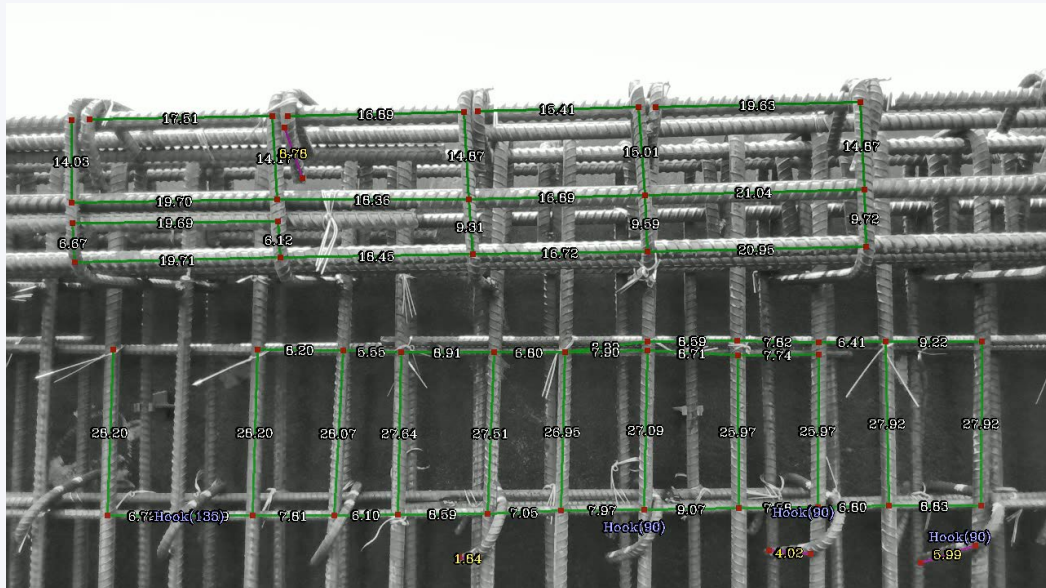


國家實驗研究院
國家地震工程研究中心
National Center for Research on Earthquake Engineering

多采工程顧問有限公司
ManySplendid

AI 1.0 (1980 – Now)

- Single or narrow tasks — **one model solves one problem**
- Requires large **labelled** datasets and supervised learning
- Discriminative AI (e.g., AlphaGo, Tesla Autopilot)



Rebar Assembly Inspection

AI 2.0 (2021 – Now)

-  Versatile multi-task models **approaching human capabilities**
-  **Foundation models pre-train on massive data then fine-tune**
-  Generative AI, LLMs, Agentic AI (e.g., ChatGPT)

 LLMs officially pass the Turing test

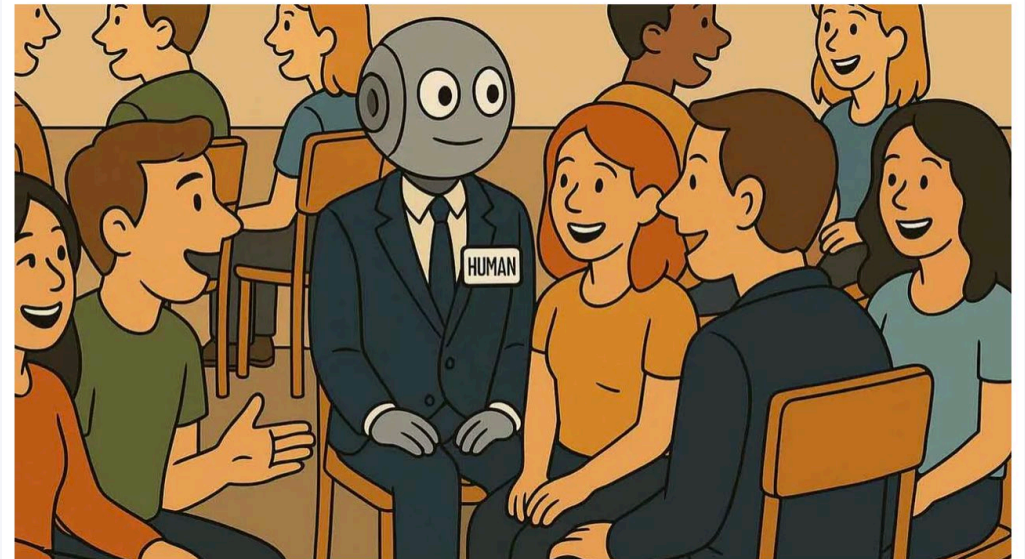
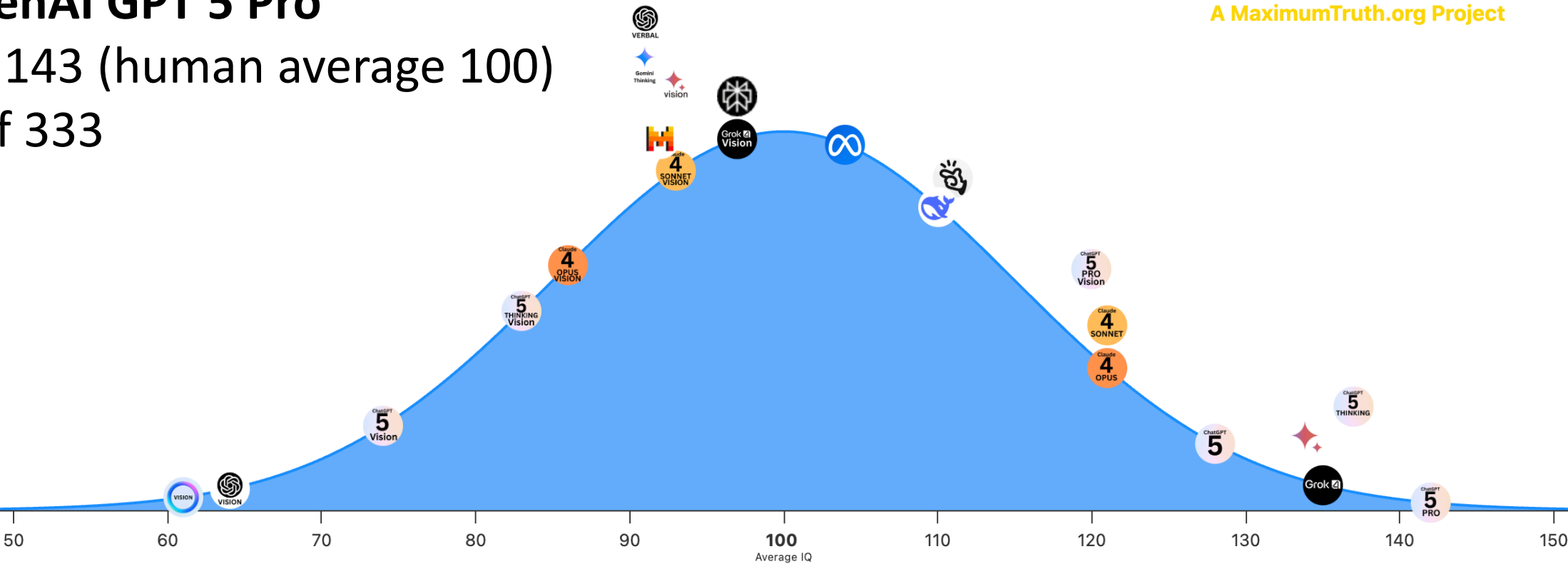


Image source: GPT-4o / The Rundown

OpenAI GPT 5 Pro
IQ: 143 (human average 100)
1 of 333

Mensa Norway quiz
A MaximumTruth.org Project



- | | | | | |
|---------------------------|----------------------------|-----------------------------|--------------------|---------------------------|
| Claude-4.1 Opus (Vision) | Claude-4.5 Sonnet (Vision) | Claude-4.1 Opus | Claude-4.5 Sonnet | Mistral |
| Llama 4 Maverick (Vision) | Gemini 2.5 Pro (Vision) | Gemini 2.5 Flash Thinking. | Gemini 2.5 Pro | GPT-4o (Vision) |
| GPT-4o | Bing Copilot | Manus | Perplexity | DeepSeek R1 |
| DeepSeek V3 | Llama 4 Maverick | Grok-4 Expert Mode (Vision) | Grok-4 Expert Mode | GPT-5-Thinking-Vision |
| OpenAI GPT 5 (Vision) | OpenAI GPT 5 Pro | OpenAI GPT 5 Thinking | OpenAI GPT 5 | OpenAI GPT 5 Pro (Vision) |

輕鬆一下：土地開發後若基地跨越兩個以上排水區域且需改變原有排水集水面積時，應依據哪一法規辦理？

- 環境影響評估法
- 水利法 第十條
- 排水管理辦法第三條
- 城市設計法第二條

你列出的四個法規中，若題目是：

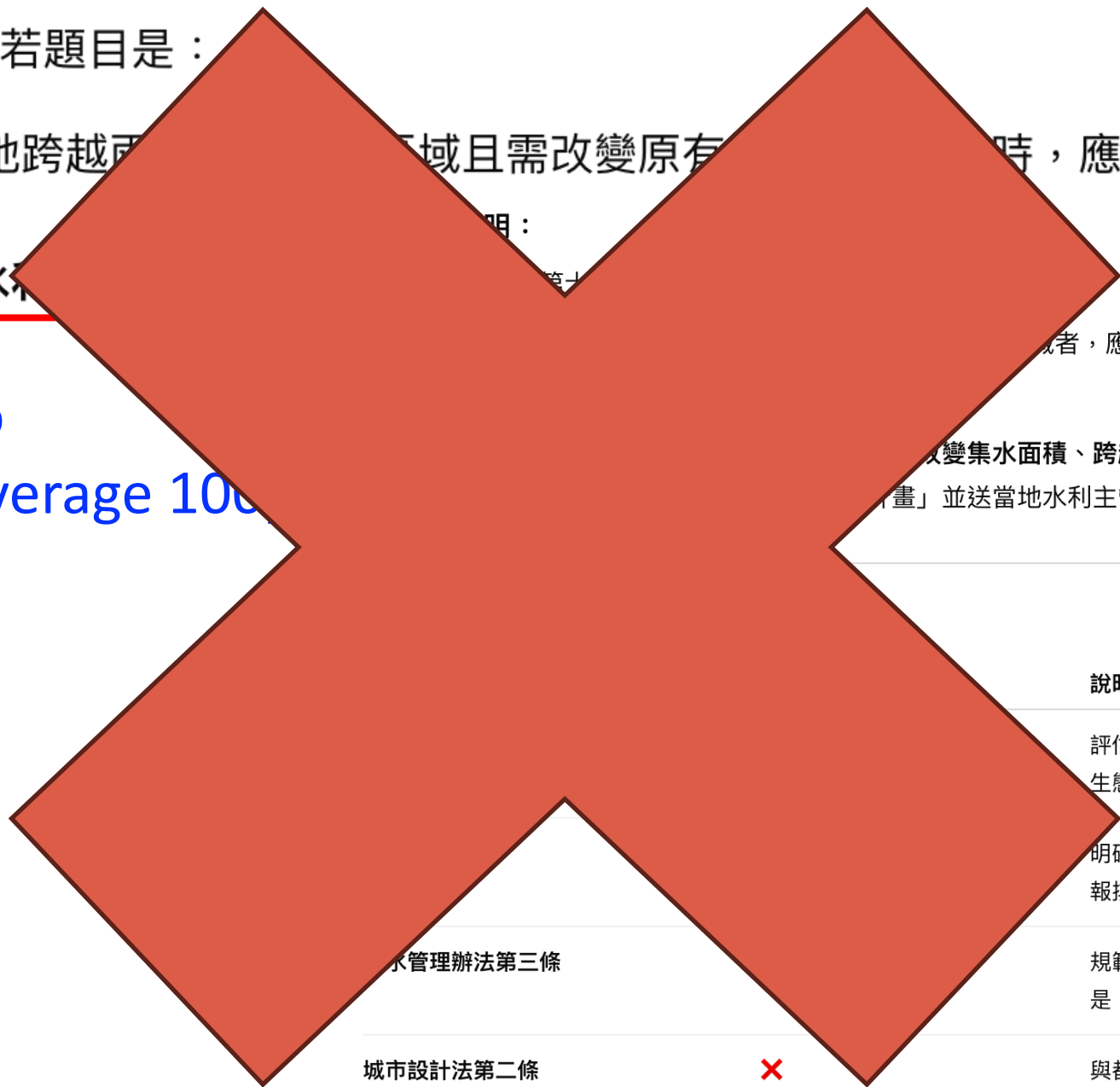
「土地開發後若基地跨越兩排水區域且需改變原有排水系統時，應依據哪一法規辦理？」

正確答案應是：☒ 《水利法》

OpenAI GPT 5 Pro

IQ: 143 (human average 100)

1 of 333



者，應擬具排水計畫，報請主管機關核准後，

改變集水面積、跨越不同排水區域，都屬於《水利法》第十條所稱之「排水計畫」並送當地水利主管機關審查。

說明

評估開發行為對整體環境的影響（噪音、水質、生態等），非專指排水區變更。

明確規範土地開發造成排水或集水區變更時應提報排水計畫。

規範排水計畫的編製原則與程序，但法律依據仍是《水利法》第十條。

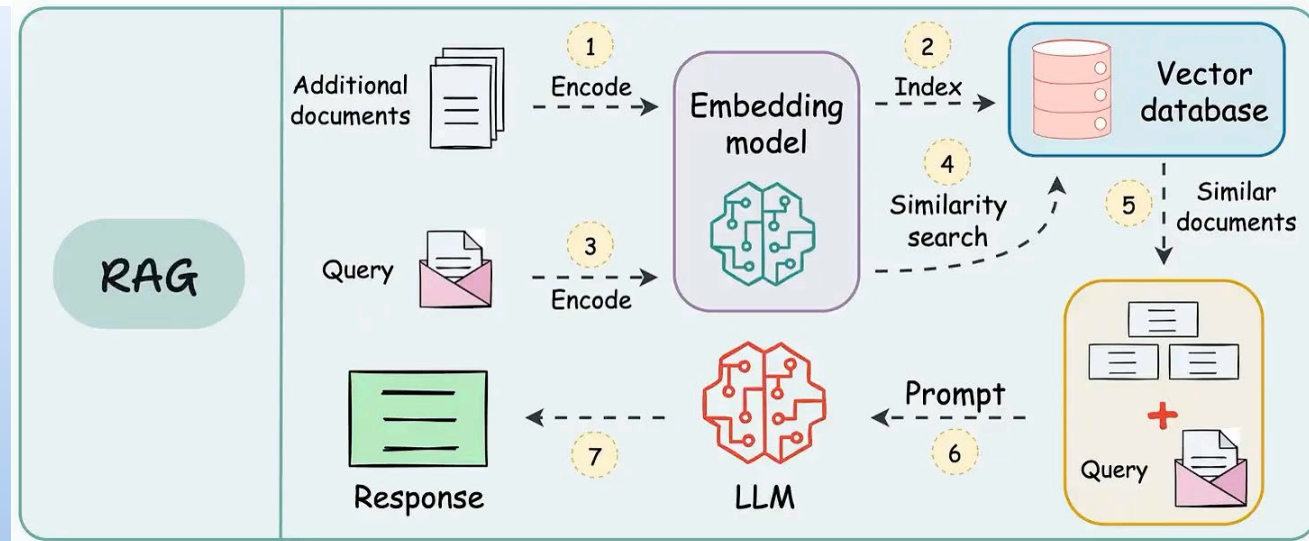
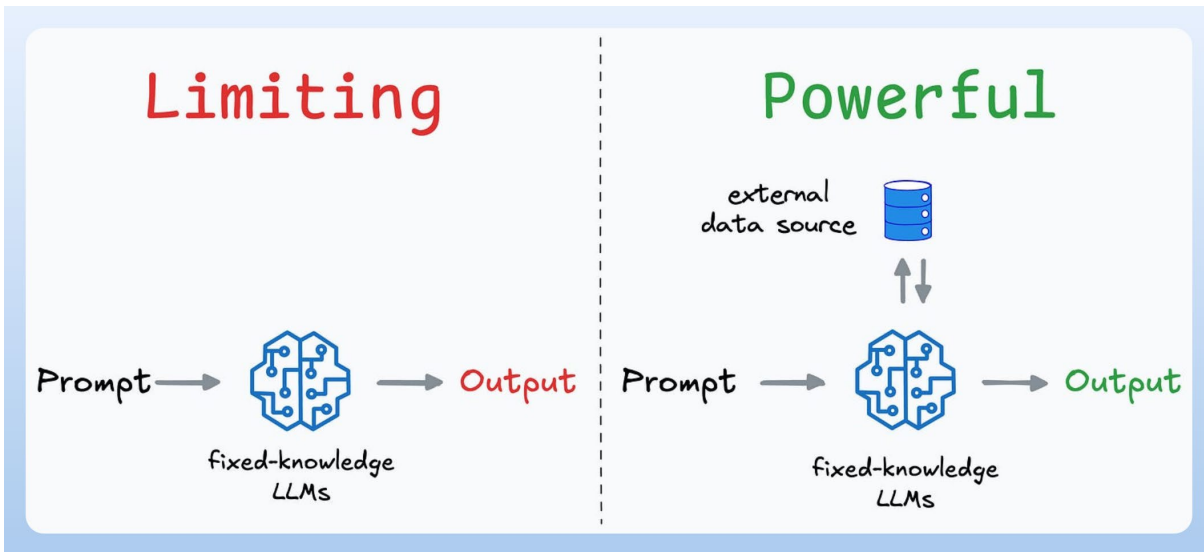
水管理辦法第三條

城市設計法第二條

×

與都市設計、土地使用規劃有關，非屬排水管理法規範範圍。

**Turning General Intelligence
into Domain Experts?!**



- **Retrieval-Augmented Generation (RAG)** allows the language model to access *external information sources* (such as documents or databases).
- The model then **uses the retrieved content** to generate responses.
- This ensures its answers are **grounded in real-world knowledge and context**, not just its pre-training data.
- As a result, it **reduces the likelihood of hallucinations**—i.e., the model making up incorrect or unsupported facts.



出流管制技術手冊

OpenAI GPT 5 Pro

IQ: 143 (human average 100)

1 of 333

根據你提供的《出流管制技術手冊（經濟部水利署水利規劃試驗所，109 年 5 月）》內容，第 4 章第 4.1 節〈集水區劃設〉明確說明：

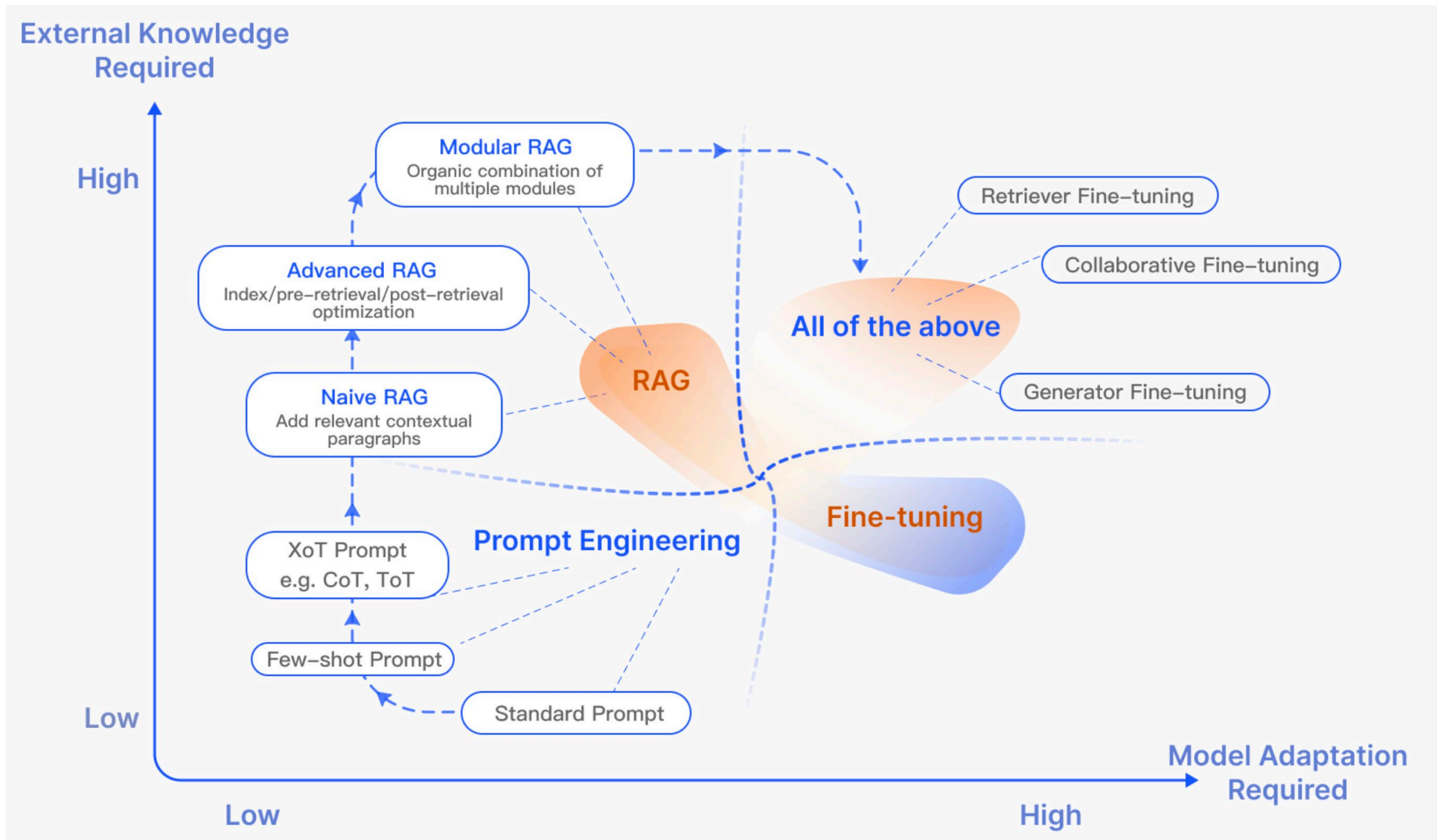
「若開發基地跨越兩個以上之排水區域，需改變原有排水集水面積者，應依據《排水管理辦法》第三條辦理；倘有涉及《水利法施行細則》第十條所稱之變更水道，應依據《水利法》第九條辦理。」

📄 出流管制技術手冊1090507函頒

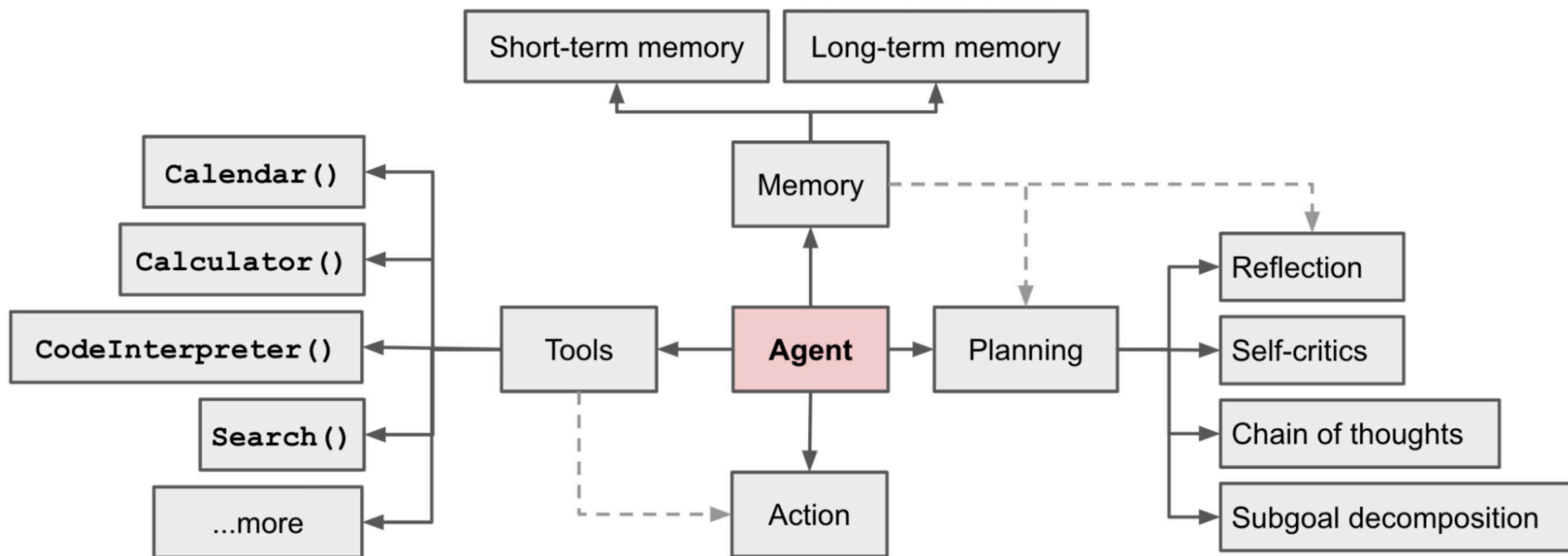
134 Pages

經濟部水利署水利規劃試驗所

中華民國 109 年 5 月



LLM-Powered Autonomous Agents: A General Problem Solver



Agent 比喻：給 LLM 加上電腦、網路和記事本，他就能查資料、記筆記、**執行任務**、回報結果

應用案例：工程查驗表單生成
與溯源檢核。

Case Study: Inspection Form
Generator with Traceability
Check。

設計 (Design) -> 施工 (Construction) -> 監造 (Inspection, Supervision)



Danjiang Bridge
New Taipei

<https://www.sinotech.com.tw/>

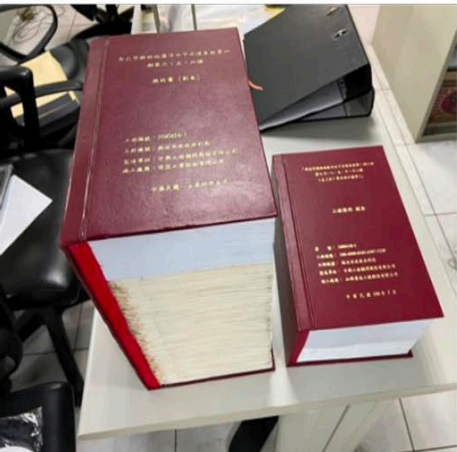
工程監造品質提升標準流程

中興工程顧問股份有限公司
SINOTECH ENGINEERING CONSULTANTS, LTD

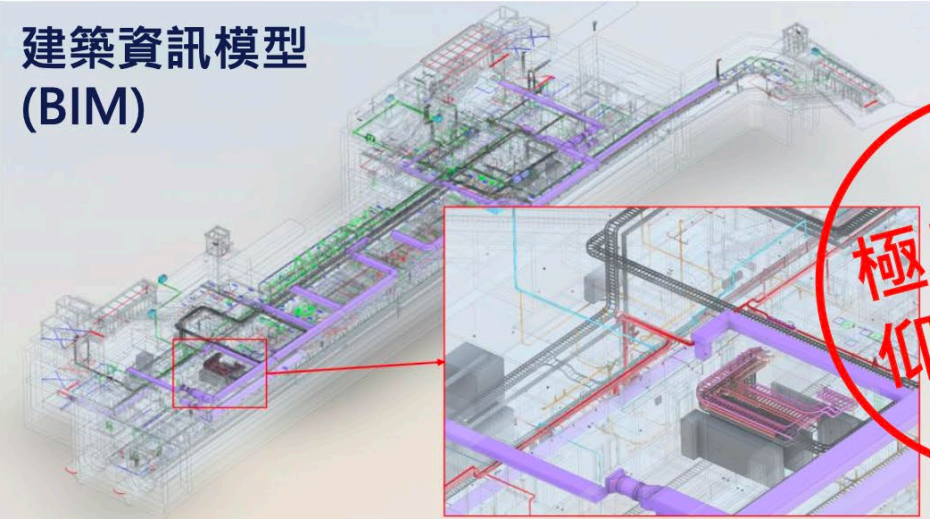
全套管基樁施工抽查紀錄表

施工規範

設計圖說



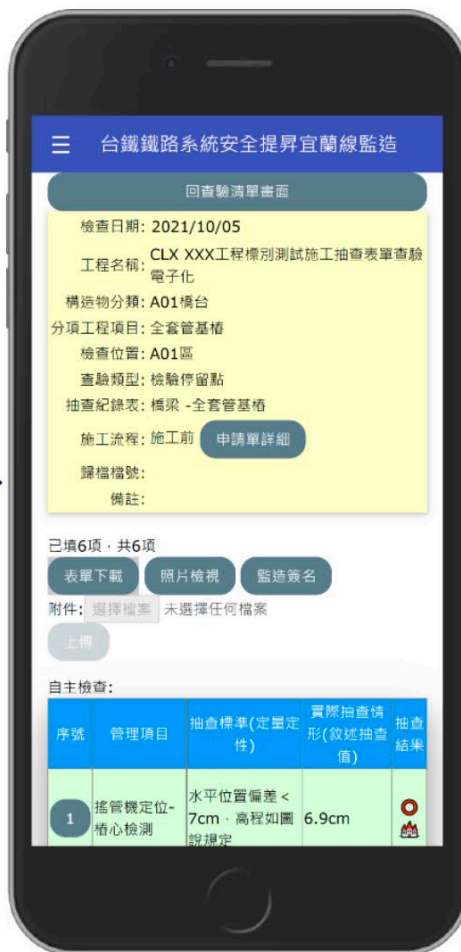
建築資訊模型 (BIM)



極度耗時
仰賴經驗

編號: _____

工程名稱	淡江大橋及其連絡道路 5K+000~7K+035 新建工程		
分項工程名稱			
檢查位置		檢查日期	
抽查時機	☒ 檢驗停留點 ☐ 不定期抽查		
施工流程	☒ 施工前 ☐ 施工中檢查 ☐ 施工完成檢查		
檢查結果	☐ 檢查合格 ☒ 有缺失需改正 / 無此檢查項目		
管理項目	抽查標準 (定量定性)	實際抽查情形 (敘述抽查值)	抽查結果
★鋼筋籠加工組合-主筋直徑、長度	依設計圖 ϕ ___ mm、L ___ m		
★鋼筋籠加工組合-箍筋直徑、間距	依設計圖 ϕ ___ mm、@ ___ cm		
★鋼筋籠加工組合-搭接長度	依設計圖主筋搭接長度 ≥ 180 cm，三點電焊之總長度不得小於主筋直徑之 5 倍		
★鋼筋籠加工組合-箍筋鉚接長度	二點電焊(各 10cm)		
★鋼筋籠加工組合-預埋 PVC 測管	PVC 測管 4 支，內徑 ≥ 50 mm，長度 = L ___ cm + 20cm		
★鋼筋籠加工組合-鋼筋籠橫斷面	每斷面至少 ___ 個、間距 ___ m		
2. 抽查結果不合格者;填至「不合格追蹤管制表第 ___ 項」進行追蹤改善			
2. 缺失複查結果			
☐ 已完改善(檢附改善前中後照片)			
☐ 未完成改善,再填至「不合格追蹤管制表第 ___ 項」進行追蹤改善			
複查日期: ___ 年 ___ 月 ___ 日			
複查人員職稱: _____ 簽名: _____			



中興無償提供PMIS公版

工程圖說溯源檢核：現況與挑戰 (Engineering Drawing Inspection: The Challenge)

溯源檢核

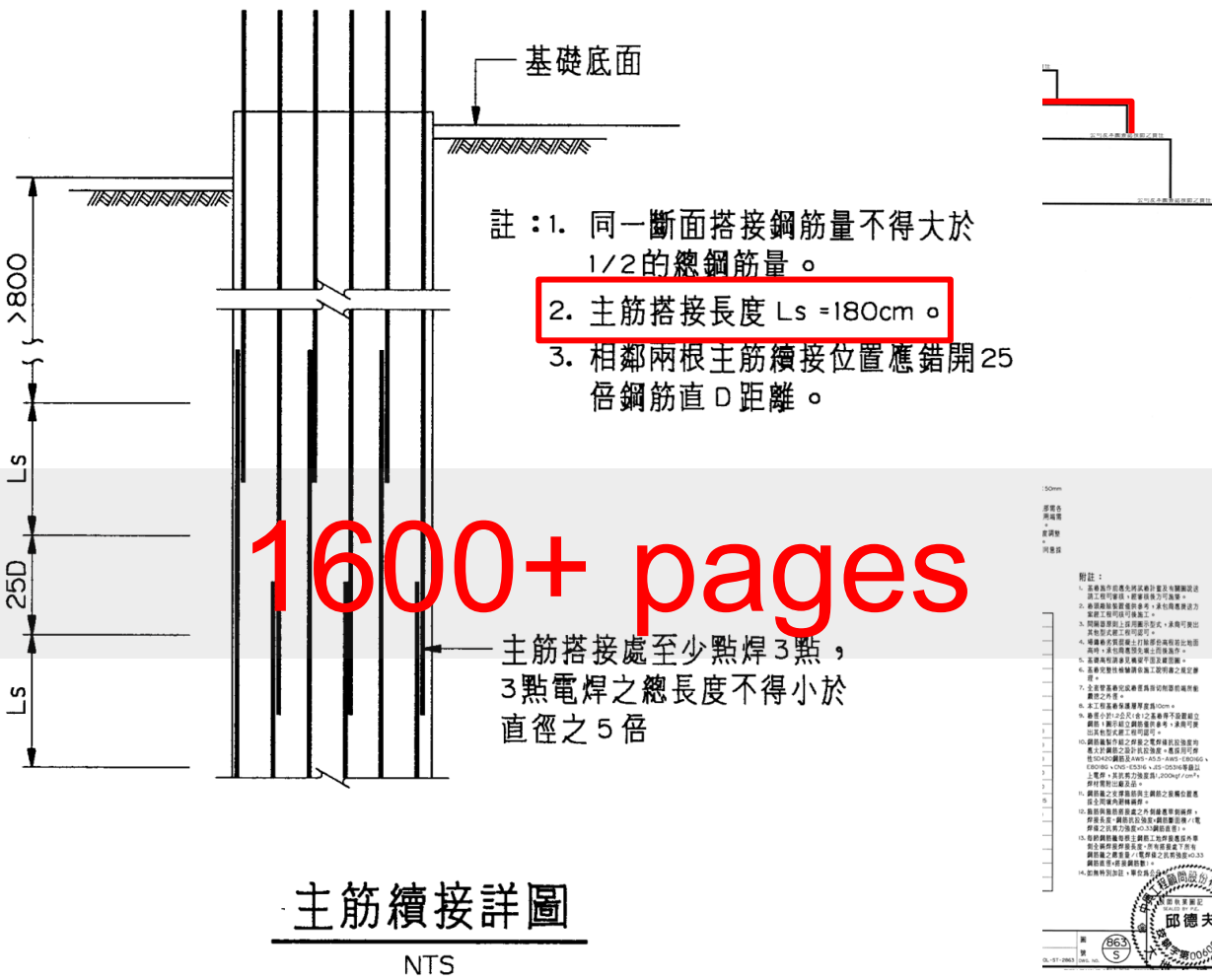
全套管基樁施工抽查紀錄表

工程基本資訊

工程名稱	淡江大橋及其連絡道路5K+000~7K+035新建工程		
分項工程名稱			
檢查位置		檢查日期	
抽查時機	☒ 檢驗停留點 ☐ 不定期抽查		
施工流程	☐ 施工前 ☒ 施工中檢查 ☐ 施工完成檢查		
檢查結果	☐ 檢查合格 ☒ 有缺失需改正 / 無此檢查項目		
管理項目	抽查標準	規範/圖說溯源	檢核結果
★鑽掘作業-套管全部壓入時最大偏心	$\leq 10\text{cm}$	[02469.3] 3.3.4 第一節及第二節鋼套管壓入時最大偏心不得大於 2cm，套管全部壓入時，最大偏心不得大於 10cm，超過此限應拔除重作	符合規範
★鋼筋籠加工組合-搭接長度	依設計圖主筋搭接長度 $\geq 180\text{cm}$ ，三點電焊之總長度不得小於主筋直徑之5倍		

源於規範

源於圖說



10mm

邵德夫

963 S

0000

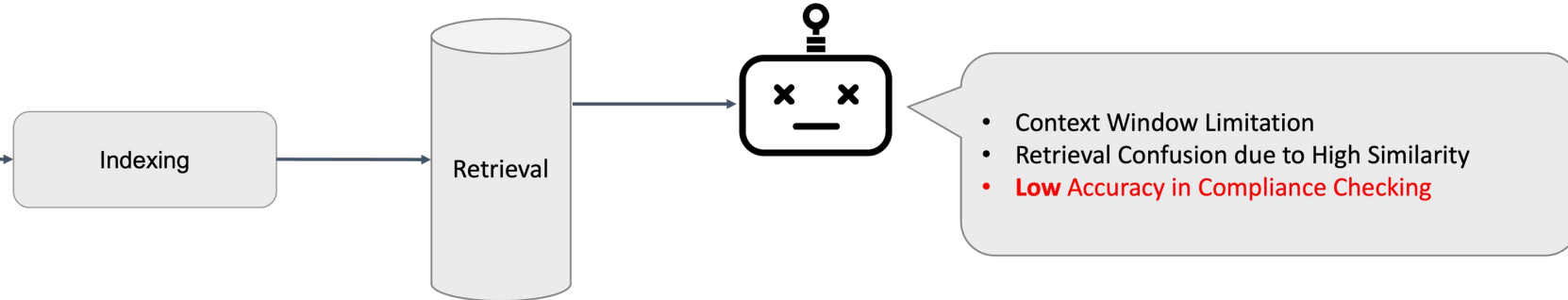
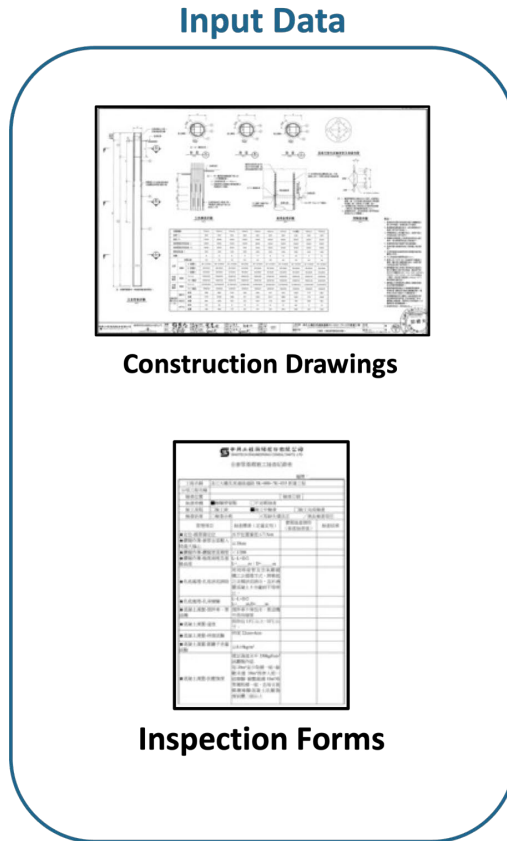
Tracing Inspection Items from Engineering Drawings

Manual Verification for Compliance Check

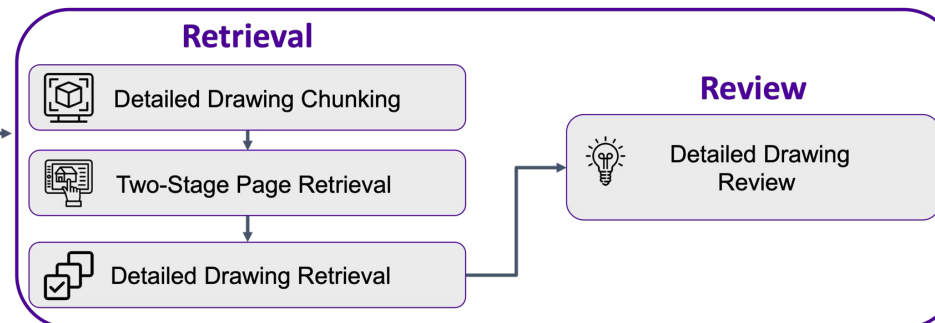


- High **Labor Costs** and **Time Consumption**
- Inconsistency and **Human Errors**
- Limited Scalability
- Difficulty in Managing Dynamic Regulations

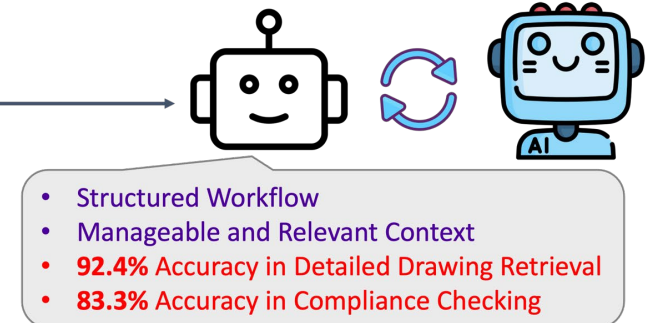
Naïve Multimodal RAG for Compliance Check with Construction Drawings



Hierarchical Detailed Drawing Retrieval

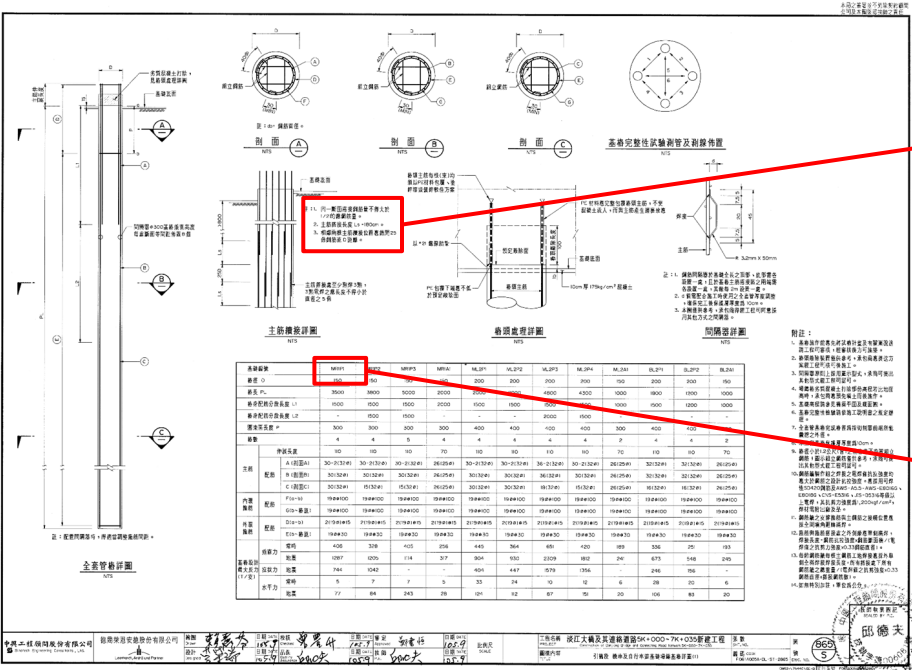


Agentic Reflection



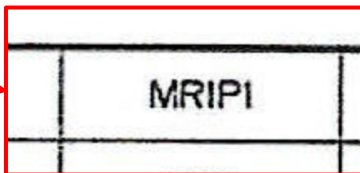
Methodology: Hierarchical Detailed Drawing Retrieval

- Two-Staged Page Retrieval
 - **Similarity search** for candidates
 - **Object detection** model for chunking
 - Utilize **LLMs** to retrieve drawings with position and content-related information

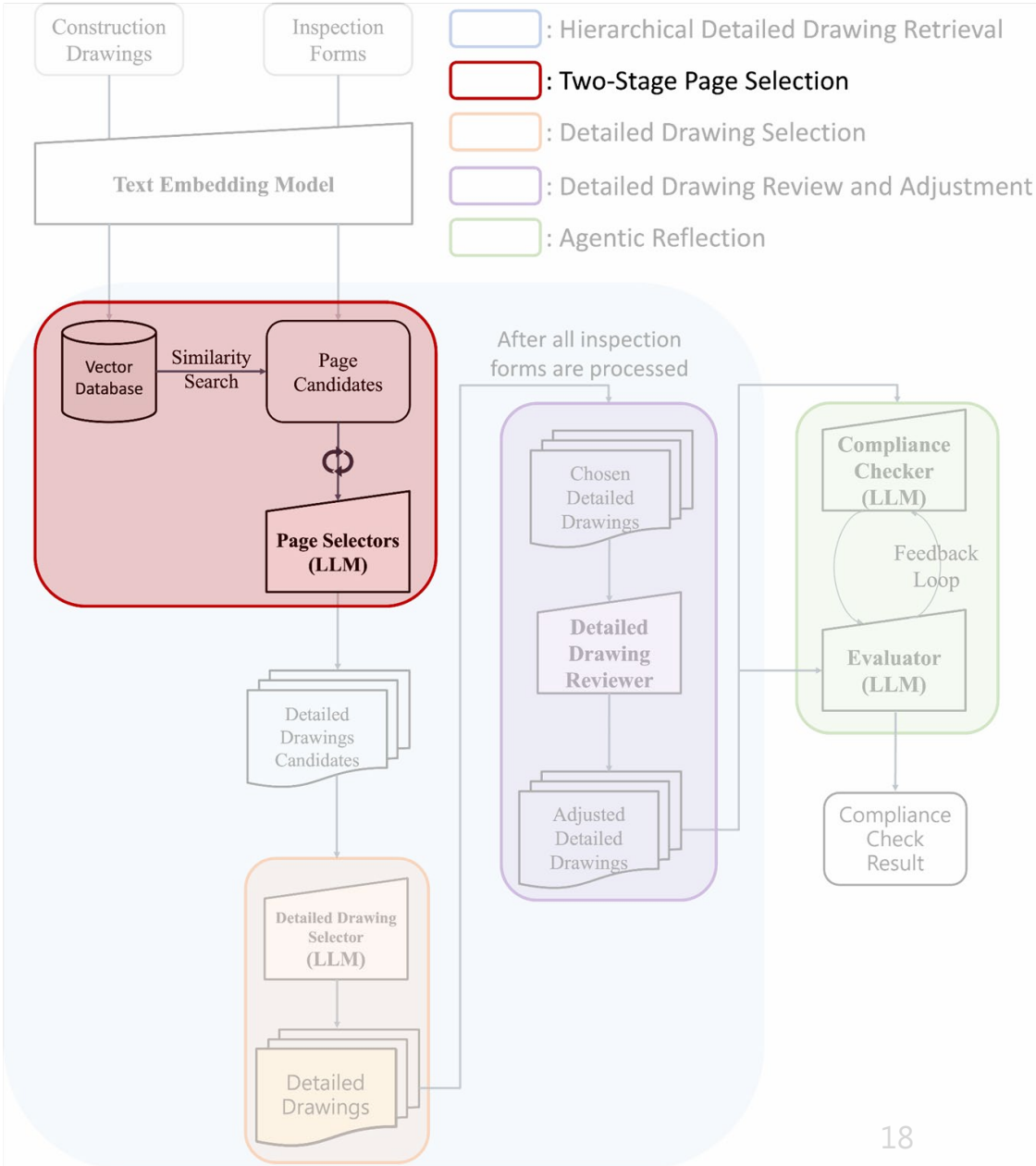


註：1. 同一断面搭接钢筋量不得大于1/2的总钢筋量。
2. 主筋搭接长度 $L_s = 180cm$ 。
3. 相邻两根主筋搭接位置应错开25倍钢筋直径D距离。

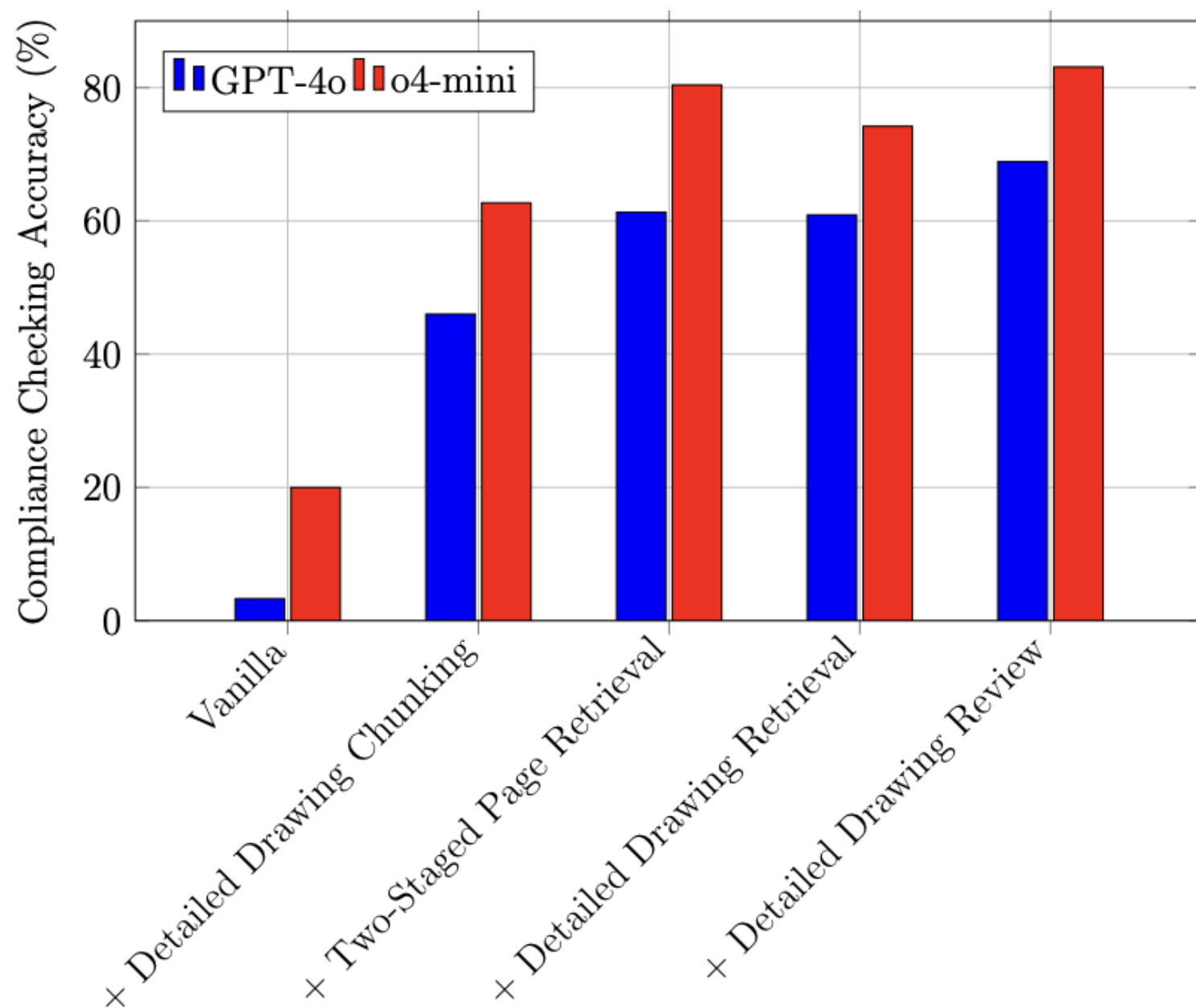
Form content-related



Position-related



Experiment Results



Inspection Forms Generation and Compliance Checking Service

施工查驗表單生成示範

用戶輸入

用戶輸入

表單模板生成

重置

Chatbot

表單生成

Chatbot



風雨無懼！小清水溪橋修復提前

12/21通車、11/22開始售票

Credit：中興工程 呂斌豪經理

● 07/24-07/25 凱米颱風侵台

● 07/27 設計單位研擬修復方案

● 08/07 設計單位提送設計圖、施工規範及預算

● 08/09 施工單位完成議價程序

● 08/16 施工單位現場開始施工

● 08/19 鋼桁架橋鋼板材料取樣檢驗

● 09/26 完成鋼桁架橋工廠假組立檢驗

● 09/30 完成橋台結構增建

● 10/15 鋼桁架橋開始構件吊裝

● 10/13 鋼桁架橋開始架設重型支撐架

● 10/24 鋼桁架橋完成所有構件吊裝

● 10/26 鋼桁架橋完成所有構件鎖固

● 10/30 橋面板完成

● 11/23 版式軌道完成

AI



監造

管理
協助事宜

施工抽查表單彙整
材料抽驗表單彙整
履約待辦事項彙整

單章規範由30分鐘
縮減至 3~5分鐘
契約條文由180分鐘
縮減至 10~15分鐘

會議事項 整理
圖說檢閱 比對
照片檢查 建議
And More...

↓
機電、訊號、系統測試
試車、自主聯合檢查

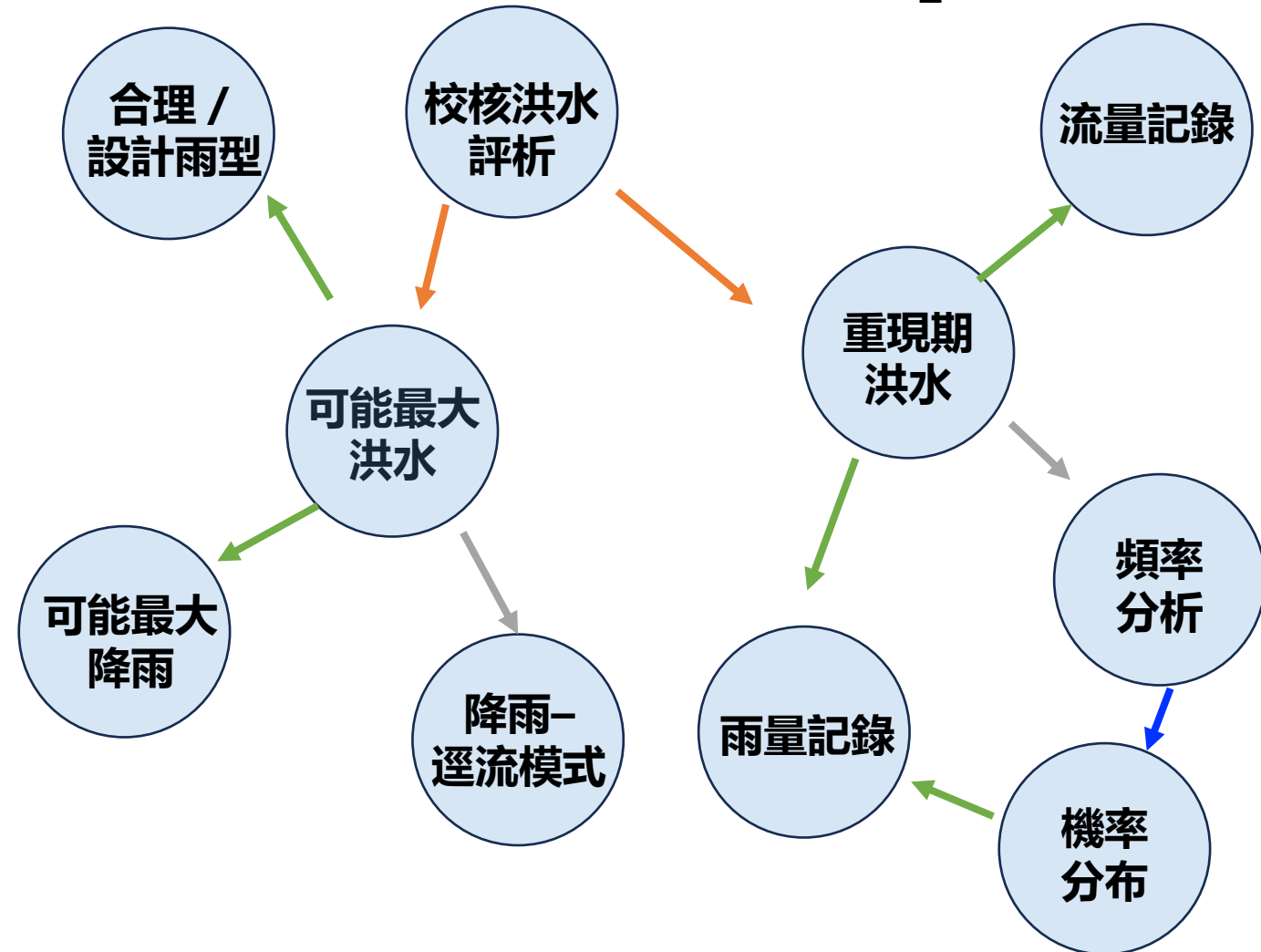
由彙整者角色轉變為檢核者的角色

應用案例：知識圖譜驅動的報告生成
與合規檢查。

Case Study: Knowledge Graph-
Enabled Report Generation and
Compliance Checking。

Turning Data into Understanding: The Power of Knowledge Graph

- ❑ Goes beyond storing data — it captures **relationships**.
- ❑ Connects fragmented information into **a coherent web of knowledge**.
- ❑ Builds a **reasoning network** that integrates knowledge and traces sources.



Knowledge Graph in the Era of LLMs

Large Language Models

Pro:

- General knowledge
- Language processing
- Generalizability

Cons:

- Hallucinations
- Black box
- Lack domain-specific / new knowledge

Knowledge Graph

Pro:

- Accuracy, Interpretability
- Domain-specific knowledge
- Evolving knowledge

Cons:

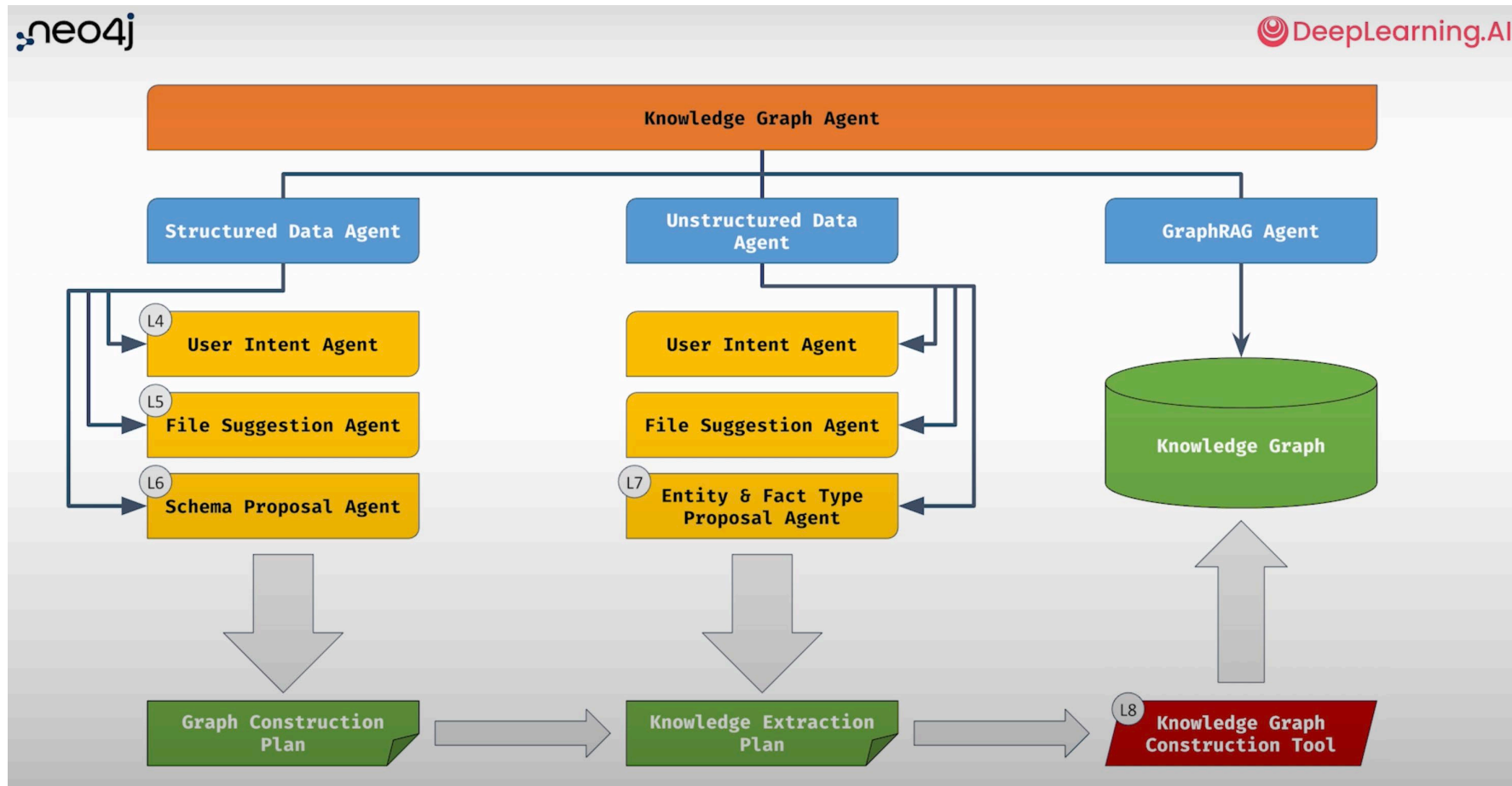
- Incompleteness
- Lack language understanding
- Complex querying



LLM and **KG** can compliment each other.

Knowledge Graph in the Era of LLMs

- ❑ **Before:** Building a knowledge graph was time-consuming and manual.
- ❑ **Now:** LLMs can help automate and accelerate knowledge graph creation.

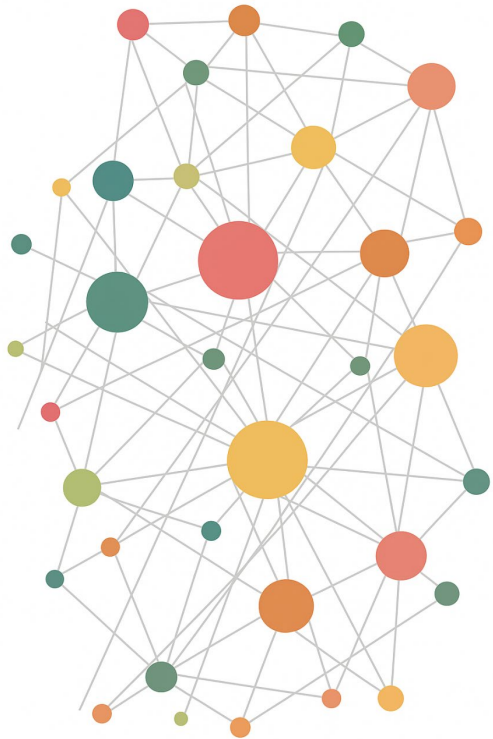


Knowledge Graph + Agentic System

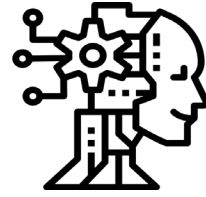
A General Engineering Task Solver



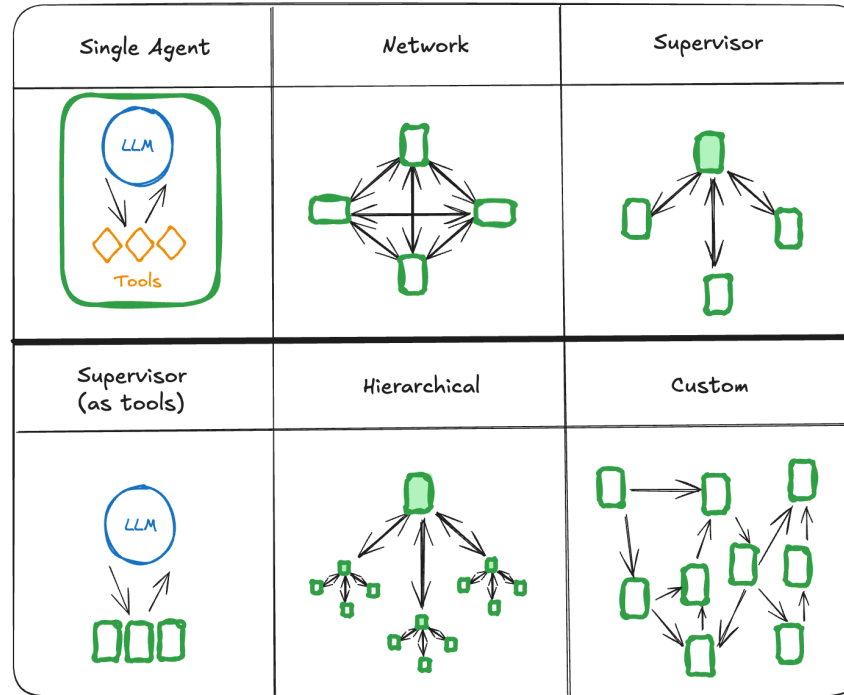
**Knowledge
Graph**



+



Agentic System

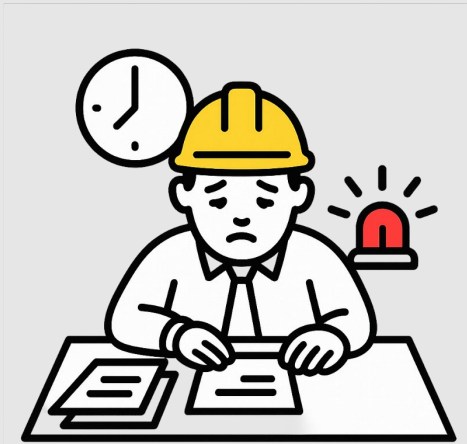


6 Common Patterns

- Engineering Document Generation 工程文件生成
- Compliance Checking 合規檢查
- ...

Engineering Report Generation 工程報告生成

“Always Working **Overtime**
to Finish Reports?”



- Difficult Cross-Disciplinary Integration
- Severe Time Pressure

Technical reports:
900+ pages, multi-teams

翡翠水庫第五次定期安全評估

綜合報告



管理單位：臺北翡翠水庫管理局

中華民國 109 年 6 月

洪水評析

水庫壩高 122.5 m，原設計總蓄水量 4.06 億 m³，依水庫壩水庫，其災害潛勢等級屬嚴重，校核洪水應採可能最大 (MF)。

最大洪水之推算，目前最常用之方式係先推估可能最大 (MP)，再經由降雨逕流模式推估可能最大洪水 (PMF)，雨量之推估，其中暴雨移位與露點調整法係屬台灣地區較大降雨事件，再由露點溫度與屏障高度等因子調整至區以推估可能最大降雨。世界氣象組織 (WMO) 統計法，無水區歷年之年最大一日降雨量，經統計與查表校正可能最大降雨。颱風模式法則是由颱風形成機制，設計水庫造成最大降雨之颱風事件；求得可能最大降雨後最大暴雨紀錄包絡線及台灣最大暴雨紀錄包絡線加以覆核合宜之 PMP，以此 PMP 經降雨逕流模式推估 PMF，台灣最大洪峰流量 (含水文站歷史最大紀錄及各水庫壩成果) 包絡線 (如克里格經驗公式法)，及世界洪峰紀錄核此 PMF 之合理性。

洪水頻率分析，由於翡翠壩可靠之洪峰流量紀錄年限大於年限，故採歷年最大洪峰流量紀錄，估計各重現期洪峰後，綜合上述各項推估結果，評估選出建議之可能最大洪峰流量之合理性。

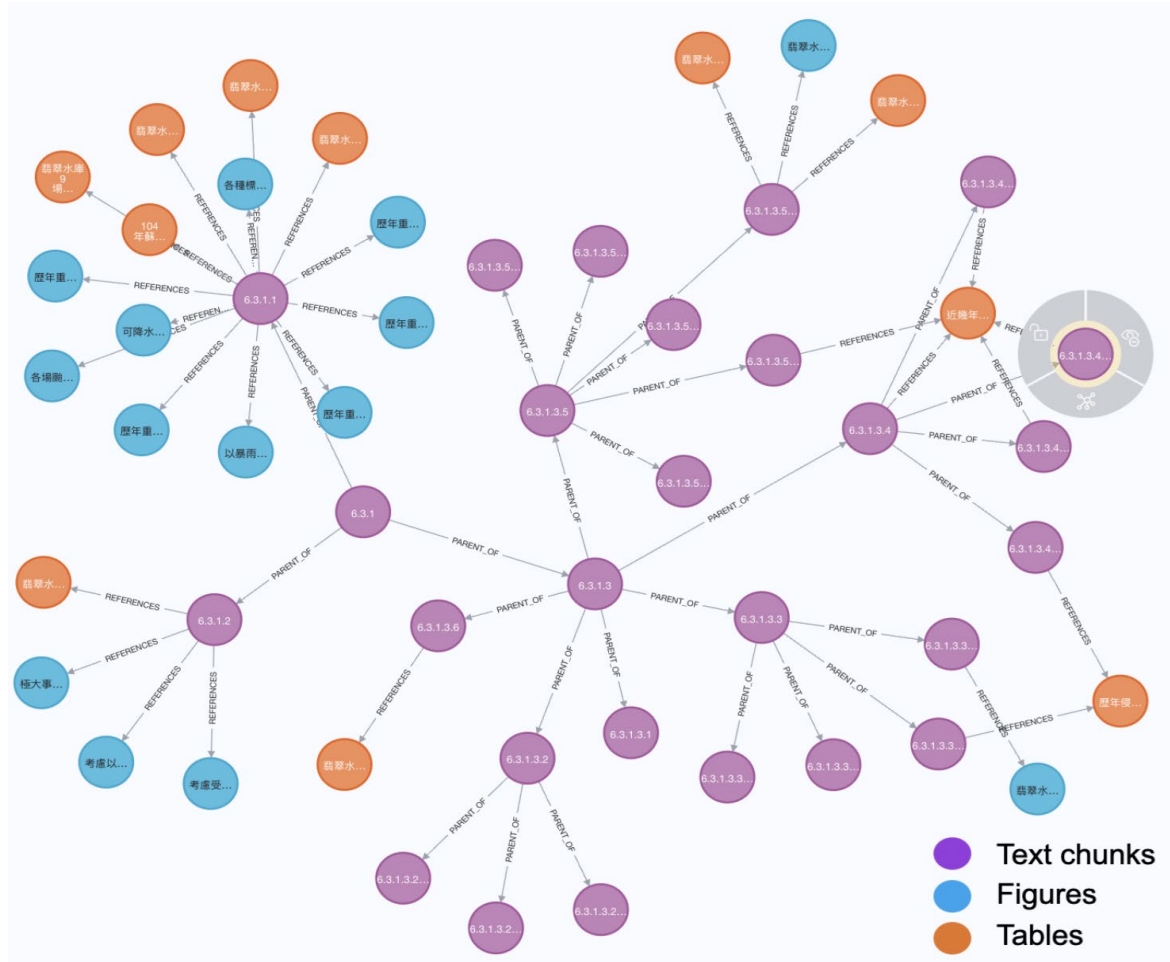
能最大降雨量估算

最大洪水之推估步驟係以增補後之氣象、水文資料，重能最大暴雨，再由可能最大暴雨配合降雨逕流模式推算洪水，因此校核分析之重點即在探討可能最大暴雨有無之推估值，本章就暴雨移位與露點調整法，世界氣象組織統計法及颱風模式法分別說明於後。

暴雨移位及露點調整法

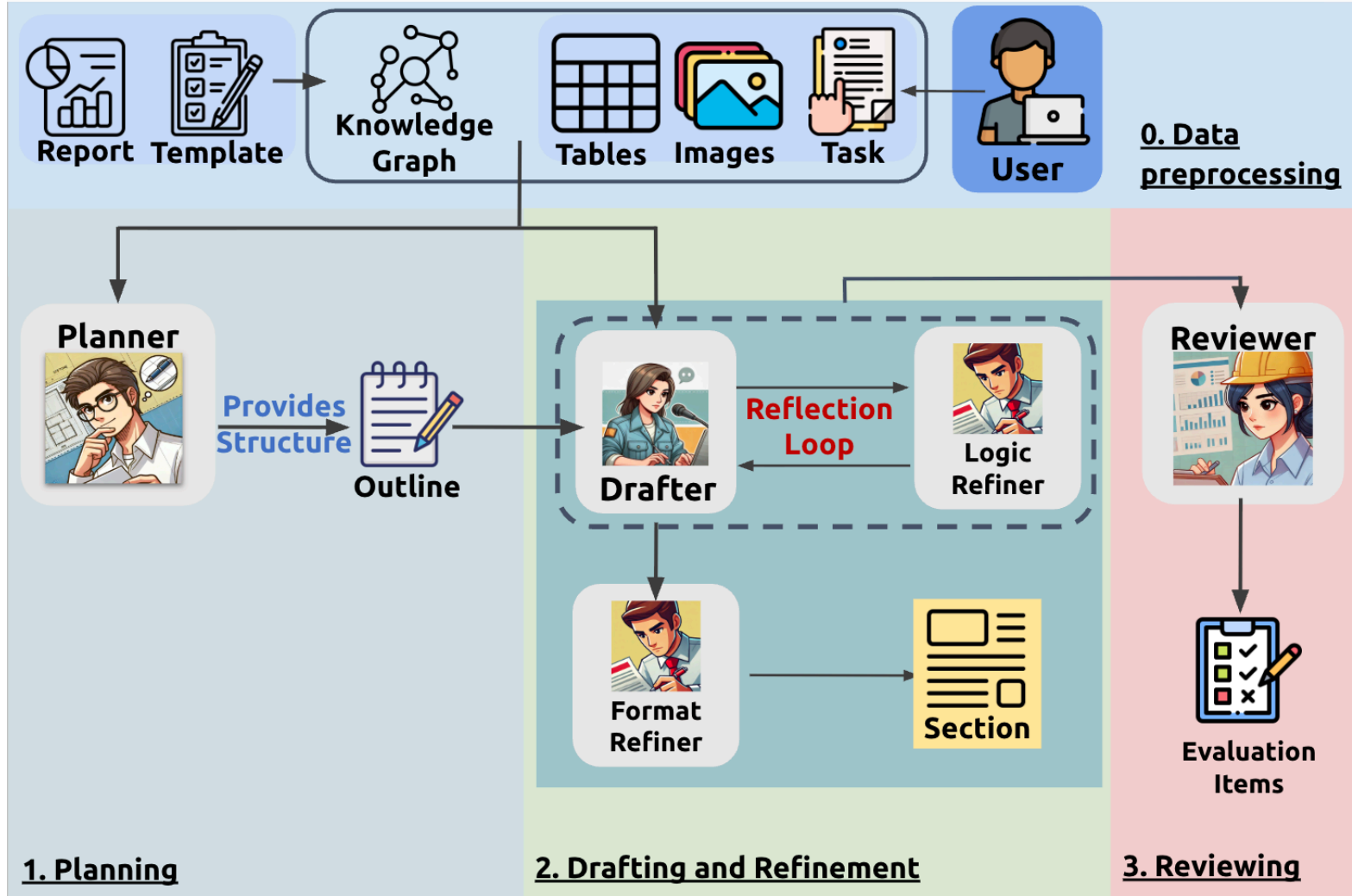
翡翠水庫第五次定期安全評估綜合報告 (臺北翡翠水庫管理局)

Knowledge Graph



- ❑ Historical paragraph texts
- ❑ Report Structure relationship
- ❑ Figure, table, paragraph relationship

Knowledge Graph + Agentic System



4 Stages

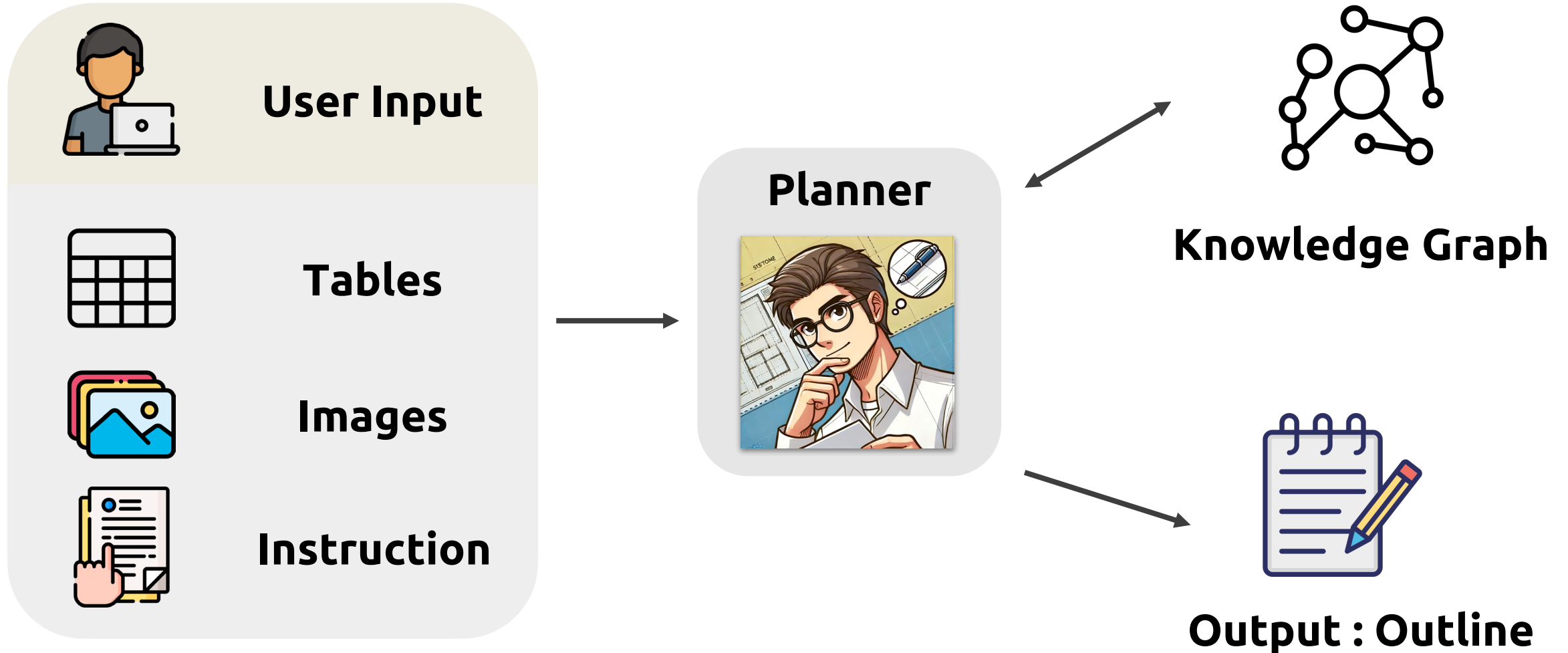
- Data preprocessing
- Planning
- Drafting and Refining
- Reviewing

4 Agents

- Planner
- Drafter
- Refiner
- Reviewer

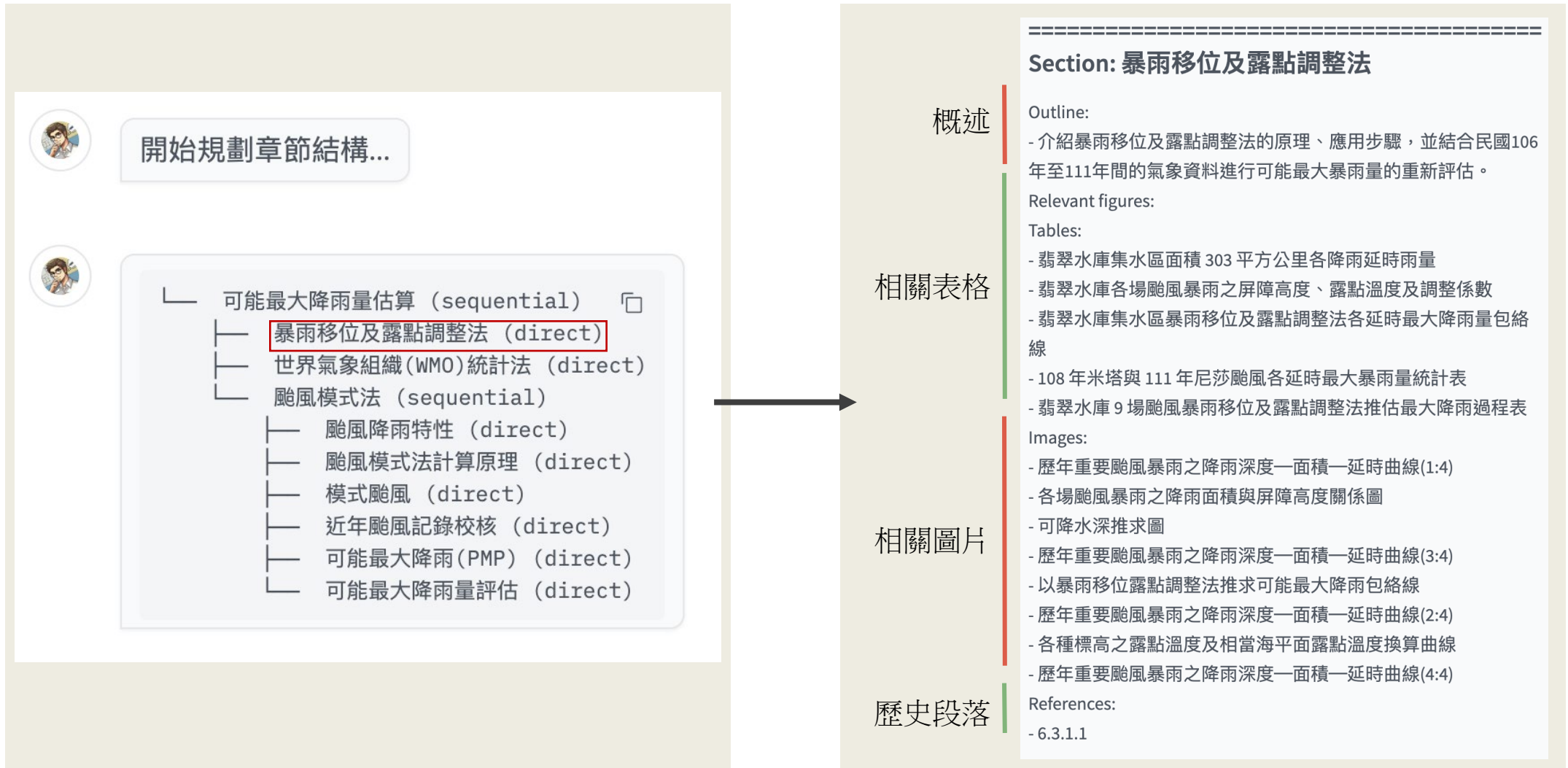
Planning

- ❑ Defines the report scope, selects key sections, and allocates new figures.



Planning

- Decompose the larger task into smaller subtasks.



Step1 登入 Neo4j 資料庫

Neo4j 資料庫 URL

neo4j+s://f315009e.databases.neo4j.io

使用者名稱

neo4j

密碼

.....

登入 Neo4j

登入狀態

Neo4j driver created successfully.

Step2 規劃寫作大綱

選擇章節

重新載入章節列表

當前選擇

尚未選擇章節

Compliance Checking 合規檢查

“Worried your report will **be rejected** for manual non-adherence?”

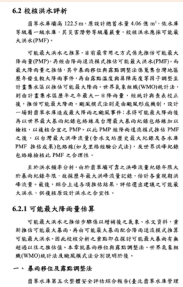


- **Ensure Regulatory Adherence**
- **Validate Comply Internal Alignment with Legal and Industry Standards**

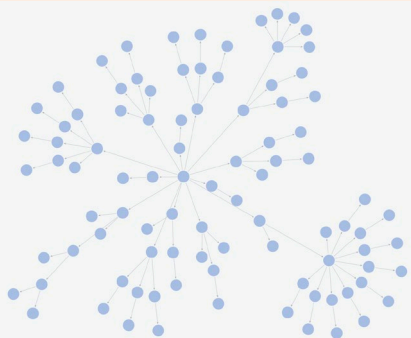


Knowledge Graph + Agentic System

0. User Input



Report



Graph

1. Regulation retrieval



LLM



Checklist

2. Compliance Check



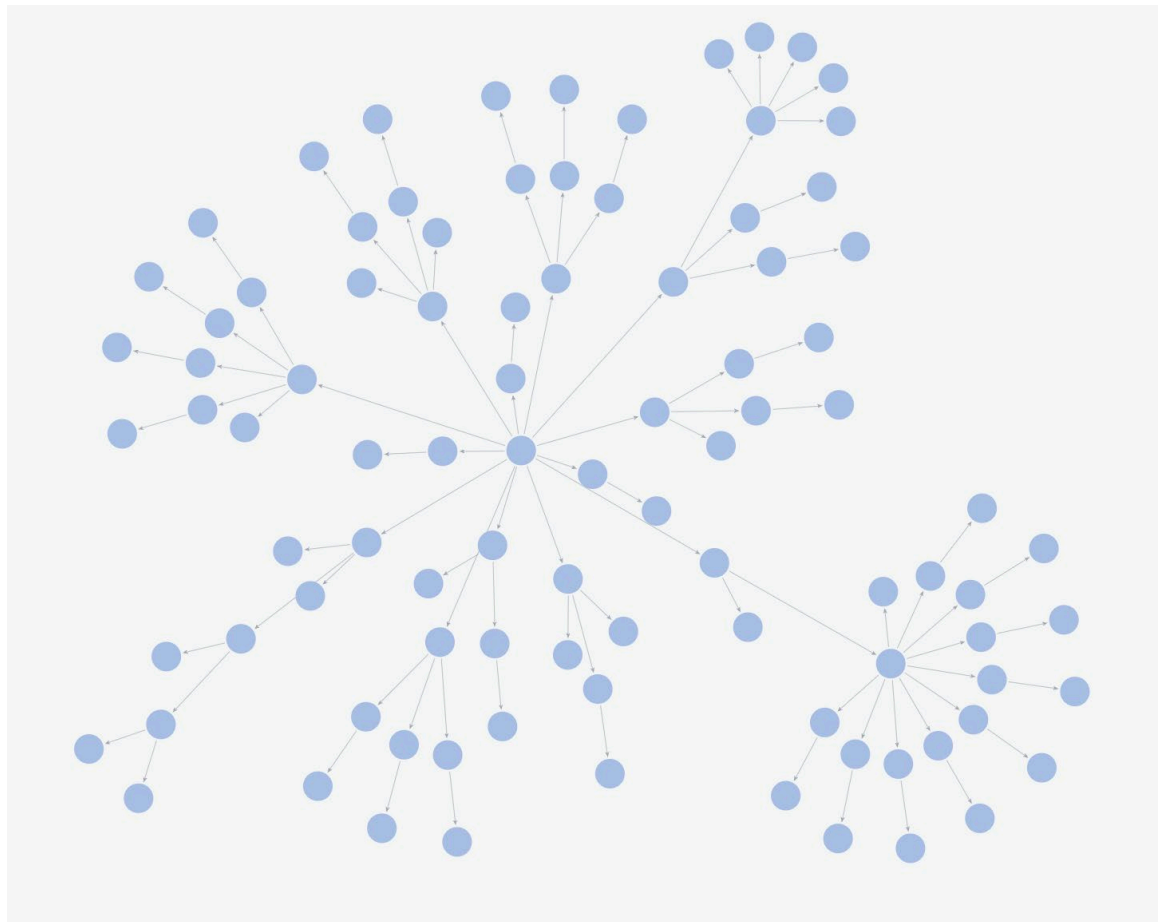
LLM



Check Result

Knowledge Graph

❑ Extract regulatory hierarchy via hierarchical chunking



Chapter 6 校核分析

└ 6.1 通則

└ 6.2 校核分析項目

| └ 6.2.1 校核地震評析

| | └ 6.2.1.1 工作內容

| | └ 6.2.1.2 MCE震源位置及規模

| | └ ...

| └ 6.2.2 校核洪水評析

| | └ 6.2.3 結構物水理評析

Neo4j 資料庫 URL

neo4j+s://0dfe4810.databases.neo4j.io

使用者名稱

neo4j

密碼

.....

登入 Neo4j

登入狀態

Neo4j driver created successfully.

Step2 上傳 PDF 文件

📄 選擇 PDF 檔案



Drop File Here

- or -

Click to Upload

上傳狀態

尚未上傳

上傳 PDF

刪除 PDF

Knowledge Graph + Agentic System

- ◆ **Reduces human errors** and enhances **consistency**
- ◆ **Alignment with domain expertise**
- ◆ **Auto-generates and updates domain knowledge graph database**, easy to expand business operations.
- ◆ **Broad Applicability:** useful for **various engineering tasks**

排水治理規劃檢討報告、治理計畫、出流管制計畫書與規劃書、逕流分擔評估報告、水利建造物檢查報告、各式技術手冊規定檢查 ...

總結與建議。

Summary and Suggestion.

總結 Summary

- **AI 會思考、說人話了：AI 2.0 時代以海量資料預訓練後微調為主要特色，能力足以擔任助理或代理人。** AI is talking and thinking like human: AI models pre-trained on massive data (foundation models) can be fine-tuned to be our useful assistants or agents.
- **從通用 AI 到工程專家：結合 RAG、微調、Agent 流程與知識圖譜，打造懂工程、會思考、能行動的智慧系統。** Integrating RAG, fine-tuning, agentic workflows, and knowledge graphs to build an intelligent system that understands, reasons, and acts in engineering.
- **工程應用案例：** 自動化各種工程任務，例如自動生成工程查驗表單與報告、構建知識圖譜整合領域知識，以及執行合規檢查，大幅提升流程效率與結果的一致性。 AI 2.0 technologies are being applied to automate various domain tasks – for example, automatically generating **inspection forms** (with traceable references to original designs), building **knowledge graphs** to integrate specialized knowledge, and performing **compliance checks** against regulations and design standards – greatly boosting operational efficiency and consistency.



Introduction to Machine Learning and Deep Learning

(2023.09.06 – Now)



以下為您本學期所開的各課程於初選第一階段階段的選課人數 (欲查閱選課名單，請點選課程名稱)

CIE 5133	521 U9230	機器學習與深度學習導論	3	陳俊杉	70	0	201
----------	-----------	-------------	---	-----	----	---	-----

▼ Week 14 - 12/7

Deep Learning for Computer Vision (IV)

📎 20221207 Deep Learning for Computer Vision (IV).pdf

📎 20221207 Deep Learning for Computer Vision (IV)_anno.pdf

Video

🔗 221208 Introduction to Machine Learning and Deep Learning L1

🔗 221208 Introduction to Machine Learning and Deep Learning L2

🔗 221208 Introduction to Machine Learning and Deep Learning L3



陳俊杉 dchen@ntu.edu.tw





臺大土木系博士班

博士班

甄試報名 4/15 截止

- 目標進入人工智慧產業
- 挑戰三年內畢業
- 前兩年每月三萬元獎助金

※ 表現優秀第三年也補助每月三萬元
※ 以土木系陳俊杉、韓仁毓、陳柏華、張家銘、張書璋等指導教授之研究領域為主。

AI研究中心

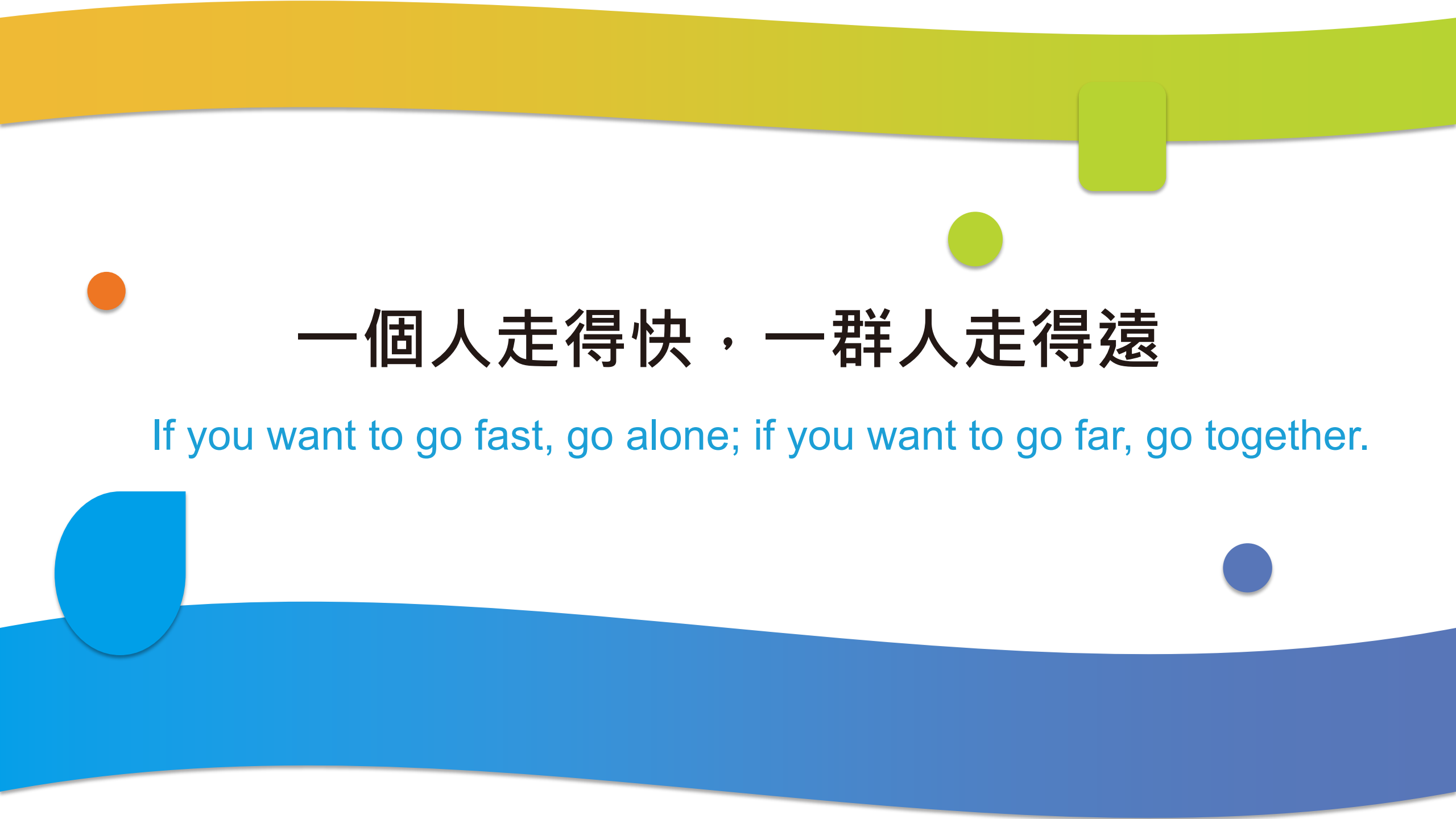
國震中心 與 台大土木 合設

✉ aiengineer@caece.net
🌐 AI.caece.net

Designed by Sunny Yang.

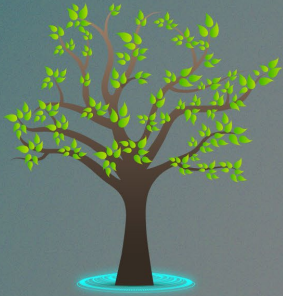
- 臺大土木系博士班於2019招生新增「人工智慧工程應用」領域
- 春季班、秋季班

www.aiengineer.tw

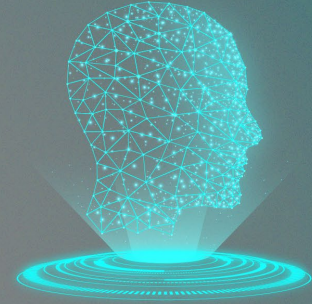


一個人走得快，一群人走得遠

If you want to go fast, go alone; if you want to go far, go together.



Green & Smart



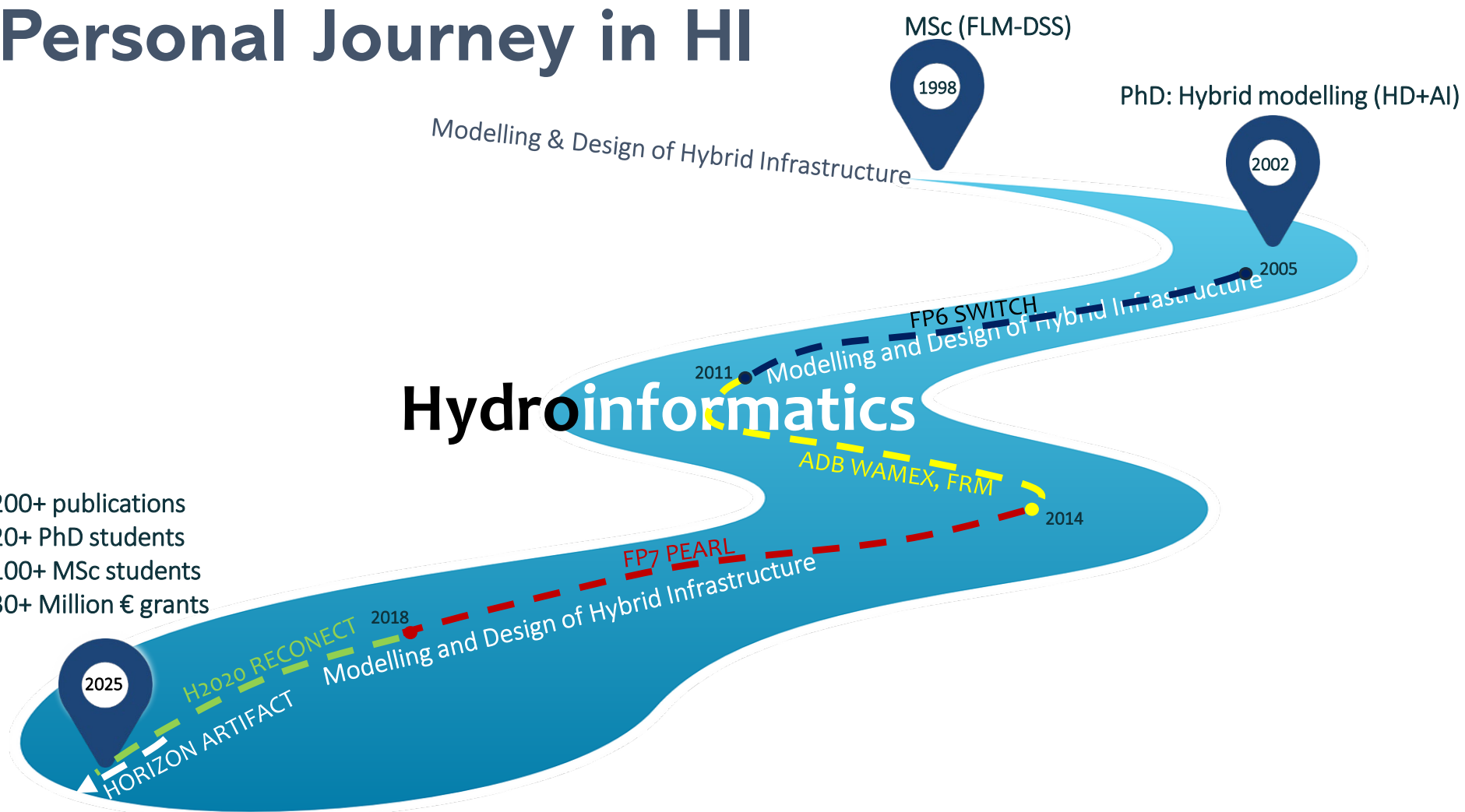
Unlocking Climate Resilience through Nature-Based Solutions and Digital Technology

Prof. Dr. Zoran Vojinovic

IHE Delft (NL), University of Exeter (UK), National Cheng Kung University (Taiwan), Belgrade University (Serbia)

Personal Journey in HI

200+ publications
20+ PhD students
100+ MSc students
30+ Million € grants



Personal Journey in AI/ML/CI/CAS

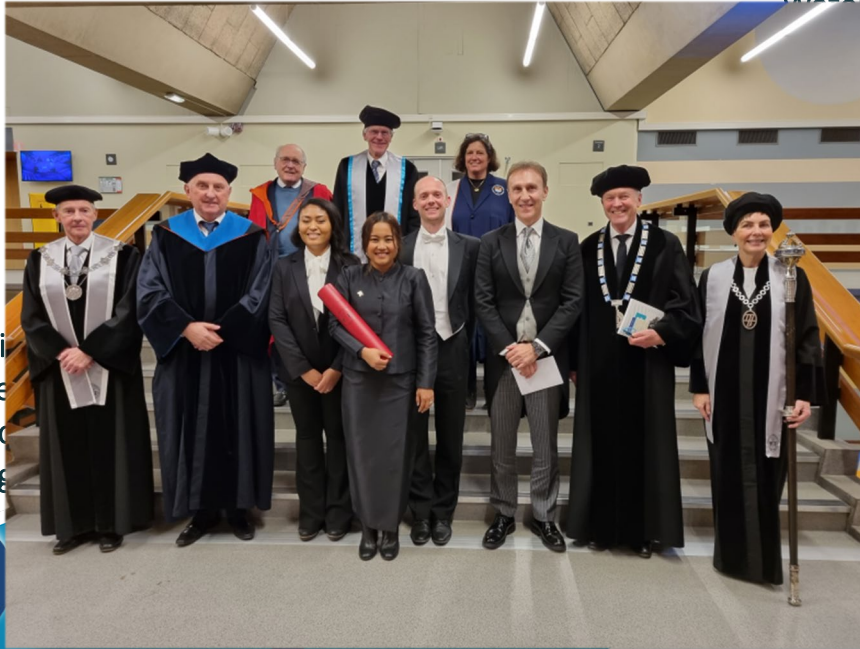
MSc (FLM-DSS)

1998

PhD: Hybrid modelling (HD+AI)

2002

Genetic Algorithms – Urban
Water Systems



200+ publications
20+ PhD students
100+ MSc students
30+ Million € generated

2025



Best Cum Laude Thesis 2021

URBANISATION



WEATHER EXTREMES

Floods in Europe 2021



Liege, Belgium, July 15, 2021.
Source: BRUNO FAHY, BELGA/AFP VIA GETTY IMAGES



Verviers, Belgium, July 15, 2021.
Source: GETTY IMAGES

Floods in Europe 2021

- Deaths: 243
- Property damage >€10 billion
- 200,000 properties left without power



SIMBACH AM INN, GERMANY - JUNE 03.
Source: Sebastian Widmann/Getty Images)GETTY IMAGES



Ahr river in Insul, western Germany.
Source: MICHAEL PROBST/AP

Netherlands 2021



Summer 2021



Spring 2021

Summer 2022 - Rhine

- During the 2022 summer (drought) the lowest measurement was 700 m³/s
- After one week of rain it is 1,300 m³/s
- After 3 weeks of rain it is 2,000 m³/s
- The average flow throughout the year is 2,300 m³/s



Beusichem harbour, summer 2022.

Source: EPA-EFE/JEROEN JUMELET

Summer 2022 – Rhine

5th September, Nijmegen



Meuse discharge:

-
- The map illustrates the Dutch Delta region, showing the North Sea to the west and various islands and polders. Major rivers like the Rhine, Meuse, and Scheldt are depicted. Key locations marked include Rotterdam, Amsterdam, and Eindhoven. Numerous projects are labeled, such as 'Dijkverbetering Oude Maas/Hoeksche Waard', 'Kribverlaging Waal Fort St. Andries', and 'Duikverbetering Bergsche Maas/Land van Altena'. The map also shows the 'Haringvliet' and 'Zuiderklip' areas.



Drought in the Netherlands

Rhine river, near Gendt in the Netherlands: 2021 - 2022



On 3 August 2022, official **water shortage** declared.

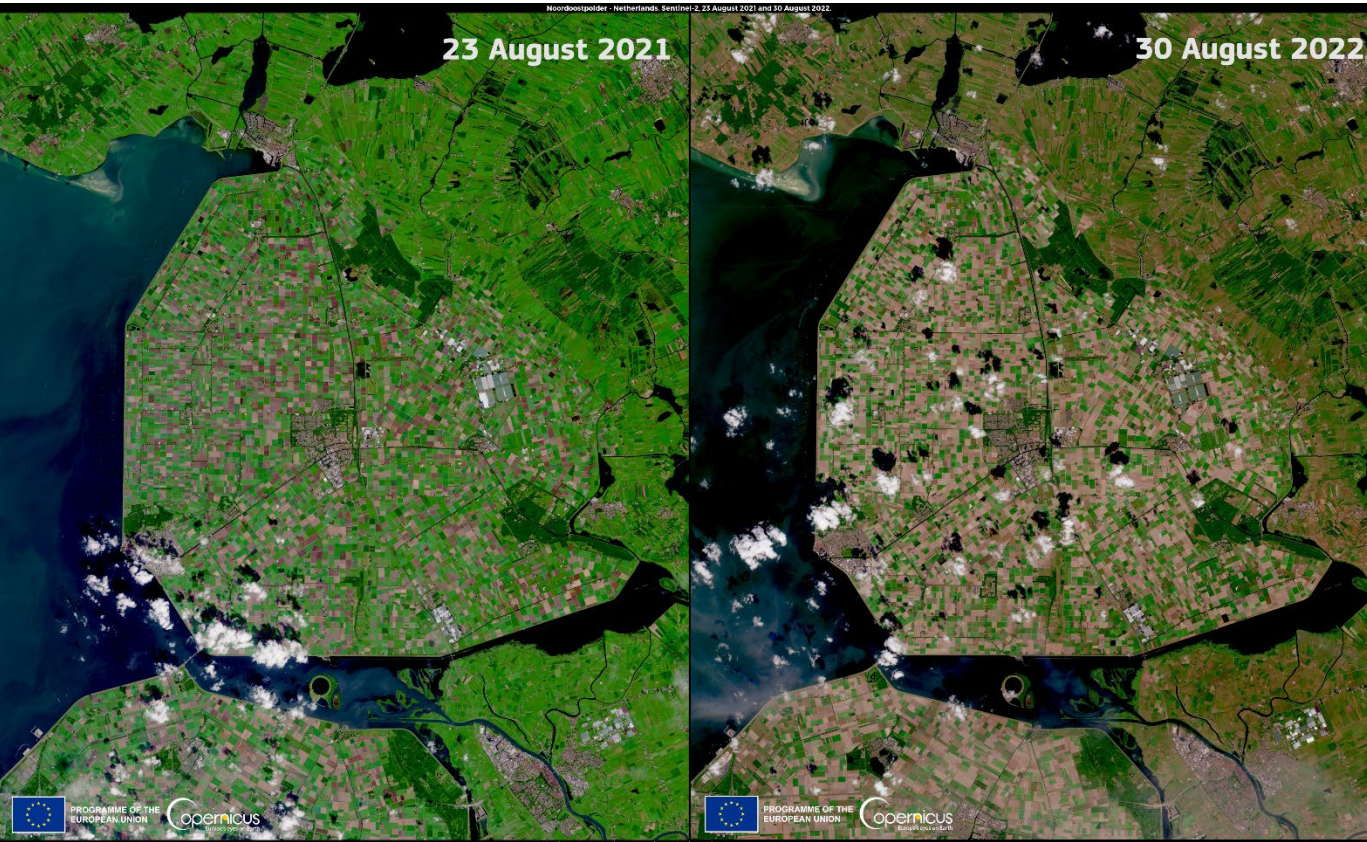
A **redistribution of water** to ensuring water supply to the dykes, the peat bogs and very vulnerable natural areas.

In the Rhine River measurements at the beginning of August in Lobith, a town on the German border, showed that the river is approaching its **lowest flow level ever recorded**.

European Union,
Copernicus Sentinel

Drought in the Netherlands

Noordoostpolder in the Netherlands



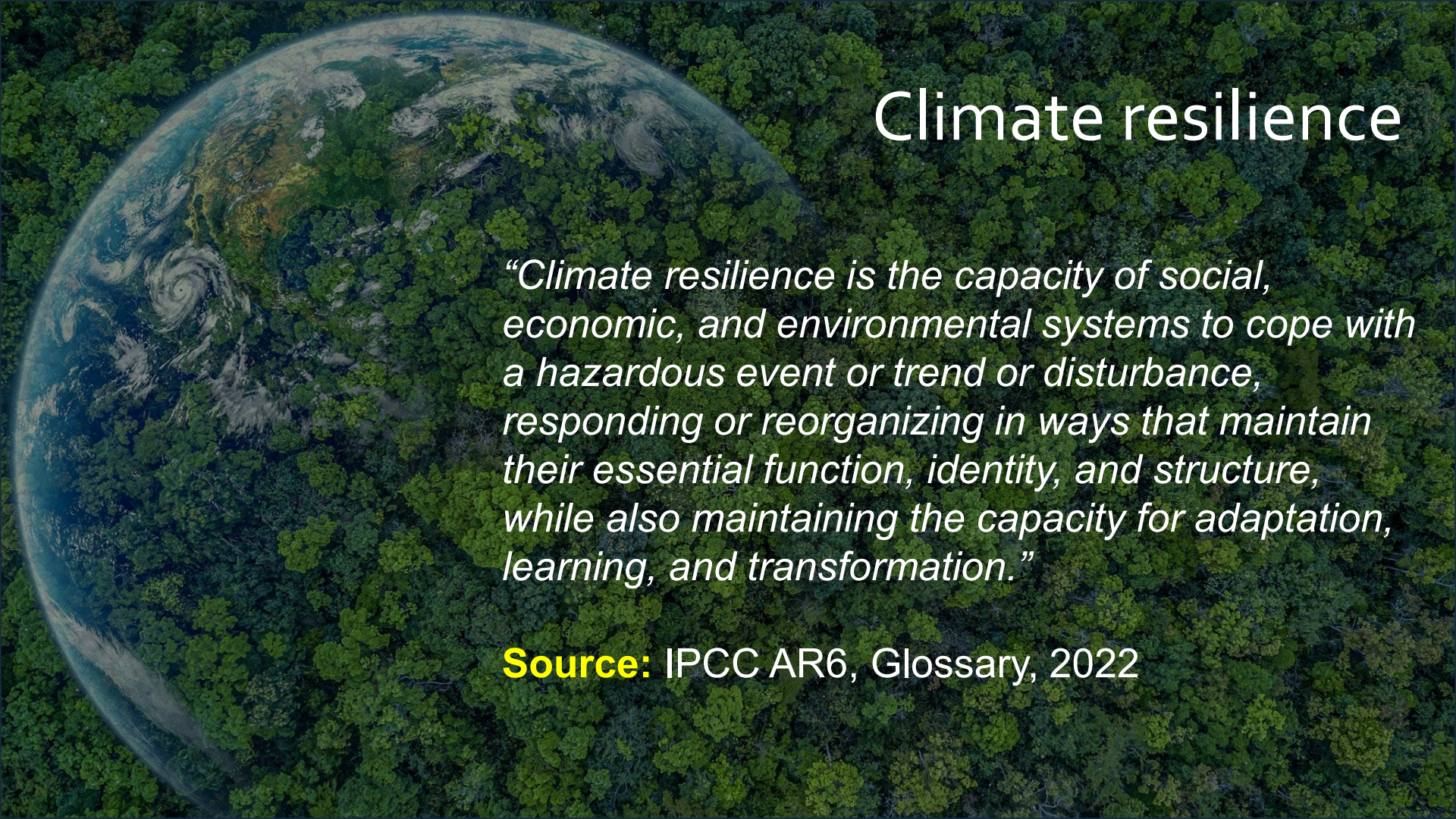
Evidence of the **severe drought** that is affecting the Noordoostpolder in the Netherlands.

Noordoostpolder is a predominantly **agricultural area**.

The **area has turned brown** due to the absence of vegetation.

Due to the drought and crop failures, there are **problems with the production of animal feed**, as well as a **lack of water reserves** used by the local fauna.

European Union,
Copernicus Sentinel



Climate resilience

“Climate resilience is the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.”

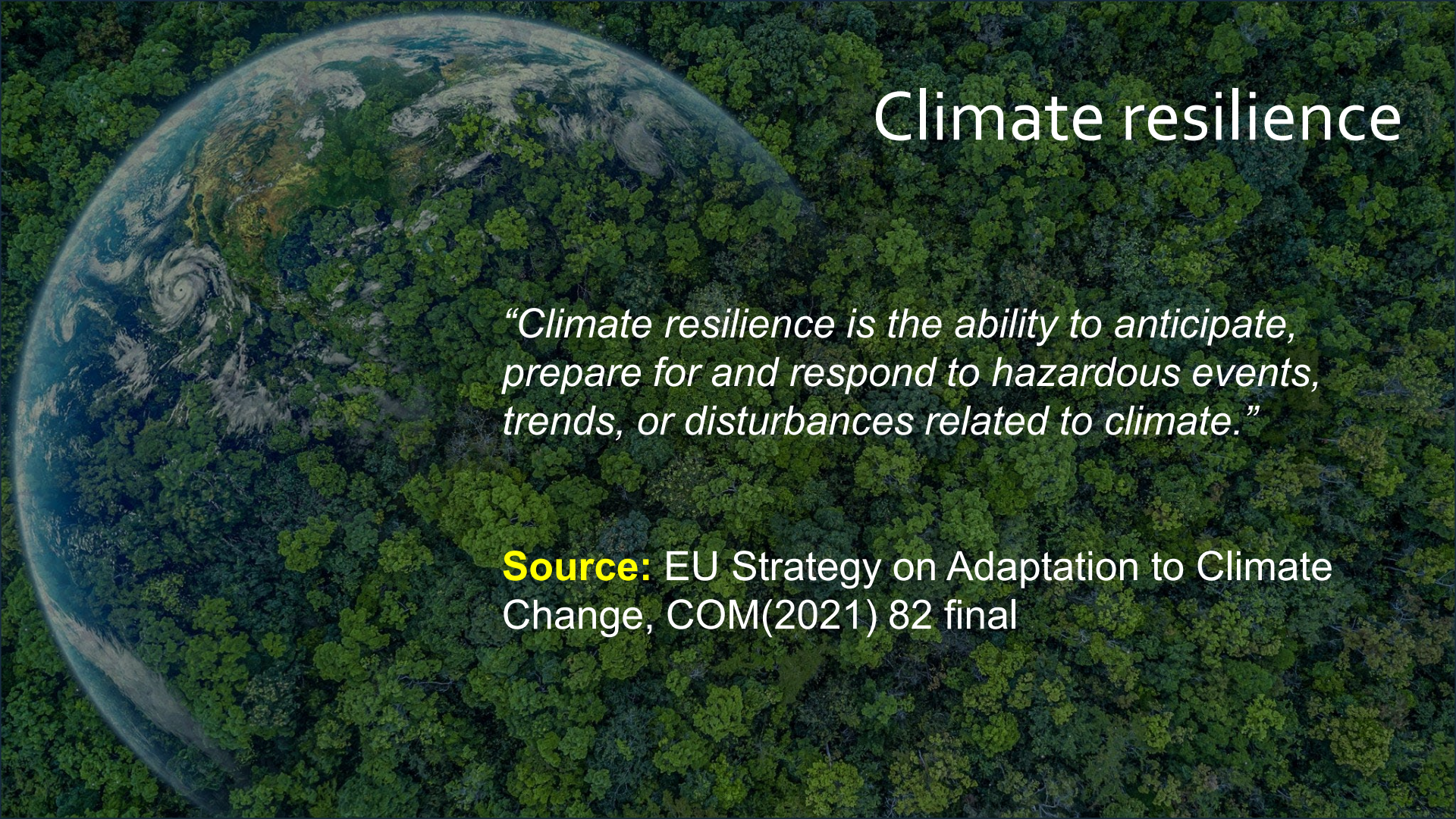
Source: IPCC AR6, Glossary, 2022



Climate resilience

“Climate resilience refers to the ability of systems and communities to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner.”

Source: UNFCCC Resilience Framework



Climate resilience

“Climate resilience is the ability to anticipate, prepare for and respond to hazardous events, trends, or disturbances related to climate.”

Source: EU Strategy on Adaptation to Climate Change, COM(2021) 82 final



Key Capacities

1. *Anticipatory Capacity: foresee, assess, and prepare*
2. *Absorptive Capacity: withstand and absorb*
3. *Adaptive Capacity: adjust and learn*
4. *Transformative Capacity: systemic and structural changes*

Climate Resilience Solutions

- Grey/NBS



- *Social*
- *Governance*

Climate Resilience Solutions

Grey Infrastructure

- Engineered structures
- Protection and hazard control
- Resistance-based
- Low flexibility
- Often short- to medium-term
- Sudden and catastrophic
- Limited — mainly hazard reduction.

Nature-Based Solutions (NBS)

- Use or mimic natural processes
- Risk reduction and ecosystem rest.
- Adaptation and absorption
- High flexibility
- Can provide long-term resilience
- Gradual degradation
- Multiple — hazard reduction

Climate Resilience Solutions

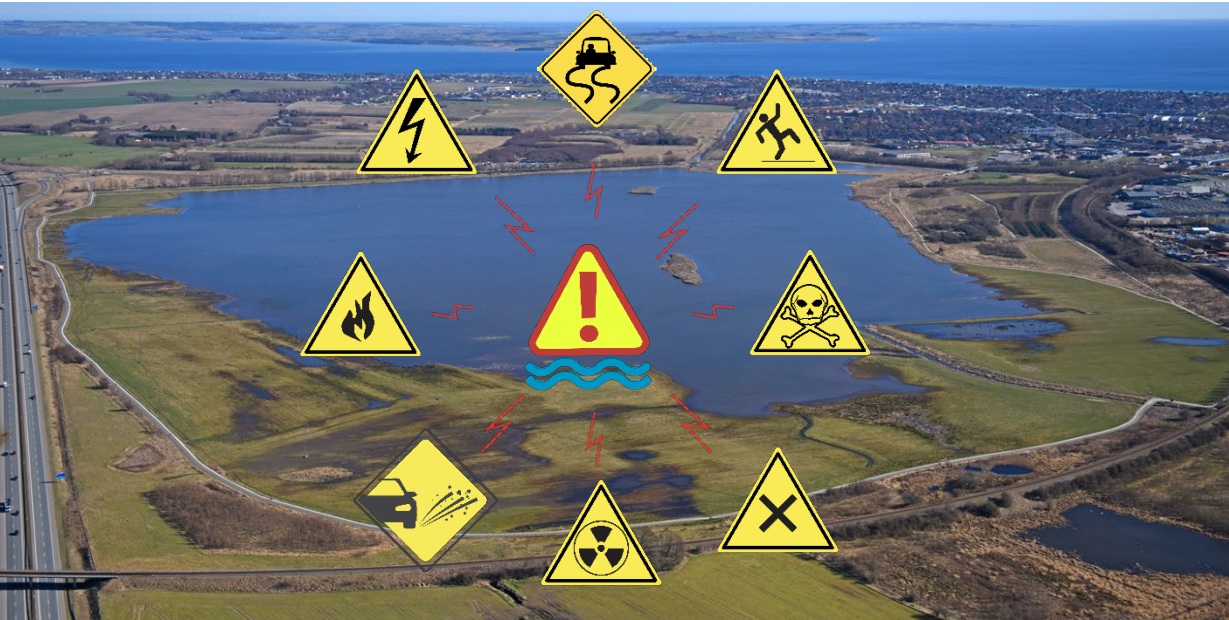
Grey Infrastructure

- Economy is typically high, due to material production (concrete, steel) and construction processes.
- Can be scaled easily but not context-sensitive; performance often declines outside design conditions.

Nature-Based Solutions (NBS)

- Economy is typically low or negative, due to carbon storage in vegetation and soils.
- Highly context-dependent but replicable through adaptive design tuned to local ecological and social conditions.

Greater Aarhus Area, Denmark



- Multiple benefits and co-benefits
- Multiple hazards
- Compounding risks
- Cascading risks



The next phase of NBS innovation?

- 
- An aerial photograph of a city landscape. In the foreground, a white, modern pedestrian bridge with railings spans a lush green area. A river flows through the middle ground, reflecting the sky. In the background, a dense urban skyline with various high-rise buildings is visible, set against a backdrop of mountains under a cloudy sky.
- Advancing the knowledge of Processes (technological aspects)
 - Scale (of implementation)
 - Multifunctionality (benefits and co-benefits, energy-water nexus)
 - Effectiveness from single and integrated solutions
 - Better integration with ecosystems
 - Holistic assessment
 - Enhancement of effectiveness and benefits through **digital technologies**



**Quantity of information
available nowadays is
unprecedented in human
history!**

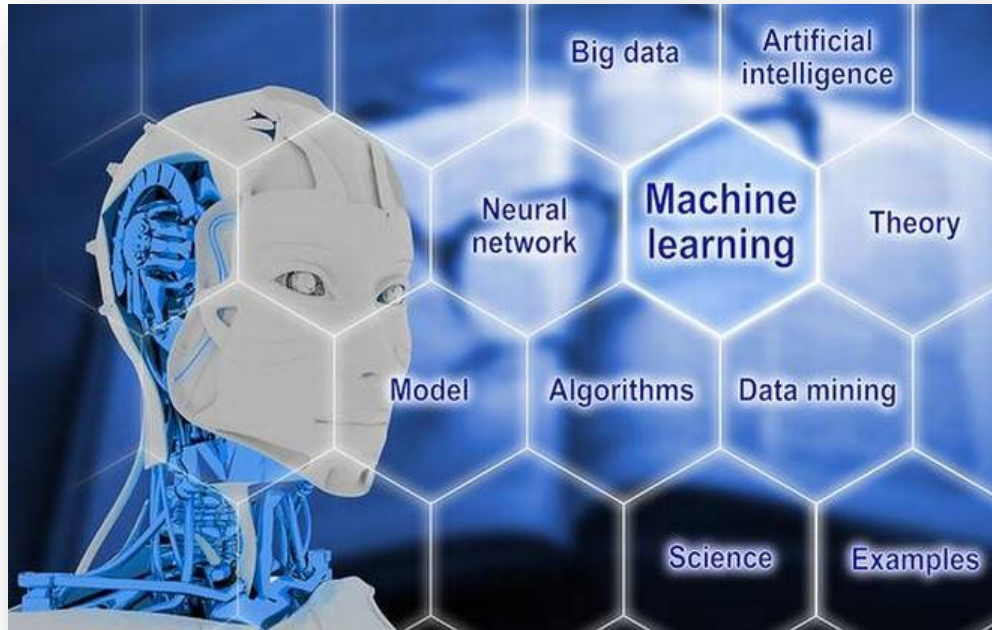
A close-up photograph of a person's hand, wearing a white lab coat, adjusting a complex scientific instrument. The instrument features a large, circular, silver-colored lens or viewing port with a black handle. Various sensors, cables, and mechanical components are attached to the device. A red label with the text "SYSTEM PERFORMANCE APPROVED" is visible on the side. The background is a blue surface, possibly a lab bench.

Ability to measure,
sense and monitor
the condition of
almost everything!

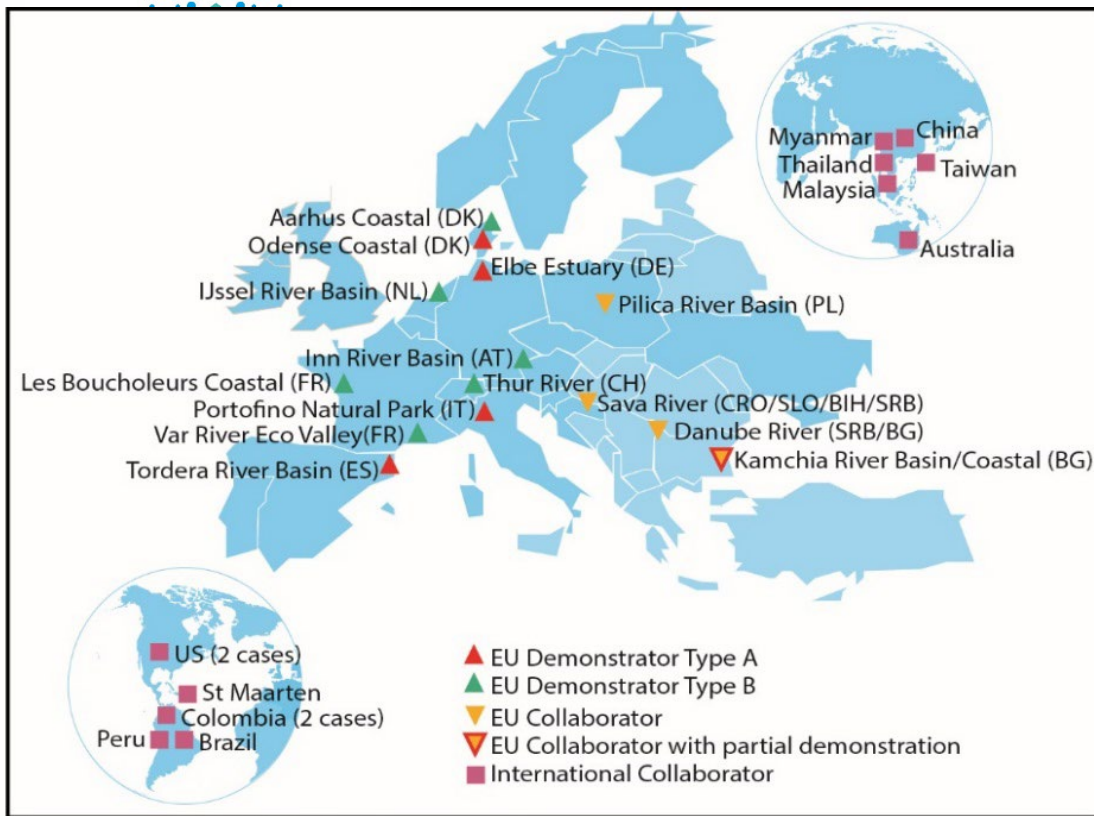
**Connected devices and
digital services
transforming many
aspects of our world**



Artificial Intelligence, Machine Learning, Computational Intelligence (Hybrid AI), Complex Adaptive Systems



- ANNs, CNNs, RNNs, PINNs, GNNs, SVMs, RF, GBM,
- Evolutionary algorithms
- Fuzzy logic
- Nonlinear dynamics, chaos theory and fractals
- CAS, Agent-Based Models,
- Generative AI,
- Cellular Automata



systems with tions for ical risk rEduCTion

- 35+ partners
- 10 EU demonstrators
- 5 EU and 12 Intl collaborators
- 6 years, started in 2018

H2020

3rd Health Programme

Types of action: IA Innovation action

DeadlineModel: two-stage

Opening date: 08 November 2016

Deadline:

07 March 2017 17:00:00

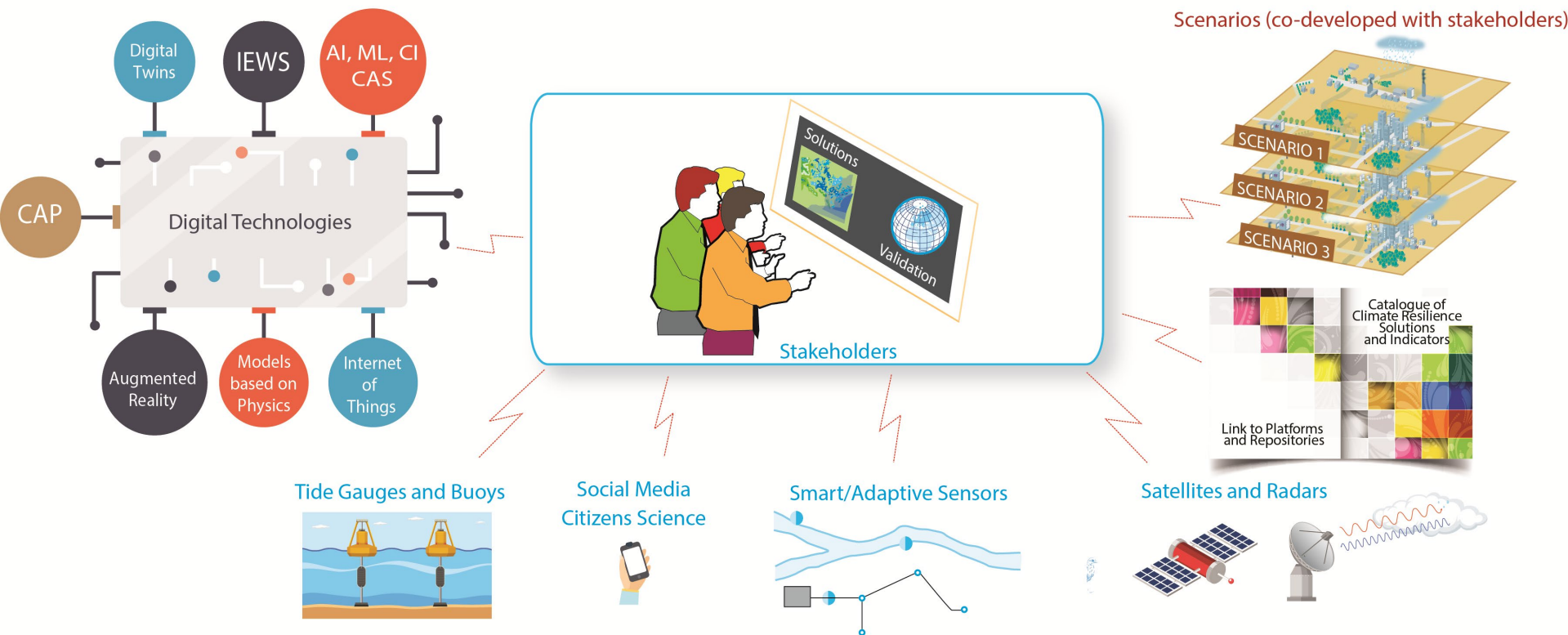
2nd stage Deadline:

05 September 2017 17:00:00

Time Zone : (Brussels time)



Digital Solutions

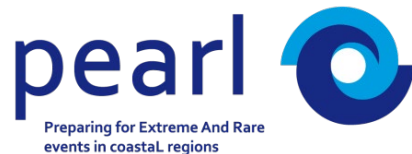


Key outputs

- Indicators and evaluation methodologies,
- Digital solutions for monitoring, planning and evaluation,
- Methodologies and design guidelines,
- Barriers/enablers, business models,
- Evidence-base from 9 NBS demonstration cases,
- Prefeasibility studies in 16 collaboration/replication cases
- 70 deliverables, 70+ publications,
- MOOCs,
- National policy influence,
- International Conference on NBS.



References:



Monitoring Nature-Based Solutions

← → ↺ https://www.telecontrolnet.nl/v3/go/main#content:content/loc/01/process;sidebar:navigator

File Alarms Overview Management View Help

Navigation

Find object

- RECONNECT
 - 1 - Demo
 - 01 - Public websites
 - DA1 - German Demonstrator
 - DA2 - ODENSE Denmark
 - DA3 - ACA Spain
 - DA4 - PORTOFINO Italy
 - DB1 - TAUW Netherlands
 - DB2 - UIBK Austria
 - DB3 - Amphi Denmark
 - DB4 - EAWAG Switzerland
 - DB5 - UNSA France
 - DB6 - UNSA France
 - EC1 - BDCA Bulgaria
 - EC2 - ERCE Poland
 - EC3a - PRONING Croatia
 - EC3b - UNBELGR Serbia
 - EC3c - UNBELGR Serbia

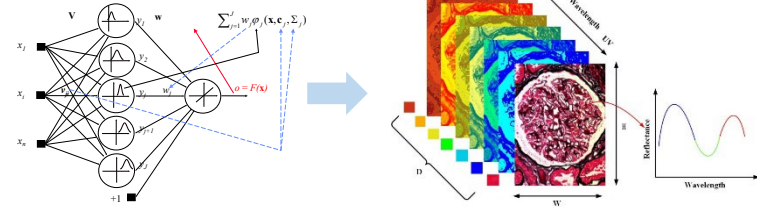
Characteristics Public websites Logbook Map Archive 01 - Public websites

US (2 cases)
St Maarten
Colombia (2 cases)
Peru
Brazil

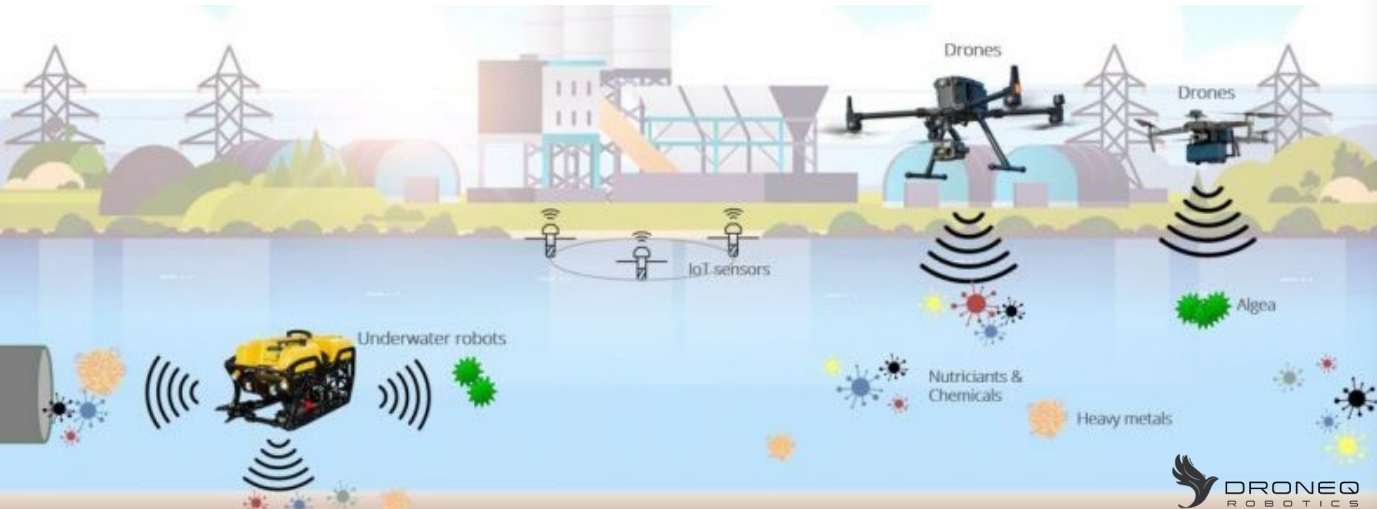
EU Demonstrator Type A
EU Demonstrator Type B
EU Collaborator
EU Collaborator with partial demonstration
International Collaborator

RECONNECT

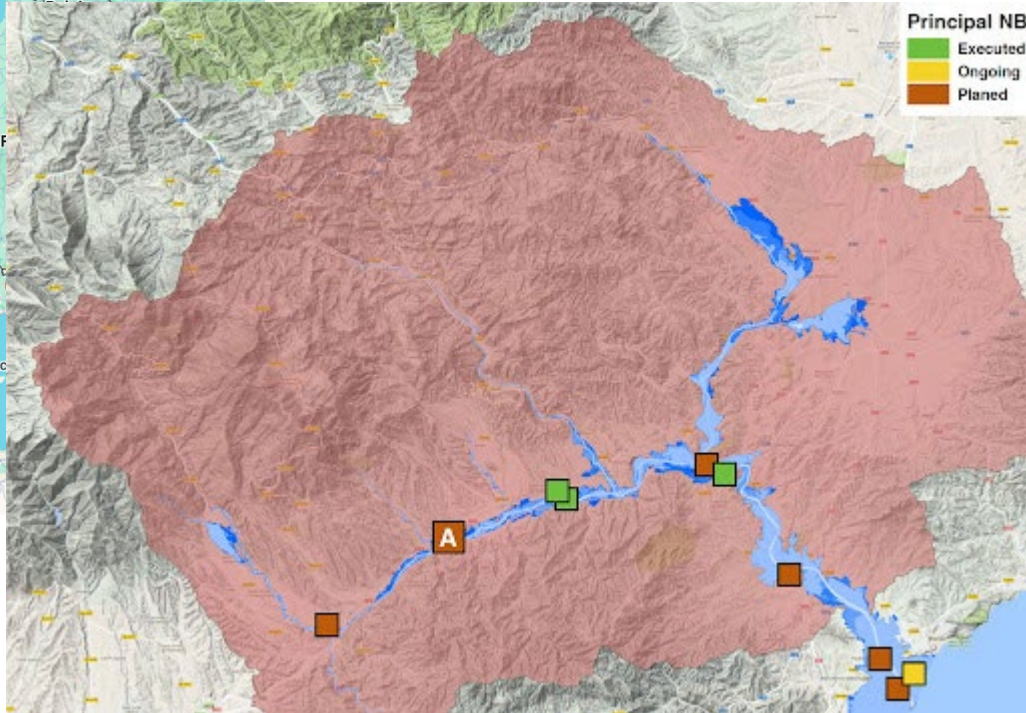
Underwater robots, drones, IoT and AI for water quality measurements



taking images via hyperspectral cameras > AI (spectroscopy)

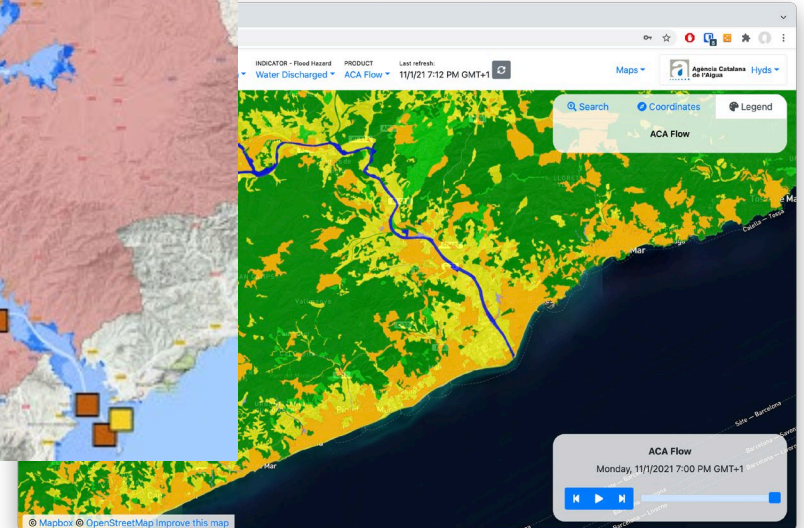


Two catchment areas outside of Barcelona

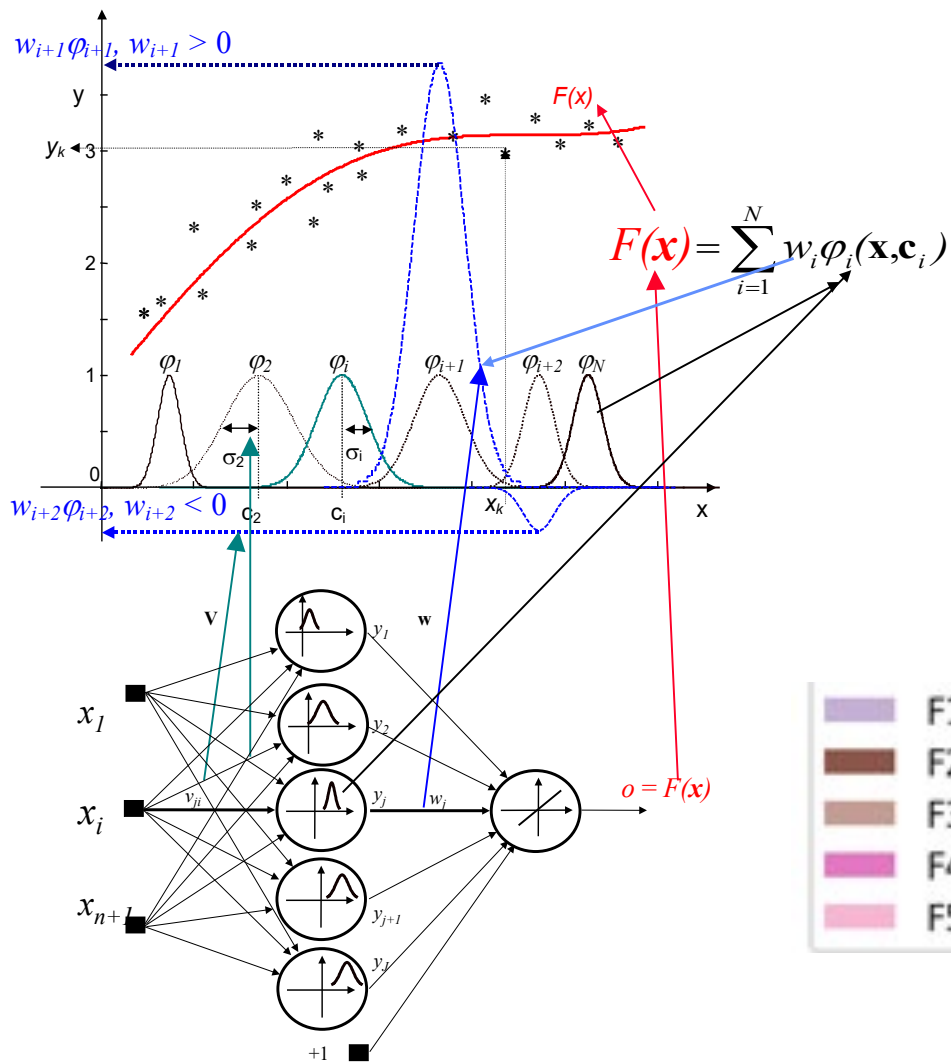


Measures:

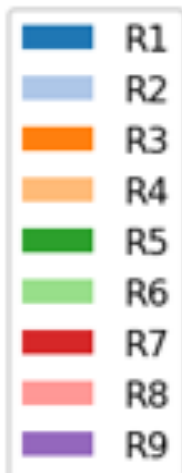
- Room for the River NBS
- Digital solutions
- Social, Governance



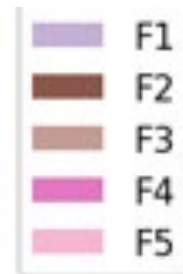
SVM



Rainfall



Flow

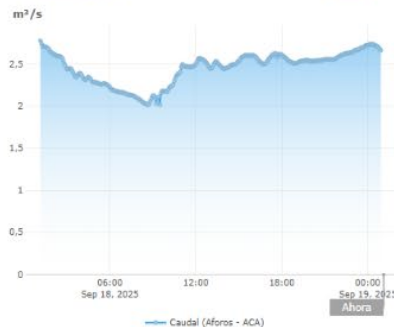


- 56,000 values per rain station
- 340,000 values per flow station
- Flow averaged to 30min averages

Santa Coloma de Gramenet (riu)

Caudal (Aforos - ACA)

2.7 m³/s



Aforament simulat del Riu Besòs

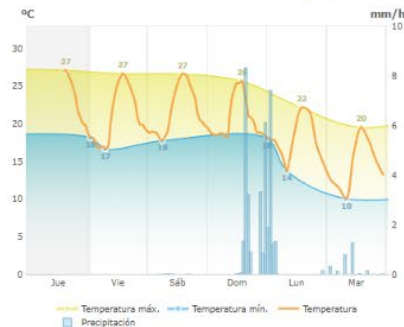
Caudal (Aforos simulats - IHE)

2.5 m³/s



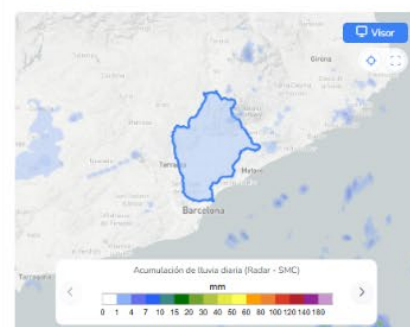
Meteorograma

ECMWF



Acumulación diaria de lluvia

Radar - SMC

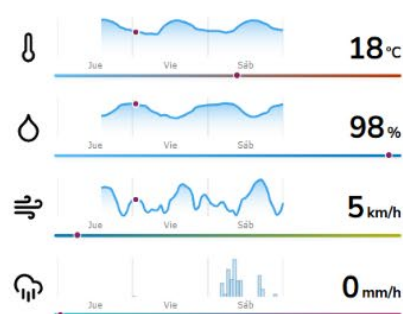


Resumen de alertas



Clima actual

ECMWF



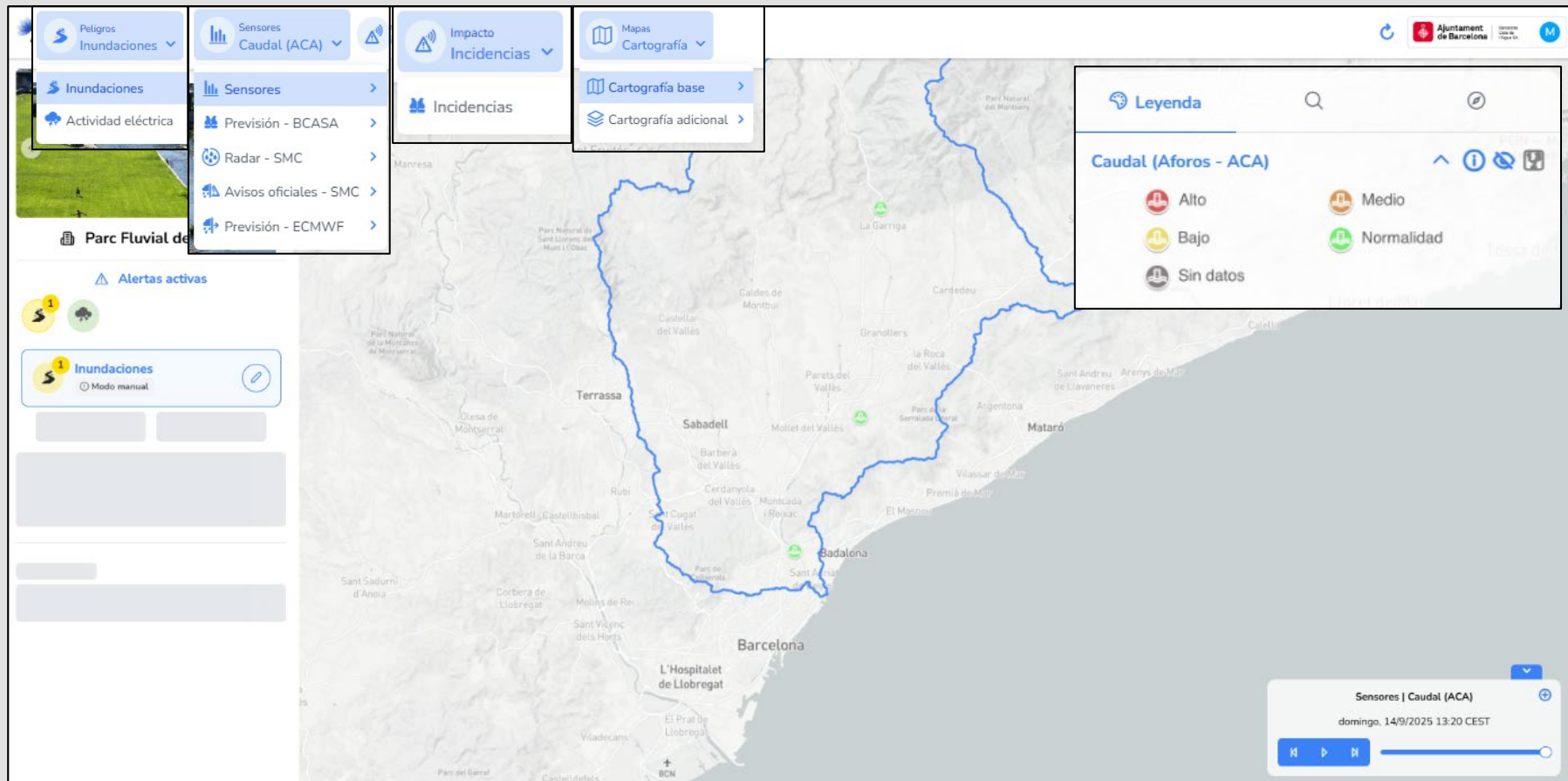
Resumen de avisos

Avisos oficiales - SMC

No hay avisos activos para los próximos 3 días

Cámara

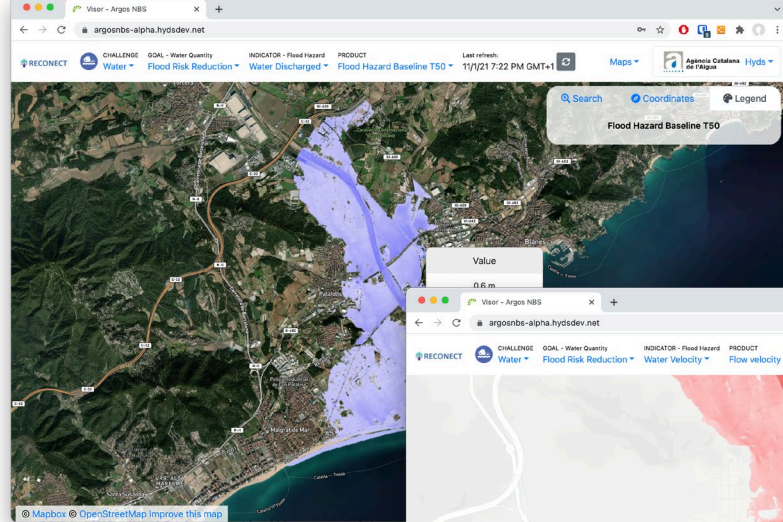
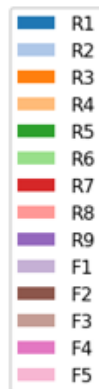




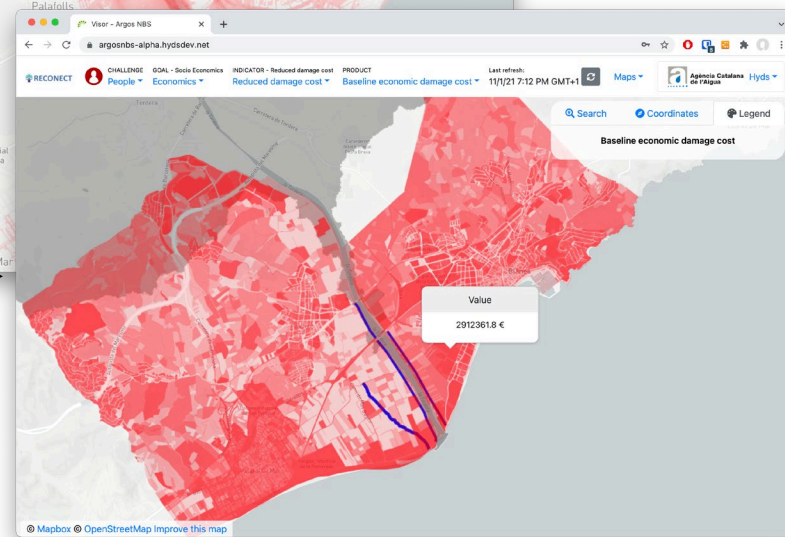
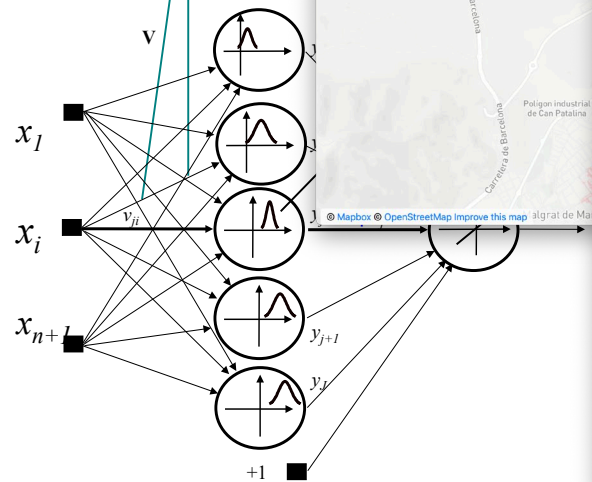
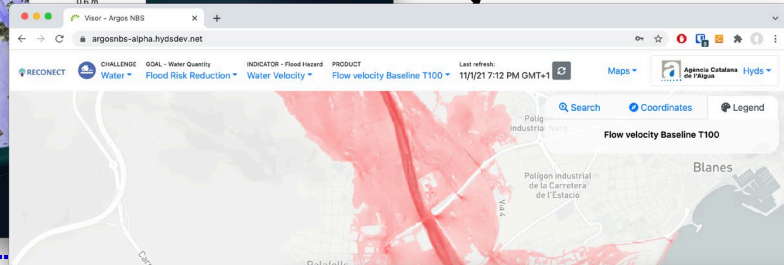
SVM - HD

Rainfall

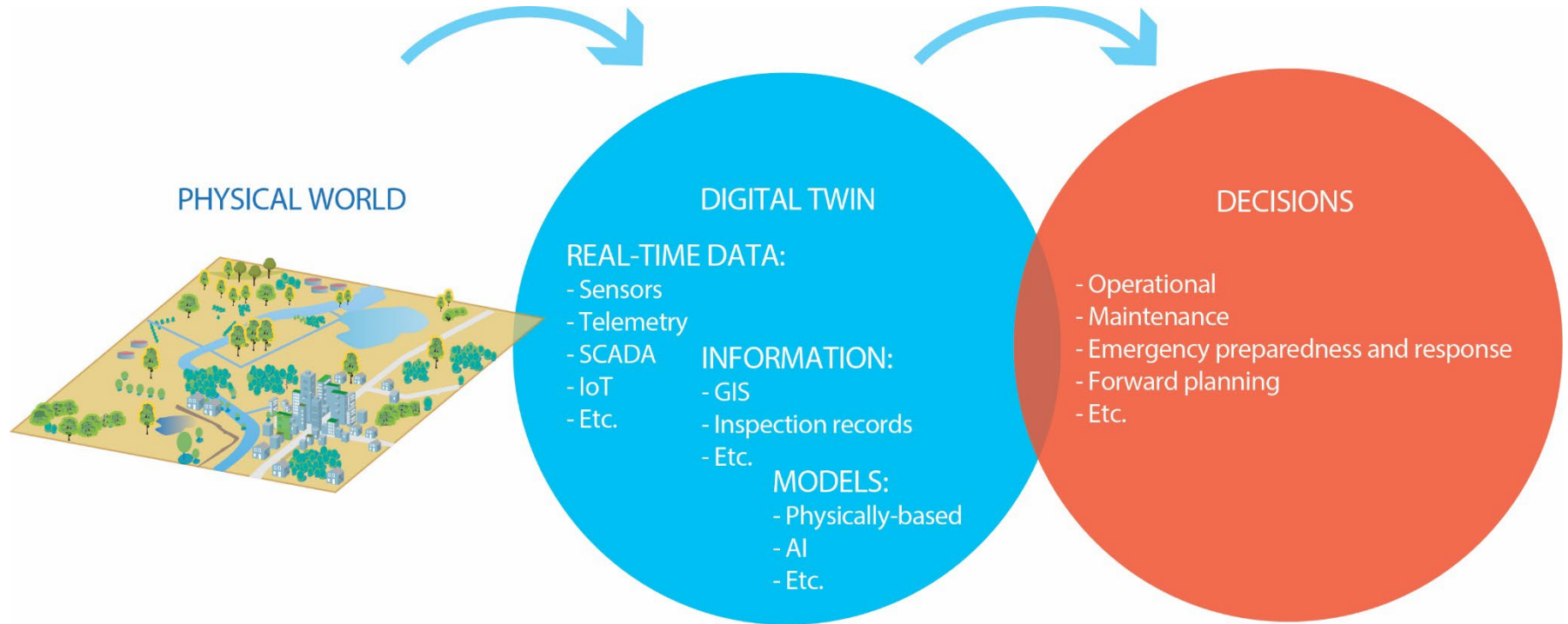
Flow



$$w_i \varphi_i(\mathbf{x}, \mathbf{c}_i)$$



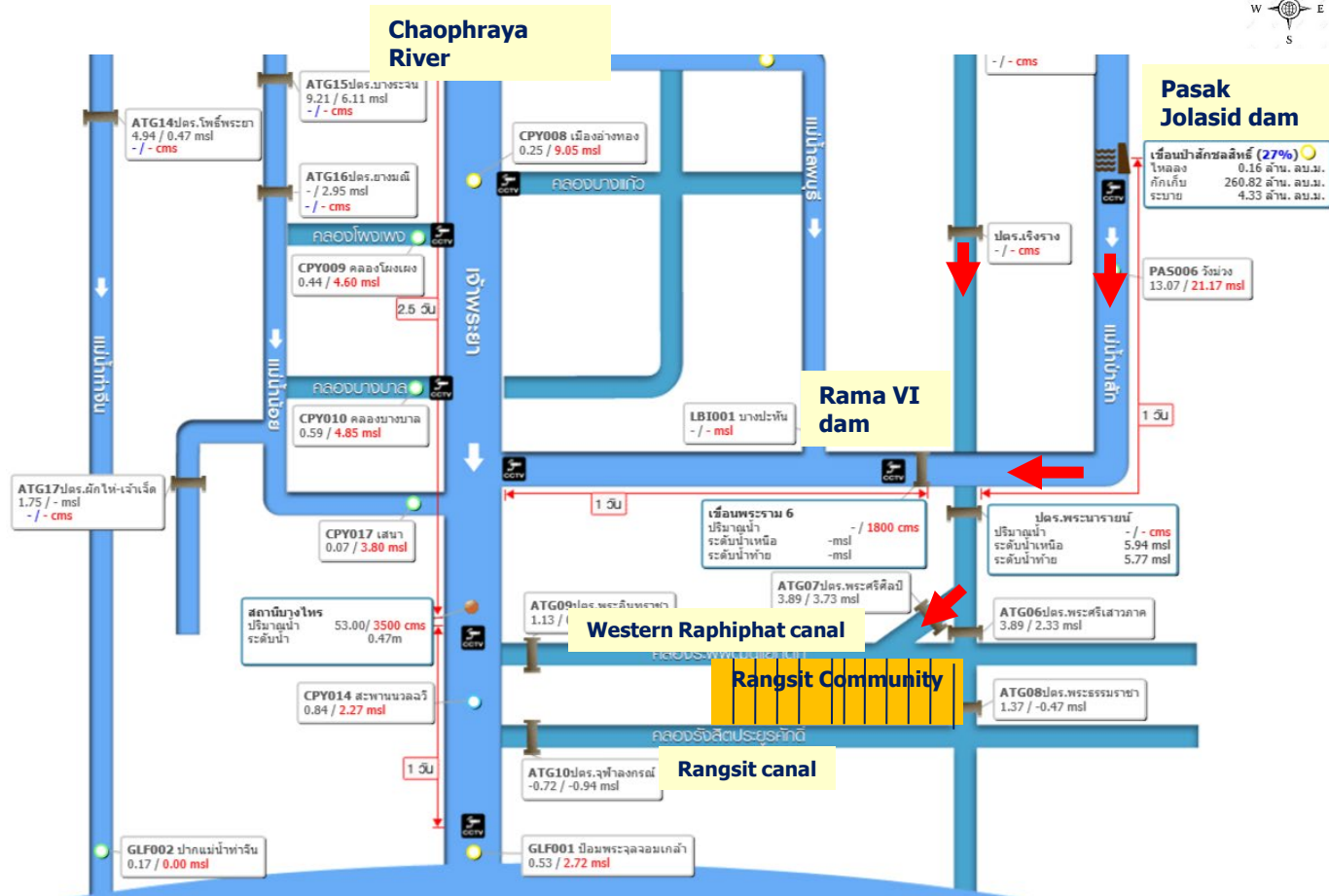
From *Data Assimilation* to *Digital Twins*



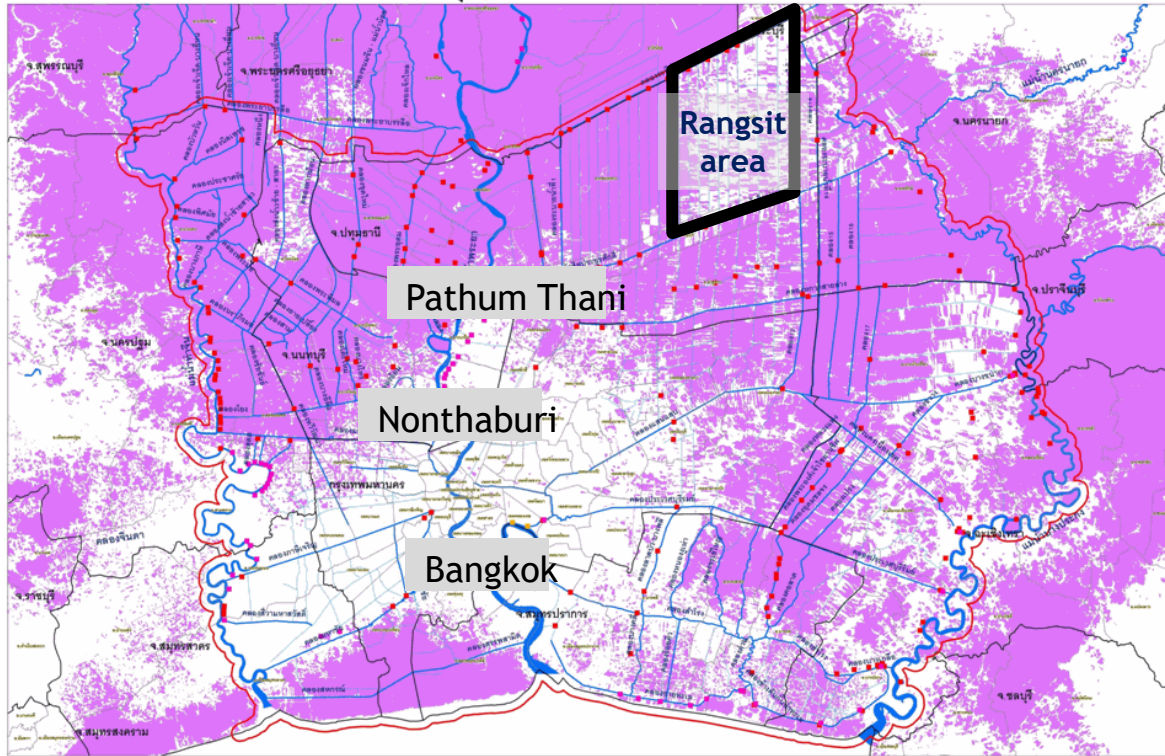
Rangsit Community, Phathumthani, Thailand



Rangsit community irrigation canal network



Extreme Event: Chao Phraya Flood 2011



During Thailand's severe flood in 2011, Rangsit community (in pink area) was **not flooded** by upkeeping the canal networks



Research article

Real time control of nature-based solutions: Towards Smart Solutions and Digital Twins in Rangsit Area, Thailand

Laddaporn Ruangpan ^{a, b}  , Mosaab Mahgoub ^b, Yared Abayneh Abebe ^b, Zoran Vojinovic ^{b, c},
Surajate Boonya-aroonnet ^e, Arlex Sanchez Torres ^b, Sutat Weesakul ^{e, f}

[Show more](#) 

[+](#) Add to Mendeley [Share](#) [Cite](#)

<https://doi.org/10.1016/j.jenvman.2023.118389>

[Get rights and content](#)

Under a Creative Commons [license](#)

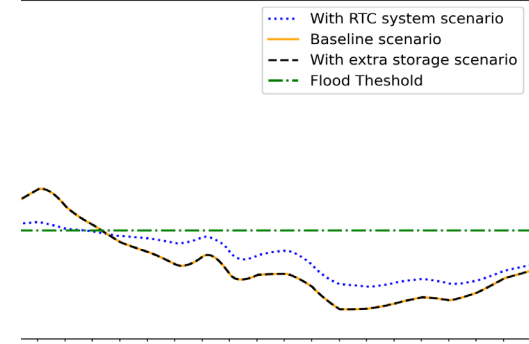
 Open access

Highlights

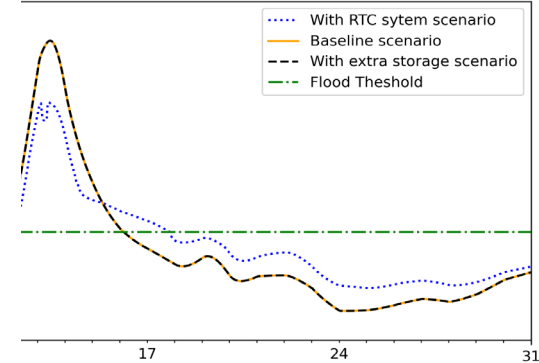
- Towards a Smart Solution by using Real Time Control (RTC).
- The potential of using RTC to improve the operation of the irrigation and drainage system.
- RTC can help to improve the effectiveness of NBS from passive to



1) Normal flood scenario

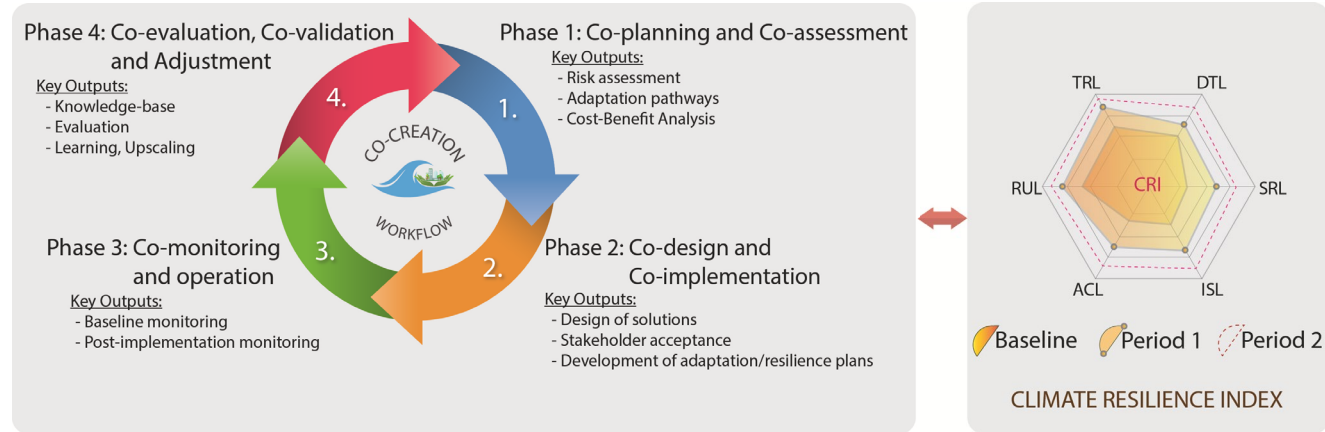


3) Extreme flood event

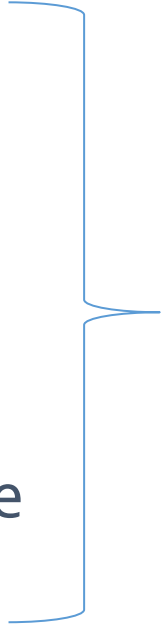


Working Towards Climate Resilience – A Framework

- Grey/NBS
- Digital
- Social
- Governance



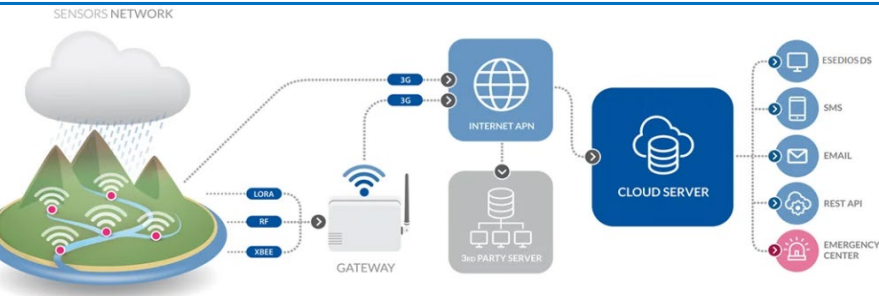
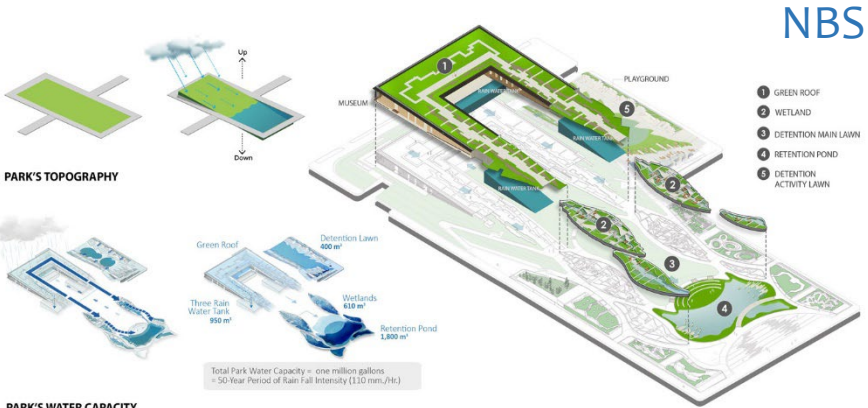
Climate Resilience Framework

- **Grey/NBS**
 - **Digital**
 - **Social**
 - **Governance**
- 

Climate Resilience Index

- Technology Readiness Level (TRL),
- Digital Twin Level (DTL),
- Societal Readiness Level (SRL),
- Impact & Sustainability Level (ISL),
- Adaptive Capacity Level (ACL), and
- Replicability & Upscaling Level (RUL)

Technology Readiness Levels (TRLs)



EWS

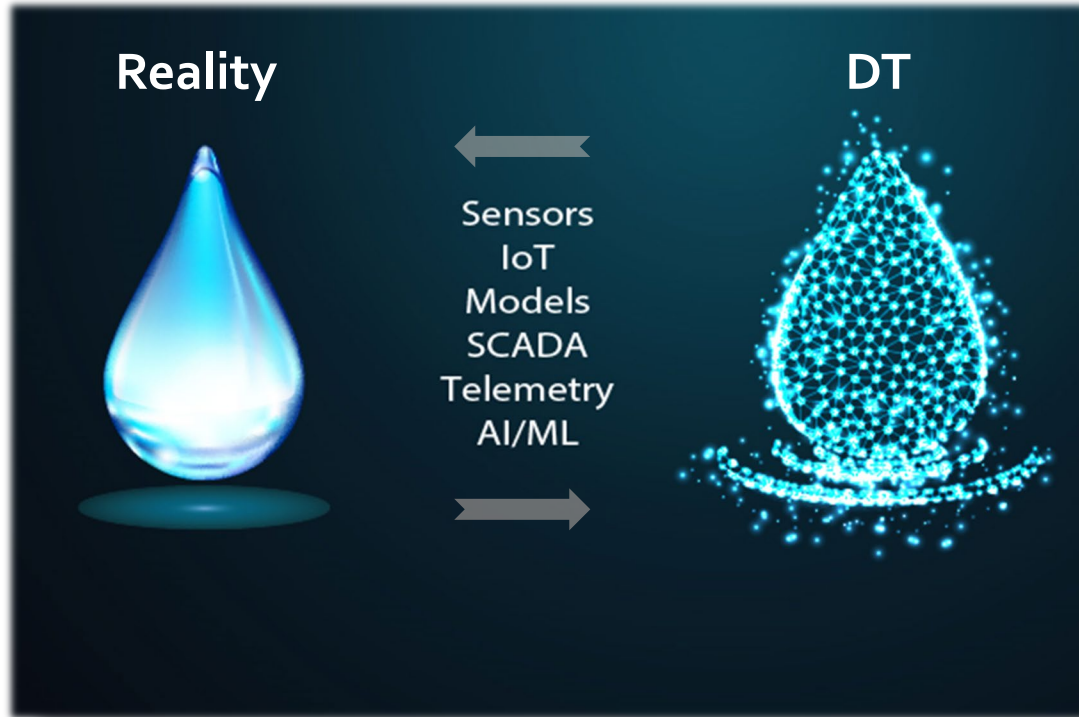
TRL Scale & Levels In EU Projects



- 9 Actual System Proven in Operational Environment
- 8 System Complete and Qualified
- 7 System Prototype Demonstration in Operational Environment
- 6 Technology Demonstrated in Relevant Environment
- 5 Technology Validated in Relevant Environment
- 4 Technology Validated in Lab
- 3 Experimental Proof of Concept
- 2 Technology Concept Formulated
- 1 Basic Principles Observed

NASA TRL Definitions (1989)

Tracking Digital Capacities > Digital Twin Levels



Digital Twin Levels of Maturity

- DTL1:** Dynamic Representation
- DTL2:** Analytics
- DTL3:** Predictive
- DTL4:** Perspective
- DTL5:** Cognitive

Societal Readiness Levels



SRL 1 – identifying problem and identifying societal readiness.

SRL 2 – formulation of problem, proposed solution(s) and identifying stakeholders.

SRL 3 – initial testing of proposed solution(s) together with stakeholders.

SRL 4 – problem validated through pilot testing in relevant environment.

SRL 5 – proposed solution(s) validated, now by relevant stakeholders in the area

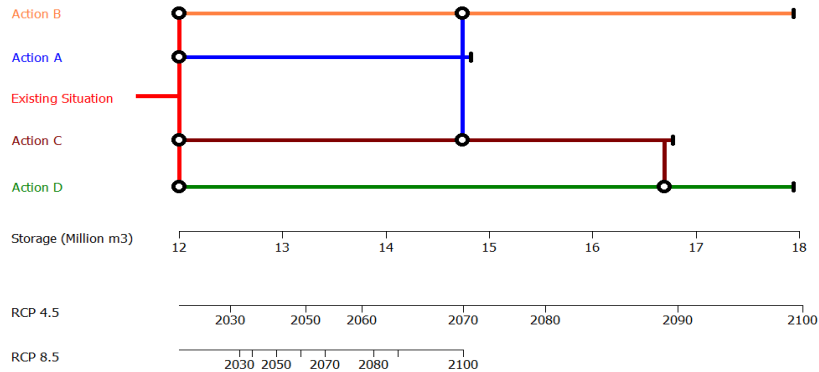
SRL 6 – solution(s) demonstrated in relevant environment and stakeholders feedback.

SRL 7 – refinement of project and/or solution and, if needed, retesting.

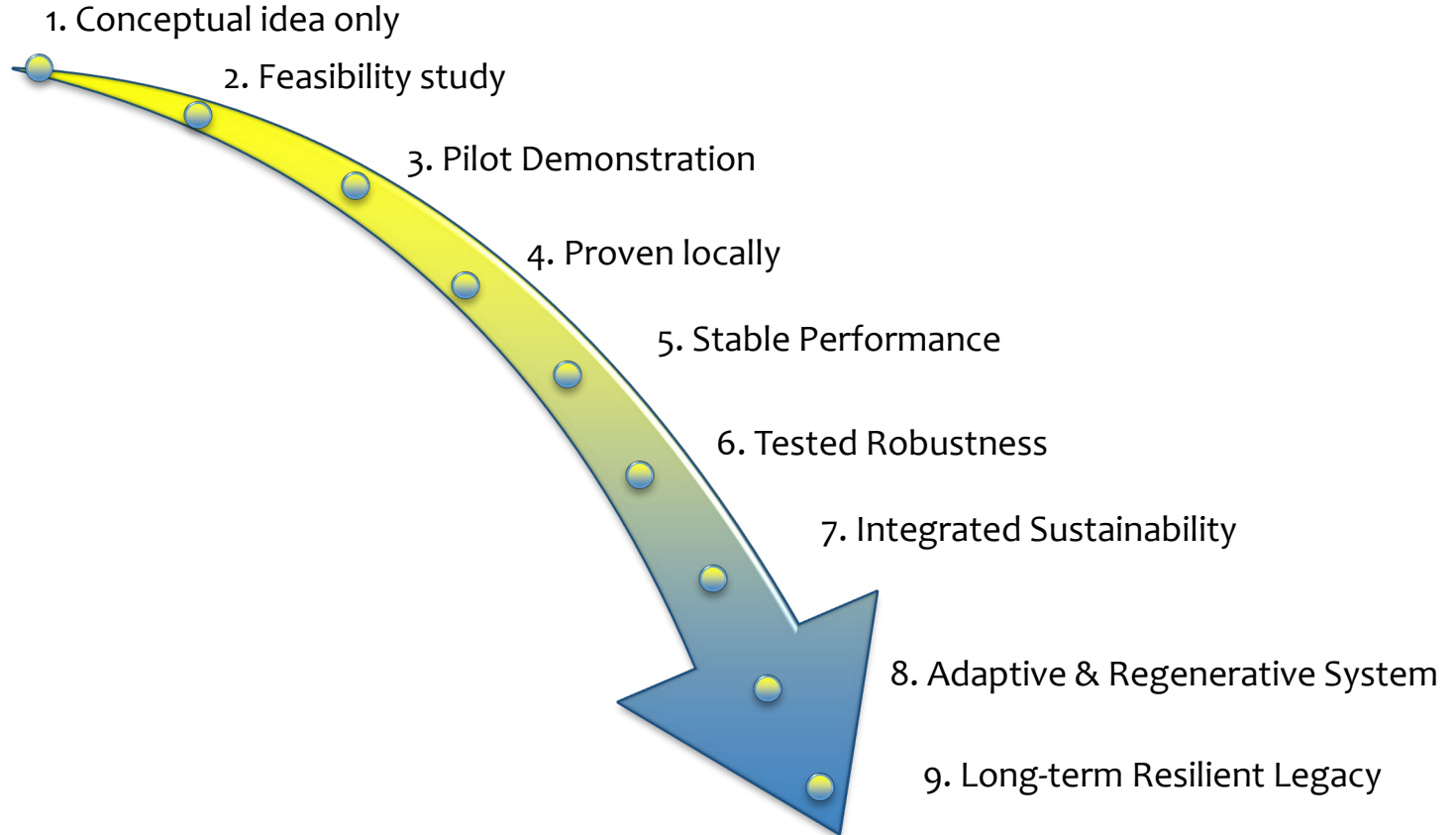
SRL 8 – proposed solution(s) as well as a plan for societal adaptation complete and qualified.

SRL 9 – actual project solution(s) proven in relevant environment.

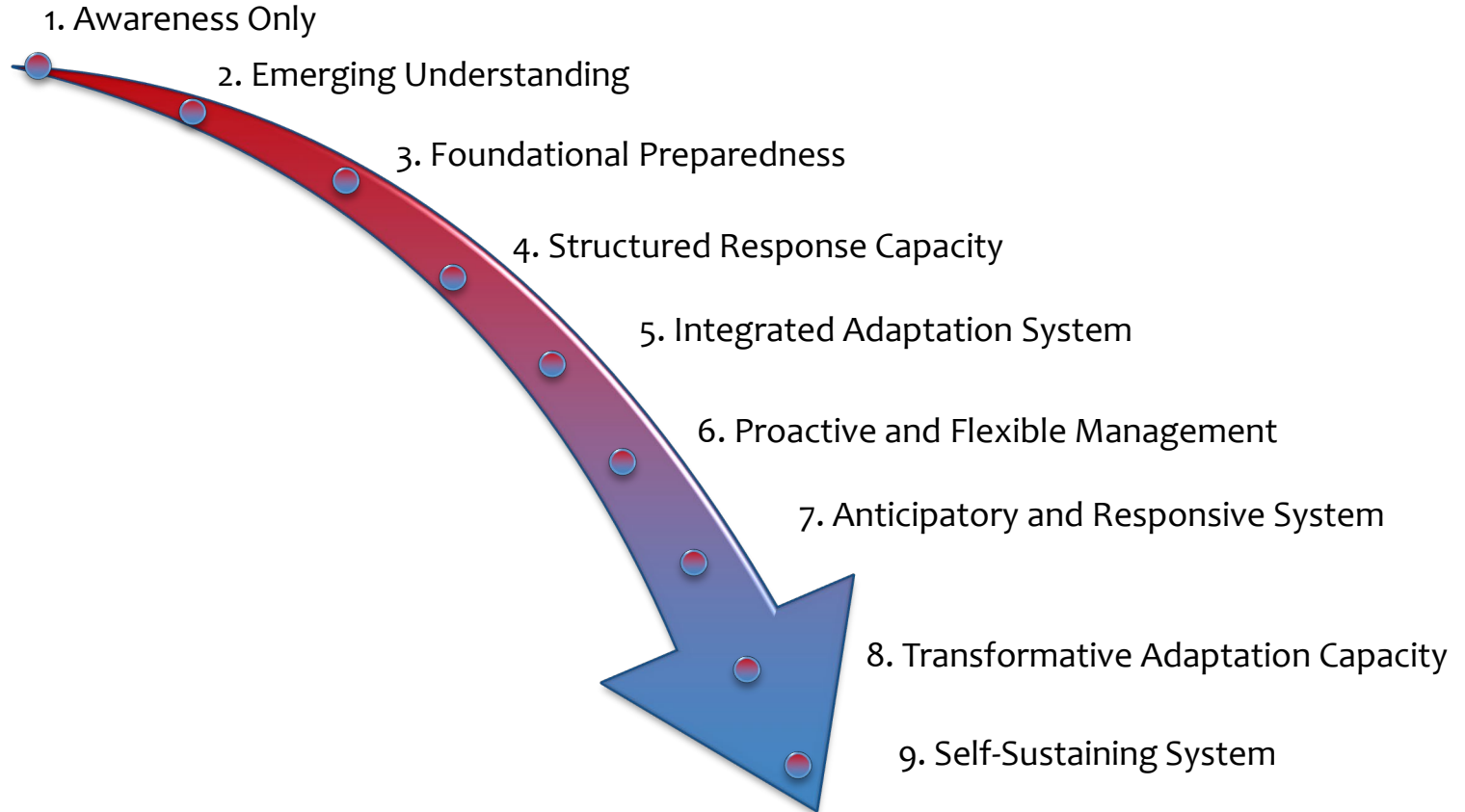
Impact & Sustainability Level (ISL)



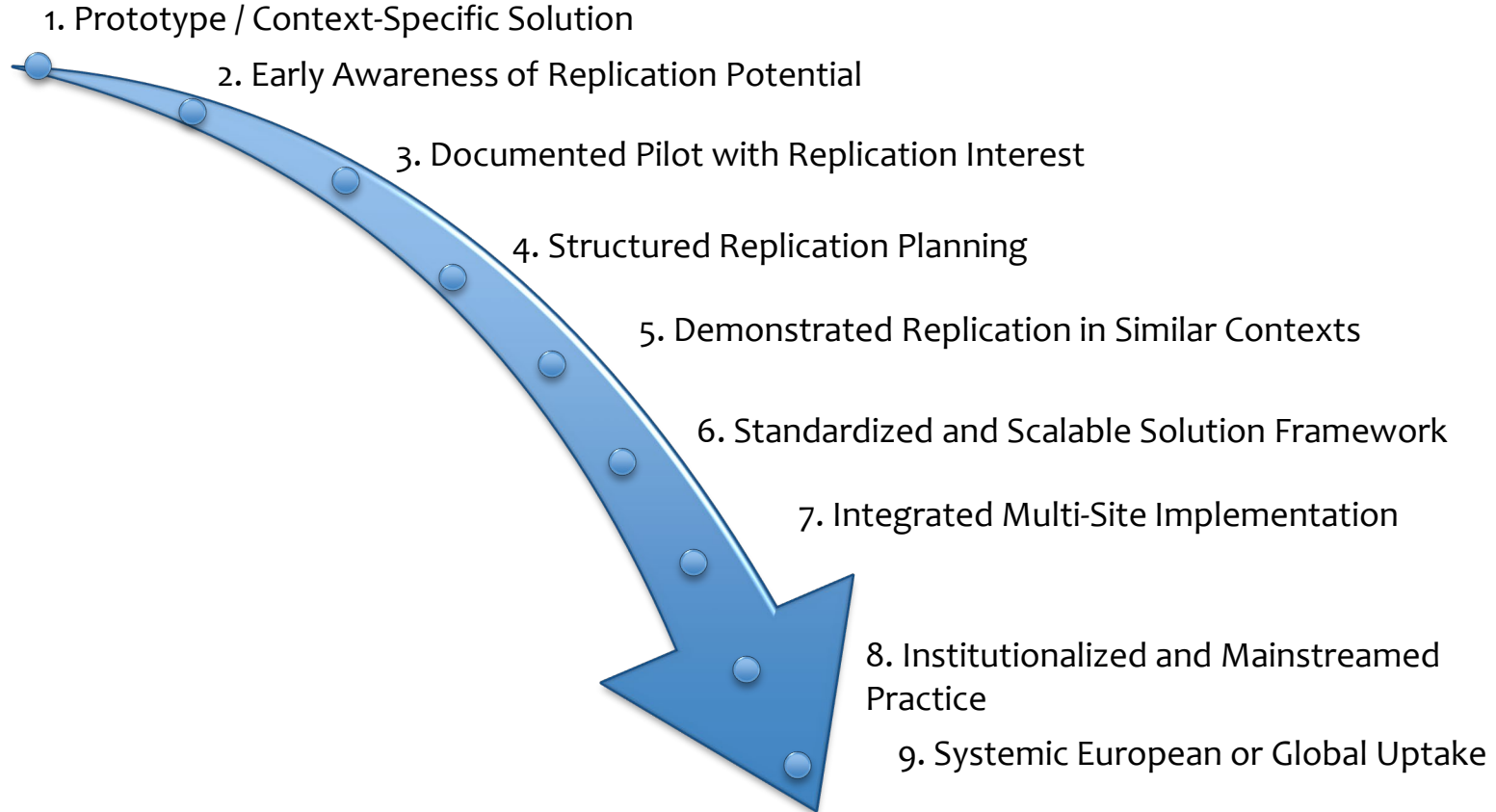
Impact and Sustainability Levels



Adaptive Capacity Levels



Replicability & Upscaling Levels



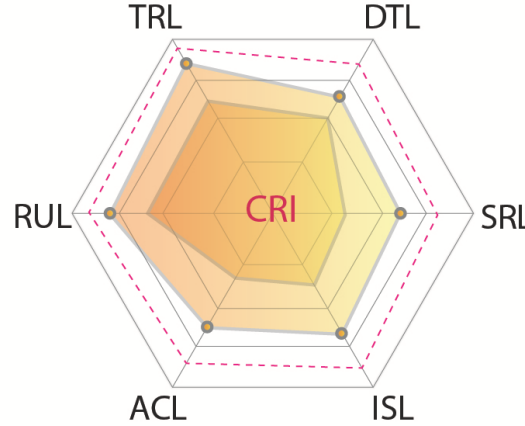


Digital Twin Maturity Model

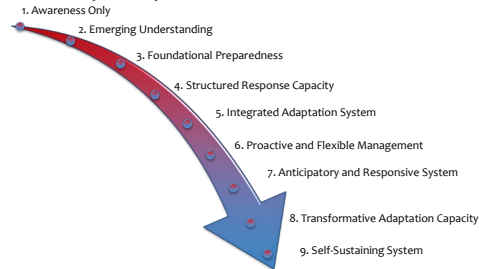


References: DNV-GL (2020). Qualification and assurance of digital twins
<https://oilgasstandards.dnvgl.com/download/dnvgl-rp-a204-qualification-and-assurance-of-digital-twins>

Replicability & Upscaling Level Levels

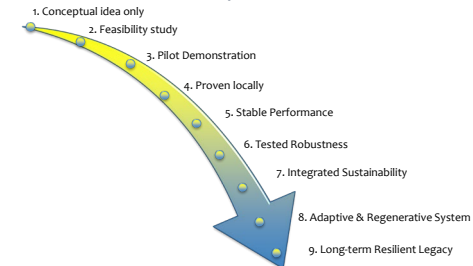


Adaptive Capacity Levels



CLIMATE RESILIENCE INDEX

Impact and Sustainability Levels



ARTIFACT

Artificial Intelligence for Flood Resilient Infrastructure



Funded by
the European Union



IHE
DELFT **Institute for
Water Education**
under the auspices of UNESCO

TUHH

TU Delft Delft
University of
Technology



THE INSTITUTE FOR ARTIFICIAL INTELLIGENCE
RESEARCH AND DEVELOPMENT OF SERBIA



ARTificial Intelligence for Flood Resilient Infrastructure



ARTIFACT

- ARTIFACT is a **Horizon Europe** (Twinning Green Deal) project
- EU project partners: **Delft University of Technology** (TU Delft), **Delft Institute for Water Education** (IHE Delft), and **Hamburg University of Technology** (TUHH)
- Project Duration: **1 October 2024 – 30 September 2027**

IVI
Project Coordinators - Senior Researchers



Dr. Veljko Prodanović



Dr. Milan Stojković



Prof. Dr. Zoran Kapelan



Prof. Dr. Zoran Vojinović



Dr. Nataša Manojlović

EU Partners
TU Delft IHE Delft TUHH



Luka Vinokić



Ana Samac



Milan Grujev



Jasmina Moskovljević



Marina Mitić



Milena Tamburić

IVI
Early-Stage Researchers

IVI
Project Manager

Three take home messages to remember



1. NBS have become important means in addressing **climate resilience**



2. **Digitalisation, data science and AI** are becoming important means in enhancing effectiveness of NBS
3. Future challenges are **not only technological**

Acknowledgements

z.vojinovic@un-ihe.org

<http://www.reconnect.eu/>



**Smart Watershed,
AI-Driven Innovation**
智慧流域AI領航
International Forum 2025

AI 賦能智慧水治理：從數據到 韌性管理

AI Empowerment for Smart Water Governance:
From Data to Resilience Management

GSD CTO: 卓伯全 Cho Bo-Chuan



基士德科技股份有限公司 台灣分公司
GSD Technologies Co., Ltd. Taiwan Branch
基士德環科股份有限公司
GSD Enviro-Tech (Taiwan) Co., Ltd.

水資源管理的任務及挑戰

Missions & Challenges of Water Resources Management (WRM)

Core Missions :

1. 防旱與水情預測

- Drought Prevention and Water Situation Forecasting.

2. 防洪與即時調控

- Flood Prevention and Real-Time Control.

3. 水資源調度與供需管理

- Water Resource Allocation and Supply-Demand Management.

4. 污水處理與再生水推廣

- Wastewater Treatment and Reclaimed Water Promotion.

5. 行政管理與決策支援

- Administrative Management and Decision Support.

Major Challenges :

氣候極端化→洪水與缺水更頻繁

- Climate extremes bring more frequent droughts and floods.

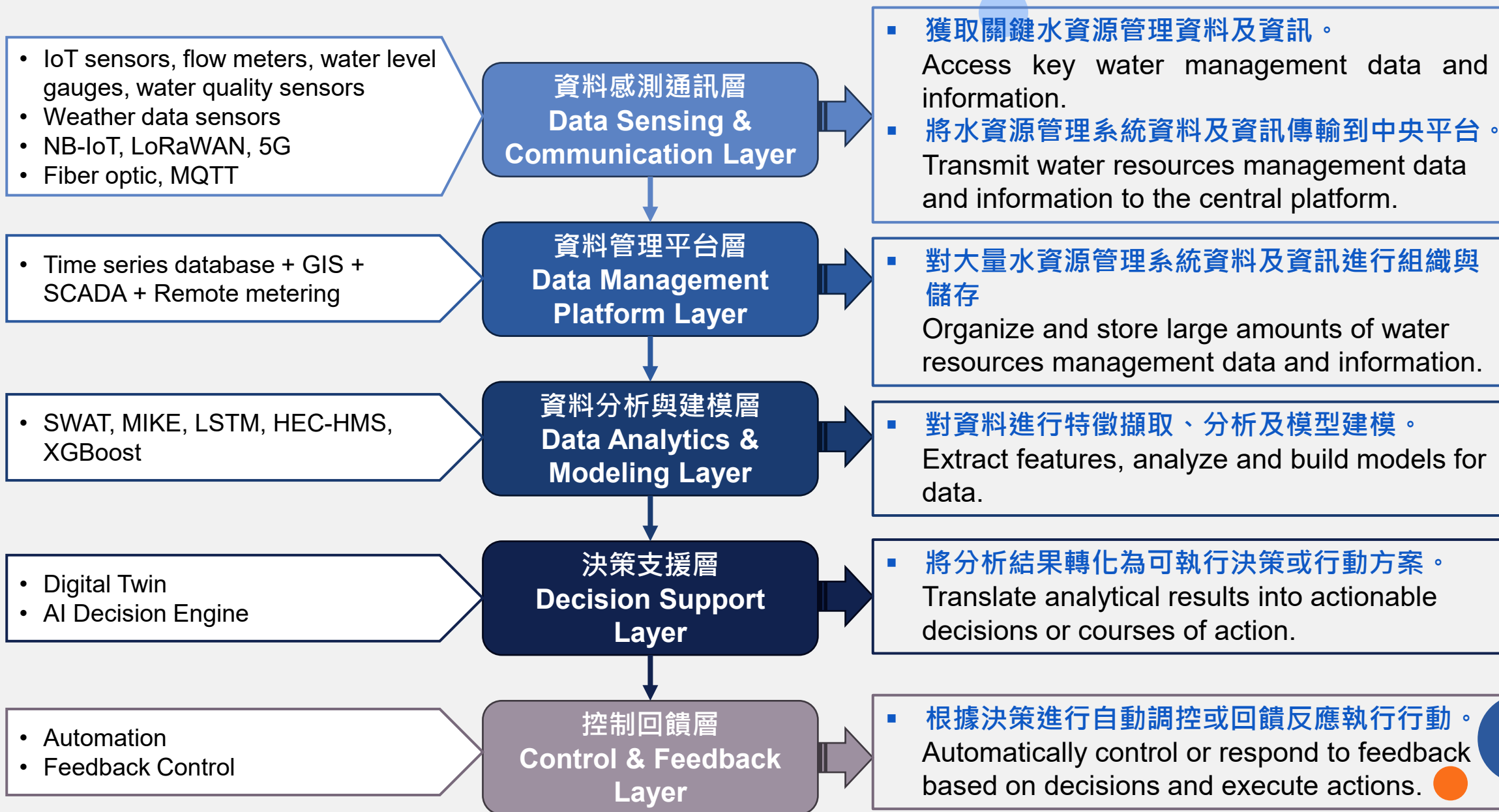
豐富的即時監測資料→如何整合運用，轉化為決策洞見與行動依據。

- The WRA's divisions already possess abundant real-time monitoring data. The next challenge and opportunity lie in how to integrate and utilize these datasets to transform information into insights and action.

民眾期待→更高透明度與更穩定供水

- And citizens demand higher transparency and more stable water supply.

AI賦能技術鏈 AI Empowerment Technology Chain



AI赋能技术链之應用

Applications of AI Empowerment Technology Chain

技術鏈層 Layer of Technology Chain	AI赋能應用 Applications	對水務產業價值 Values
感測與通訊層 Sensing & Communication Layer	- IoT+LPWAN/5G：布建高密度、低功耗感測網（如NB-IoT、LoRa），提升監測覆蓋率。 IoT sensors, low-power wide-area networks (LPWAN/5G). - 智慧感測：引入 AI 邊緣運算（Edge AI），即時檢測異常訊號（如水位異常突升、泵浦震動異常）。 Edge AI for real-time anomaly detection (sudden water level rise, pump vibration anomalies).	- 提升水文監測即時性與準確性，為旱災、洪災預測提供基礎數據。 Enhance the real-time and accuracy of hydrological monitoring. Provide reliable data foundation for drought and flood prediction. - 減少人力現勘頻率，強化防災即時性。 Reduce the frequency of on-site surveys by manpower and enhance the immediacy of disaster prevention.
資料管理平台層 Data Management Platform Layer	- ETL/數據湖建置：建立專屬的「水資源大數據平台」，整合水文、氣象、用水、污染排放等多源資料。 Data lake and ETL integration to unify meteorological, hydrological, water use, and pollution datasets. - 資料治理：導入DataOps/MLOps，確保資料可追溯、品質可控。 Data governance with DataOps/MLOps to ensure traceability and quality control.	- 提升資料一致性，支撐跨局處、跨領域決策。 Improve data consistency across agencies. - 強化政策透明度與民眾信任，支援ESG報告與國際永續指標。 Enhance policy transparency and public trust, support ESG and sustainability reporting.

AI賦能技術鏈之應用

Applications of AI Empowerment Technology Chain

技術鏈層 Layer of Technology Chain	AI賦能應用 Applications	對水務產業價值 Values
資料分析與建模層 Data Analysis & Modeling Layer	• 時序預測：LSTM/ARIMA預測水庫蓄水量、用水需求、降雨分布。 Time-series forecasting (LSTM, ARIMA, XGBoost) for reservoir storage and water demand. • 洪水預測：RNN與數位孿生模擬洪峰，支援即時閘門調度。 Flood prediction with RNNs and digital twins for real-time gate operations. • 最佳化演算法：跨流域水源調度、多部門用水分配模擬。 Optimization algorithms for cross-basin water allocation and multi-sector demand management.	• 改善水情預警精準度，延長應變時間。 Increase accuracy of drought and flood early warning. • 降低人為判斷誤差，提升政策科學化。 Enable science-based decision-making, reduce human judgment errors.

AI賦能技術鏈之應用

Applications of AI Empowerment Technology Chain

技術鏈層 Layer of Technology Chain	AI賦能應用 Applications	對水務產業價值 Values
決策支援層 Decision Support Layer	• 決策儀表板 (Dashboard) : 即時顯示水庫調度、洪水風險、再生水利用率。 Real-time dashboards for reservoir operations, flood risk, and reclaimed water utilization. • 自動生成建議 : AI 模型根據數據提出「建議限水區域」「建議放流量」。 AI-assisted recommendations for water rationing, release volume, or emergency planning. • NLP智慧客服 : 自動回覆民眾用水/限水查詢。 NLP-powered smart assistants to respond to public inquiries.	• 決策流程加速，縮短資訊發布時間。 Accelerate decision-making processes and shorten reporting cycles. • 政策溝通更透明，增強民眾信任。 Improve transparency and strengthen citizen engagement.

AI賦能技術鏈之應用

Applications of AI Empowerment Technology Chain

技術鏈層 Layer of Technology Chain	AI賦能應用 Applications	對水務產業價值 Values
控制回饋層 Control & Feedback Layer	- 自動控制：AI與SCADA結合，自動調整閘門、抽水泵運作。 AI-driven integration with SCADA for automatic gate and pumping station control. - 智慧加藥/曝氣：應用於污水處理與再生水廠，降低能耗與碳排。 Intelligent dosing and aeration optimization in wastewater and reclaimed water plants. - 循環學習：系統自動修正模型，提升長期精度。 Closed-loop learning systems for continuous model improvement.	- 從「被動應變」轉為「主動預防」。 Shift from reactive response to proactive prevention. - 降低人力依賴與誤操作風險。 Reduce manpower dependency and operational risks.

Summary of AI Empowerment Technology Chain

- 透過「水資源AI賦能技術鏈」，從「數據蒐集 → 預測模擬 → 決策建議 → 自動控制」建立一個**智慧水循環管理機制**，使水務系統由傳統被動應變轉向**主動、智慧、永續治理**。

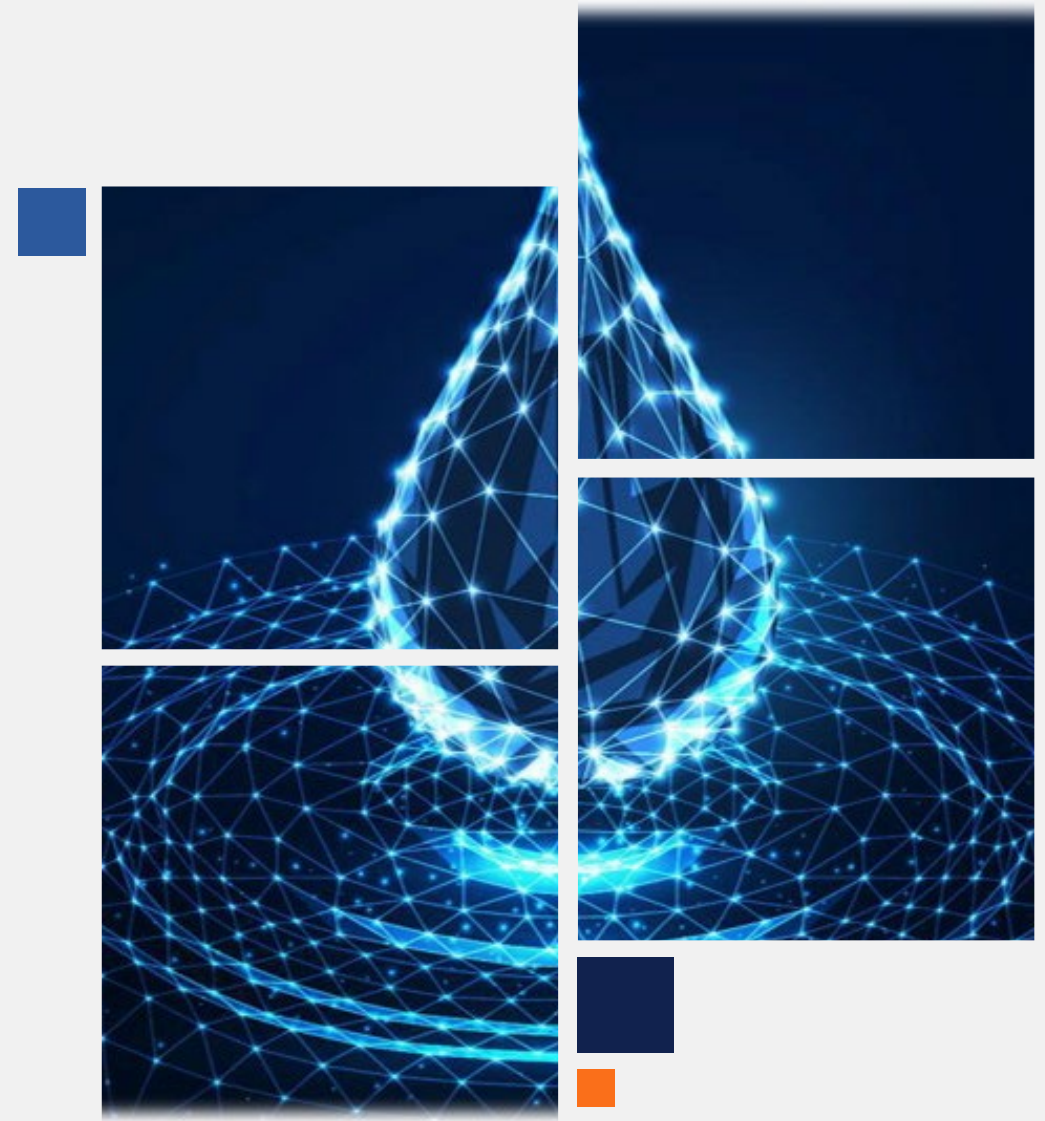
The AI empowerment technology chain enables the Water Resources Management System to build a closed-loop **smart management mechanisms**, transforming operations from “data collection → predictive modeling → decision support → automatic control.” AI empowers the Water Resources Management System to transition from passive emergency response to **proactive, intelligent, and sustainable water governance**.

- 具體價值（Key benefits）：

- 1. 防災韌性**：更精準的旱災、洪水預測與自動調度。
Resilience – More accurate drought and flood forecasts with proactive disaster mitigation.
- 2. 資源永續**：多目標調度最佳化，提高水利用效率，推動再生水。
Sustainability – Optimized water allocation, higher reclaimed water utilization, reduced carbon footprint.
- 3. 治理透明**：即時儀表板、自動化報表，提升決策公開性。
Transparency – Automated dashboards and reports to strengthen public trust.
- 4. 營運效率**：智能控制與巡檢，減少人力依賴，強化維運可靠度。
Efficiency – Smart inspection and predictive maintenance to lower costs and risks.

AI賦能技術應用案例

The Application Cases of AI Empowerment
Technology in the Core Missions of the
WRM



1. 防旱與水情預測

Drought Prevention and Water Situation Forecasting

防旱預警水晶球Drought Early-Warning Crystal Ball

■ 目的

- 水庫蓄水量預測與水情告警。讓每個民眾都能依各自的需求，掌握即時水情狀況，並讓企業單位、政府機關能及早因應即將到來的旱情。

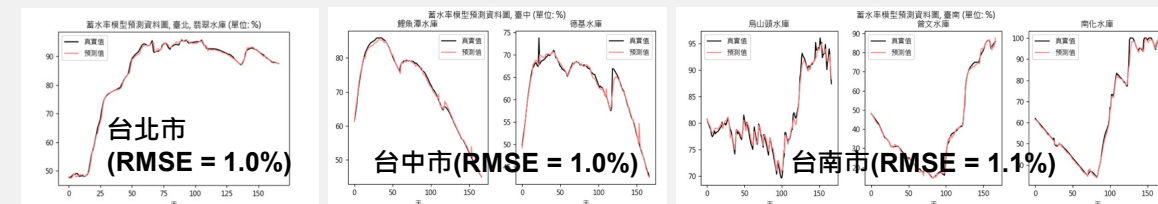
■ 資料來源

- 交通部中央氣象署
 - 觀測資料查詢系統(降雨、氣溫) <https://e-service.cwb.gov.tw/HistoryDataQuery/>
- 經濟部水利署
 - 水庫蓄水統計表<https://fhy.wra.gov.tw/fhy/Monitor/Reservoir>
 - 水利署生活用水量統計<https://data.gov.tw/dataset/58694>
 - 水利署灌溉面積與灌溉用水量統計<https://data.gov.tw/dataset/58701>
 - 水利署養殖面積與養殖用水量統計<https://data.gov.tw/dataset/58700>
 - 水利署畜牧數與畜牧用水量統計<https://data.gov.tw/dataset/58699>
 - 水利署工業用水量與工業面積<https://data.gov.tw/dataset/58692>
- 環境部
 - 重大點源放流水自動連續監測資訊公開查詢系統<https://a0-cwms.epa.gov.tw/cwmspublic/>

■ AI建模

- 利用水資源循環架構中每一層資料作為模型之輸入，判斷到達乾旱警報之天數，包括：水庫蓄水率預測模型，及水情燈號預測模型。

■ 水庫蓄水率預測模型(LSTM+Multi-CNN)



■ 水情燈號預測模型(決策樹+混淆矩陣)



■ 核心價值與效益

- 任何人皆能知悉即時水情狀況；
- 透過水情預警，企業單位能提前知悉未來的供水量，政府機關也能及早進行水資源調配，進而提早因應旱象的到來，減少缺水所造成的影響。
- 幫助企業單位進行未來的用水規劃，以達到最佳的經濟效益；
- 整合跨部門的資料，幫助政府機關找出最合適的水資源調配決策，以達到節水、放流水循環再利用、降低旱象發生的風險。

防旱預警水晶球之應用

Application of Drought Early-Warning Crystal Ball

- 提前數日甚至數週預測缺水風險，提升乾旱應變能力。

Predict water shortage risks days or even weeks in advance, enhancing drought preparedness.

- 輔助水庫調度決策，減少限水對民生與產業的衝擊。

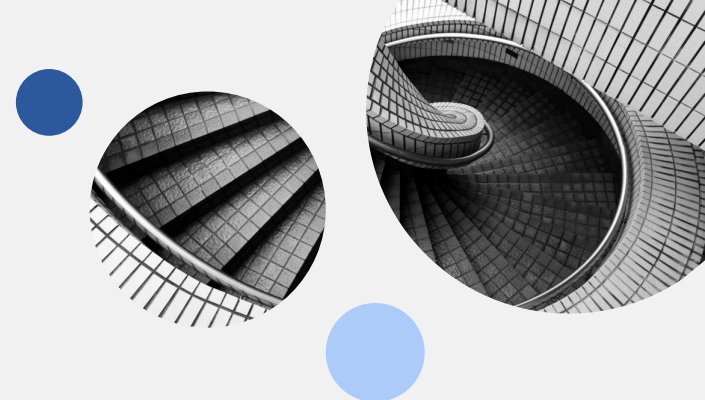
Support reservoir allocation decisions, reducing the impact of water restrictions on citizens and industries.

對防旱與水情預測任務之效應

Effects on drought prevention and water situation forecasting tasks.

提高應變能力，支持科學化調度

Improve resilience and support scientific allocation.



2. 防洪與即時調控

Flood Prevention and Real-Time Control

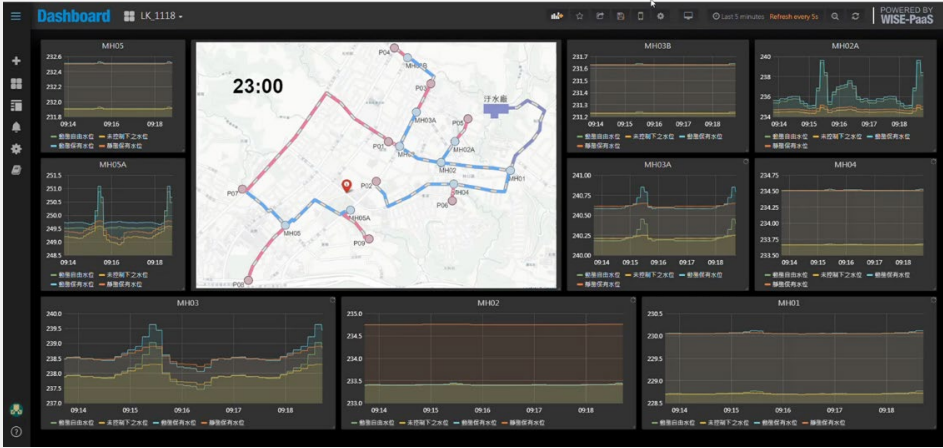
污水揚水站水位調控Water level control at sewage pumping stations

- 目的
 - 充分應用污水下水道系統水量涵容能力，減少揚水站抽水機啟動頻率，達到穩定進流及節能減碳效益。
- 資料來源
 - 地理資訊系統GVP資料；
 - 水資源回收中心集水區民生用水量資料；
 - 水資源回收中心放流水水量及水質數據（水溫、pH、COD、SS、EC等）；
 - 污水下水道水力分析數據（管網系統分布路徑，下水道高程、管徑、坡度等）；
 - 污水揚水站抽水泵性能資料、抽水量歷史數據、馬達起停時間歷史數據等。

AI建模

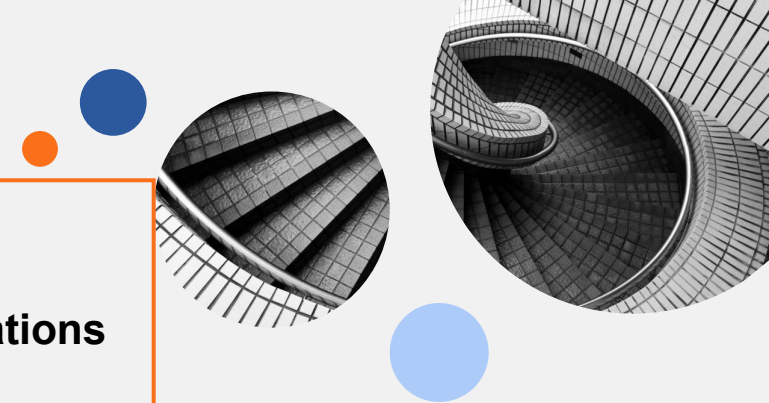
演算法	線性迴歸	類神經網路
函數建立方式	線性	非線性
參數數量	不可變動	可變動
修正參數之演算法	最小平方	梯度下降法
可否找出影響較大的自變數	可	否
預測能力 (RMSE)	管線有匯流的情況下：預測SWL高達0.25；預測DWL高達0.54。	0.146

智慧進流控制模擬



效益

1. 短期
 - 平均節電費用每月約28.6萬元；
 - 處理系統約增加3,000 CMD處理能力。
2. 中期
 - 可明顯減少抽水機故障頻次，延長使用壽命；
 - 污水處理成本下降，水質異常現象大幅減少。
3. 長期
 - 處理量能增加，擴建預算約可減少40%；
 - 延長下水道系統使用年限。



污水揚水站水位調控之應用

Application of Water level control at sewage pumping stations

- 改善暴雨洪峰預測準確度。
Improve the accuracy of storm peak flood forecasts.
- 自動建議或直接執行閘門操作，縮短反應時間。
Automatically recommend or directly execute gate operations, shortening response times.
- 降低人為誤判風險。
Reduce the risk of human error.



對防洪與即時調控任務之效應

Effects on flood prevention and real-time control tasks.



縮短反應時間，降低人為誤判
Shorten reaction time and reduce human error.

3. 水資源調度與供需管理

Water Resource Allocation and Supply-Demand Management

數位模擬與自動化決策支援系統

Digital simulation and automated decision support system

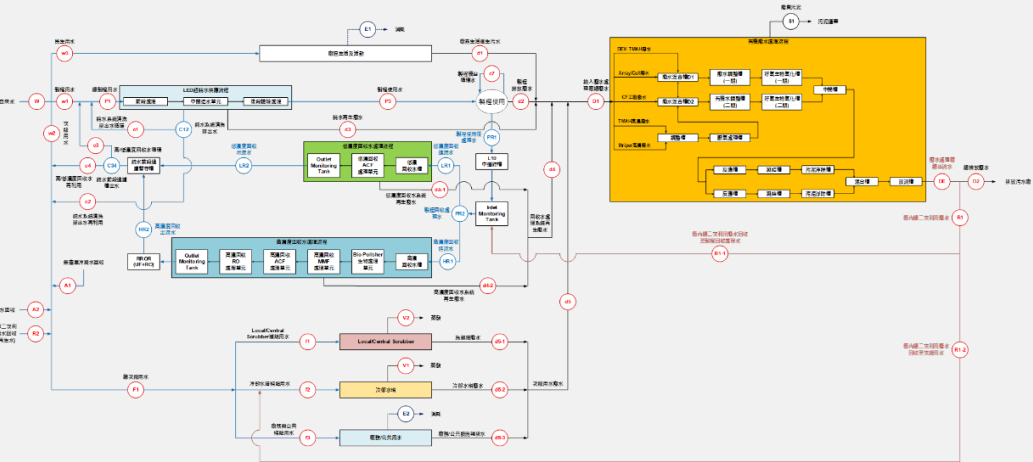
■ 目的

- 動態用水平衡評量工具及水資源的監控指標，掌握關鍵用水資訊，精進水資源管理效率。

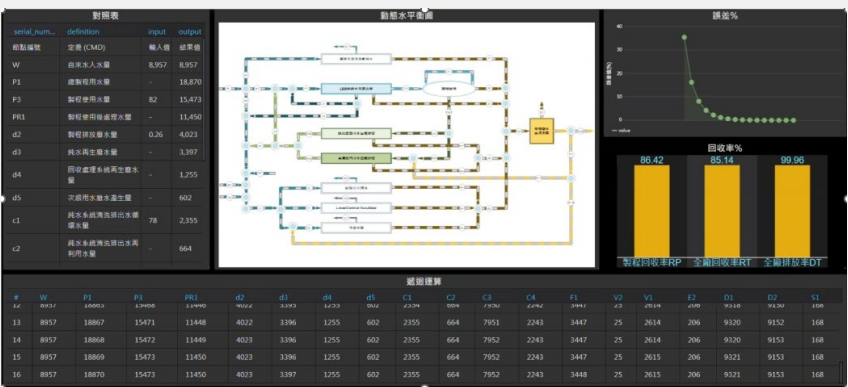
■ 資料來源

- 廠區用水來源、種類及使用量資料；
- 廠區用水節點與水平衡關係資料；
- 製程用水處理程序進 / 出流監測 / 檢測資料；
- 回收水處理程序進 / 出流監測 / 檢測資料；
- 污(廢)水處理程序進 / 出流監測 / 檢測資料。

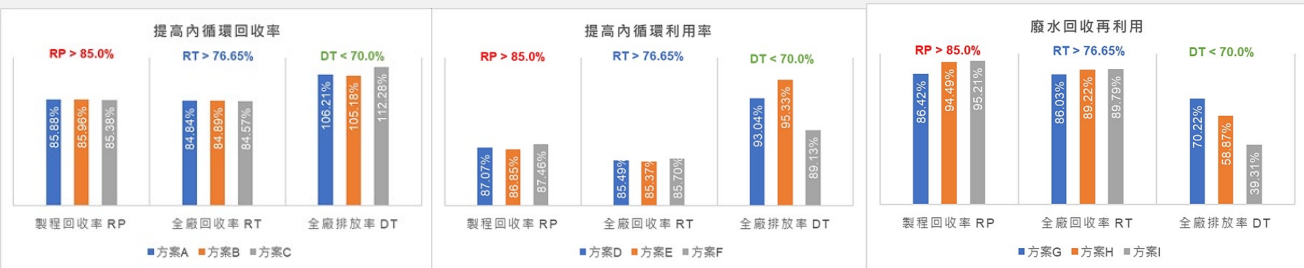
■ 用水平衡關係建立



■ 數位模擬模型建置



■ 模擬結果與自動決策



- 提高內循環利用率對製程回收率RP及全廠回收率RT的效應略大於提高內循環回收率。
- 提高內循環回收率及利用率均會造成全廠排放率DT的大幅提高。
- 廢水處理廠排放水回收作為冷卻水塔補助用水或回收再處理20%作為製程用水均可大幅提升RP及RT。
- 回收作為製程用水對DT的效應大於回收作為冷卻水塔補助用水者4。

數位模擬與自動化決策支援系統之應用

Application of Digital simulation and automated decision support system

- **用水量預測**：結合時序模型（LSTM、ARIMA）與氣象資料，預測未來需求。支持「多目標調度」（防洪、抗旱、供水安全）。

Water demand forecasting: Combining time-series models (LSTM, ARIMA) with meteorological data to predict future demand. Support multi-objective allocation (flood control, drought mitigation, water supply security).

- **調度優化**：利用 AI 演算法（XGBoost、模糊邏輯等）進行跨流域分配，兼顧公平性與效率。提升再生水與灌溉水利用率，減少水資源浪費。

Allocation optimization: Using AI algorithms (XGBoost, fuzzy logic, etc.) to allocate water across basins, balancing fairness and efficiency. Improve the utilization of reclaimed and irrigation water, reducing waste of water resources.

對水資源調度與供需管理任務之效應

Effects on water resource allocation and supply-demand management tasks.

兼顧公平、效率及永續

Balancing fairness, efficiency and sustainability.

4. 污水處理與再生水推廣

Wastewater Treatment and Reclaimed Water Promotion

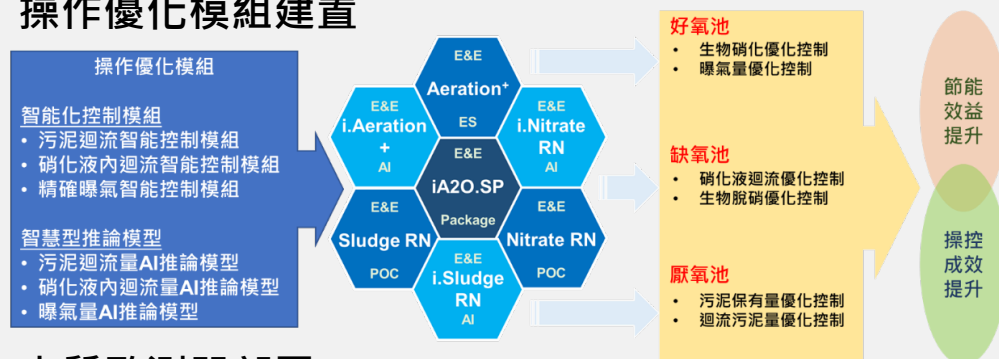
程控智聯—污水處理程序操作優化

AIoT Process Control—Wastewater treatment process operation optimization

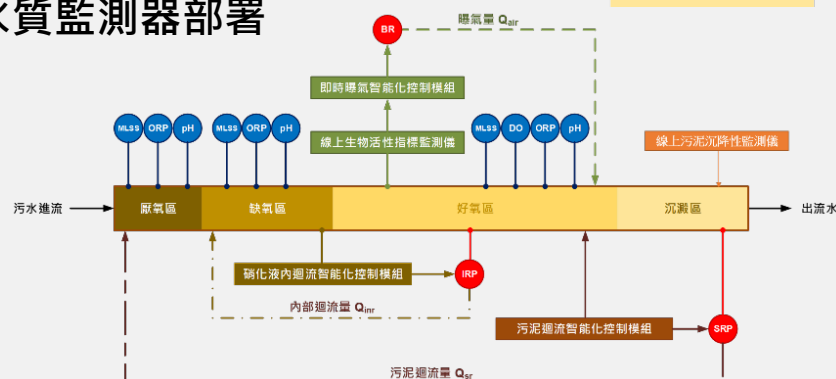
■ 目的

- 導入污（廢）水管理系統AIoT管理平台進行A2O程序操作優化策略及智能化控制與智慧型操作管理方案的建置與執行工作，以同時達到水質處理及操控成效與節能效益提升的目標。

■ 操作優化模組建置



■ 水質監測器部署



■ 演算法

- 智能化控制模組—Fuzzy-PID
- AI推論模型—ANN、GBM、XGBoost

■ 成效評估與效益分析

1. 水質處理成效

- 平均放流水COD = 25 mg/L、 $\text{NH}_3\text{-N}$ = 1.05 mg/L及TN = 4.49 mg/L。其中，TN放流水水質均可控制在環評承諾的10 mg/L以下。
- 平均COD、 $\text{NH}_3\text{-N}$ 及TN之去除率，分別為93.6%、94.7%及78.7%。其中， $\text{NH}_3\text{-N}$ 及TN之水質處理提升成效高達4.9%及10.5%。

2. 操控成效

- 智能化與智慧型控制具有即時反應A2O系統的動態變化提供控制決策的能力，來解決因水力時間停留不足影響操作的問題。
- 智能化與智慧型控制具有因應動態污染負荷的能力，並即時提供良好的控制決策；且能有效控制活性污泥的生長環境及條件，進而達到提供A2O系統穩定性的功能。

3. 節能及減碳效益

- A2O程序之平均單位廢水用電量分別為0.27 kWh/m³，遠低於國內污水處理廠單位廢水用電量0.38~0.80 kWh/m³。
- 年可節省用電量為109,992~116,268度，相當於節省約NT\$ 27.5~29.1萬元電費。年減碳量可達60.94~64.41 Ton CO₂e。

精確控制技術—精確曝氣控制

Precise aeration control technology

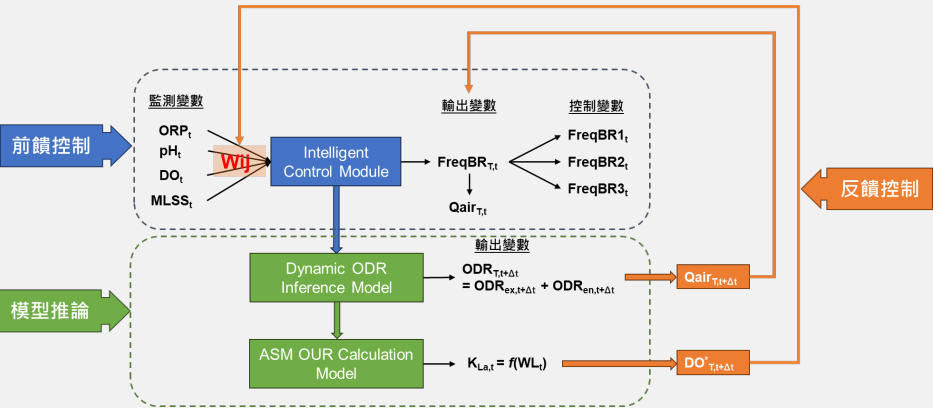
■ 目的

- 提供一種即時、動態且具智能化之精確曝氣方法，使用於各類污廢水生物曝氣池之曝氣控制。

■ 技術特徵

- 精確曝氣控制技術係指「即時滿足生物反應需氧速率的動態曝氣控制方法」。應用於各類連續進流式（如A2O、AO、氧化渠、活性污泥法）及批分進流式（ICEAS、SBR、CAAS）等生物曝氣池之曝氣量智能化控制。
- 精確曝氣控制技術，不僅可避免現行曝氣控制方法的問題及缺失外，更可依據生物曝氣池中活性污泥的生物活性進行曝氣量的調整，使生物曝氣池兼具最佳生物反應狀態及曝氣能耗最小化的功能，進而達到水質達標及曝氣節能兼籌並顧之效。

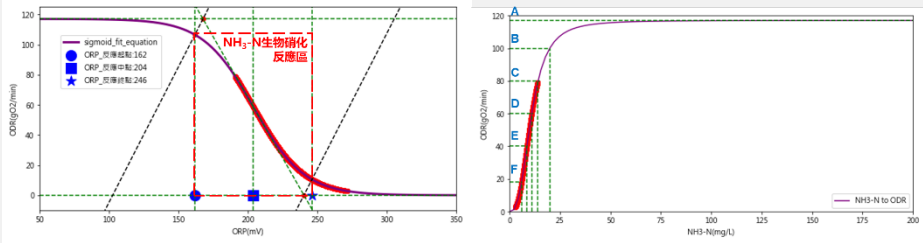
■ 精確曝氣控制邏輯



■ 成效評估與效益分析

1. 活化生物反應活性

- 活性污泥生物活性落在NH₃-N生物硝化反應中點及終點區，確定有NH₃-N生物硝化反應發生。出流水NH₃-N濃度可控制在20 mg/L以下。



2. 節電效益

- 精確曝氣控制之節電效率隨著ODR及出流水質濃度的降低而增加。節電效率可達14.53%以上。

曝氣控制點	ODR (gO ₂ /min)	NH ₃ -N (mg/L)	鼓風機用電量 (kWh)	節電效率 (%)
A (參考點)	117	48	6,886.80	---
B	100	20	5,886.15	14.53
C	80	14	4,708.92	31.62
D	60	11	3,531.69	48.72
E	40	9	2,354.46	65.81
F	18	6	1,177.23	82.91

3. 系統異常時機判斷與控制

- 應用ORP監測異常廢水納入時機，及異常廢水衝擊程度。
- 應用ODR控制異常廢水納入量，使異常廢水的衝擊可被減至最低。

精確控制技術—精確加藥控制

Precise chemicals dosing control

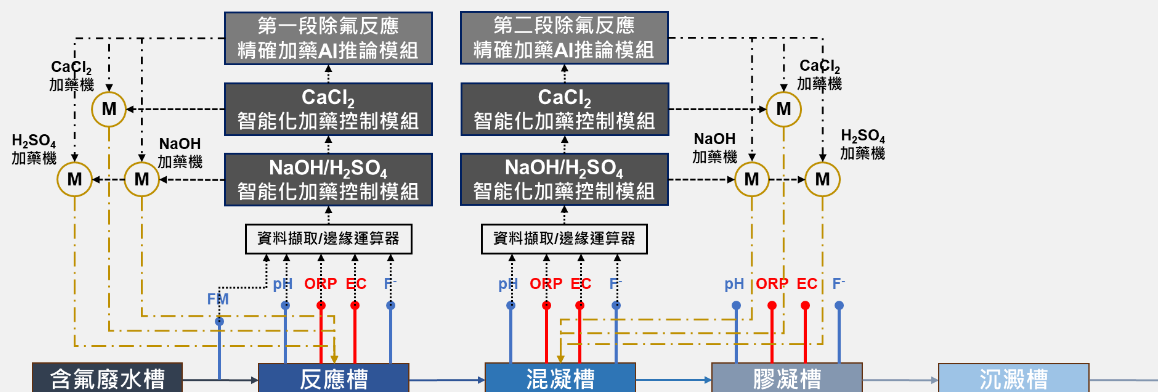
■ 目的

- 建立一個廣泛應用於高科技產業氫氟酸廢水處理程序精確加藥控制的方法，以同時穩定處理成效、降低藥劑成本與碳排放。

■ 技術特徵

- 精確加藥控制技術係指「符合化學反應特徵點的藥劑量控制方法」。以化學除氟反應為例，反應特徵點為鈣離子 (Ca^{2+}) 與氟離子 (F^-) 電性中和的時機點，此時界達電位達最低點。化學除氟反應控制在此特徵點，則可 CaCl_2 超量添加產生電性逆轉效應，而需再藉由超量加藥降低氟離子濃度的情況。

■ 精確加藥控制模組建置

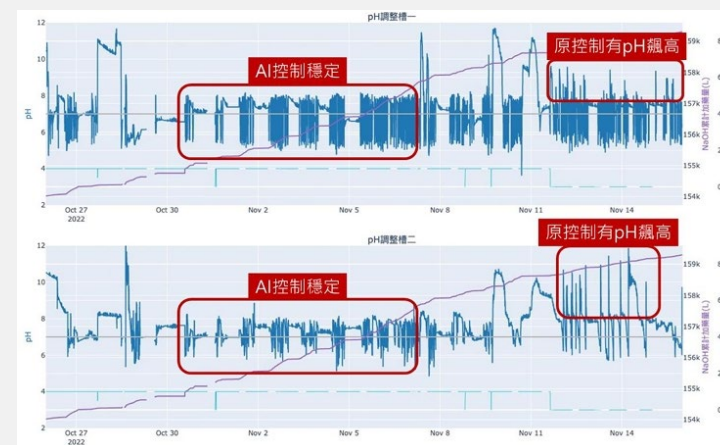


■ 演算法

- 智能化控制模組—Fuzzy-PID、RL
- AI推論模型—ANN、GBM、XGBoost

■ 成效評估與效益分析

1. pH控制的穩定度



2. 節藥效益分析

- NaOH節藥效益10.57~16.36%
- CaCl₂節藥效益26.46~43.01%

設備健康管理：防洪抽水泵

Equipment Health Management: Flood Control Pumps

目的

- 智慧防洪抽水泵健康監測與預警系統建置—都市防洪抽水健康監控與壽命管理。
- 導入AIoT智慧感測與分析模組，建構防洪抽水泵之設備健康管理系統，透過即時數據收集與分析，掌握設備劣化趨勢，提前預測關鍵異常點，達成以下目標：
 - 降低抽水機突發故障率；
 - 強化防洪韌性與應變效率；
 - 最佳化維修資源配置；及
 - 延長設備使用壽命等。

AI模型建置

輸入變數	輸出變數
- 功率負載異常指標 (Load Variation) - 馬達溫升速率 (ΔT/時間) - 震動頻譜 (FFT 分析後的特徵值) - 抽水效率變異 (實際抽水量與額定效率差值)	- 設備健康指數 (0~1) - 異常風險預測分類 (正常 / 輕微異常 / 高風險) - 維修建議與預測剩餘壽命 (Remaining Useful Life, RUL)



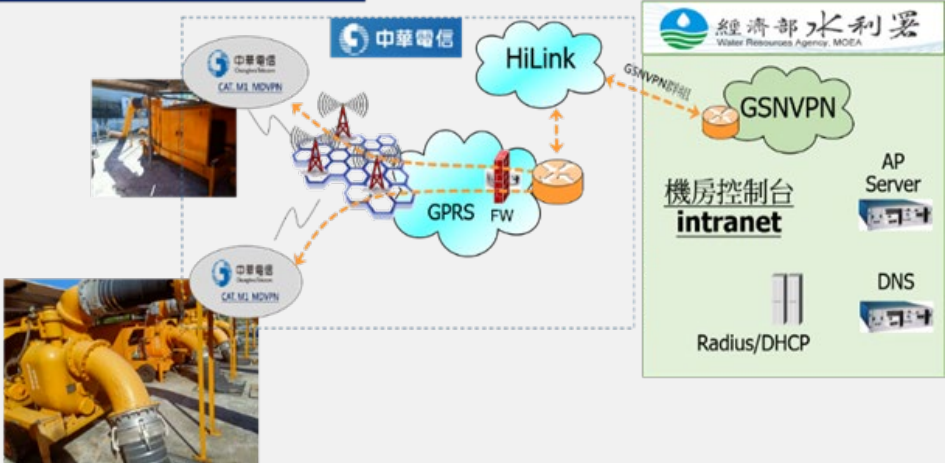
演算法

- 類神經網路 (ANN) 建立非線性設備劣化關聯；
- 支援向量機 (SVM) 進行分類異常偵測；
- 逐步回歸 (Stepwise Regression) 輔助篩選關鍵特徵。

應用

- 本系統應用於高風險地區抽水站，整合AI模組並連接震動、溫度及流量感測器，建構即時健康儀表板。當健康指數低於0.3時即啟動黃色警戒，低於0.15時發出紅色預警並通知維護單位進行巡檢。
- 規劃整合至城市災防平台，與降雨即時資料結合，提升抽水站智慧應變能力與調度策略。

整合至 GSN VPN 網路平台



程控智聯、精確控制及設備健康管理技術之應用

Application of AIoT process control, precision control and equipment health management technologies

- **污水廠操作優化**：應用 AI 於加藥與曝氣控制，降低能耗並提升水質穩定度。
Wastewater plant operation optimization: Applying AI to chemical dosing and aeration control, reducing energy consumption and improving water quality stability.
- **再生水水質監測**：結合感測器與異常偵測模型，確保回用水安全。
Reclaimed water quality monitoring: Combining sensors and anomaly detection models to ensure the safety of reused water.
- **智能巡檢與設備健康管理**：導入智慧檢測與預防性維護，延長設施壽命。
Smart inspection and equipment health management: Introducing smart diagnostics and preventive maintenance to extend facility lifespans..

對污水處理與再生水推廣任務之效應

Effects on wastewater treatment and reclaimed water promotion tasks.

節能減碳，提升水質穩定，推動再生水利用

Energy conservation and carbon reduction, improving water quality and stability, and promoting the use of recycled water.

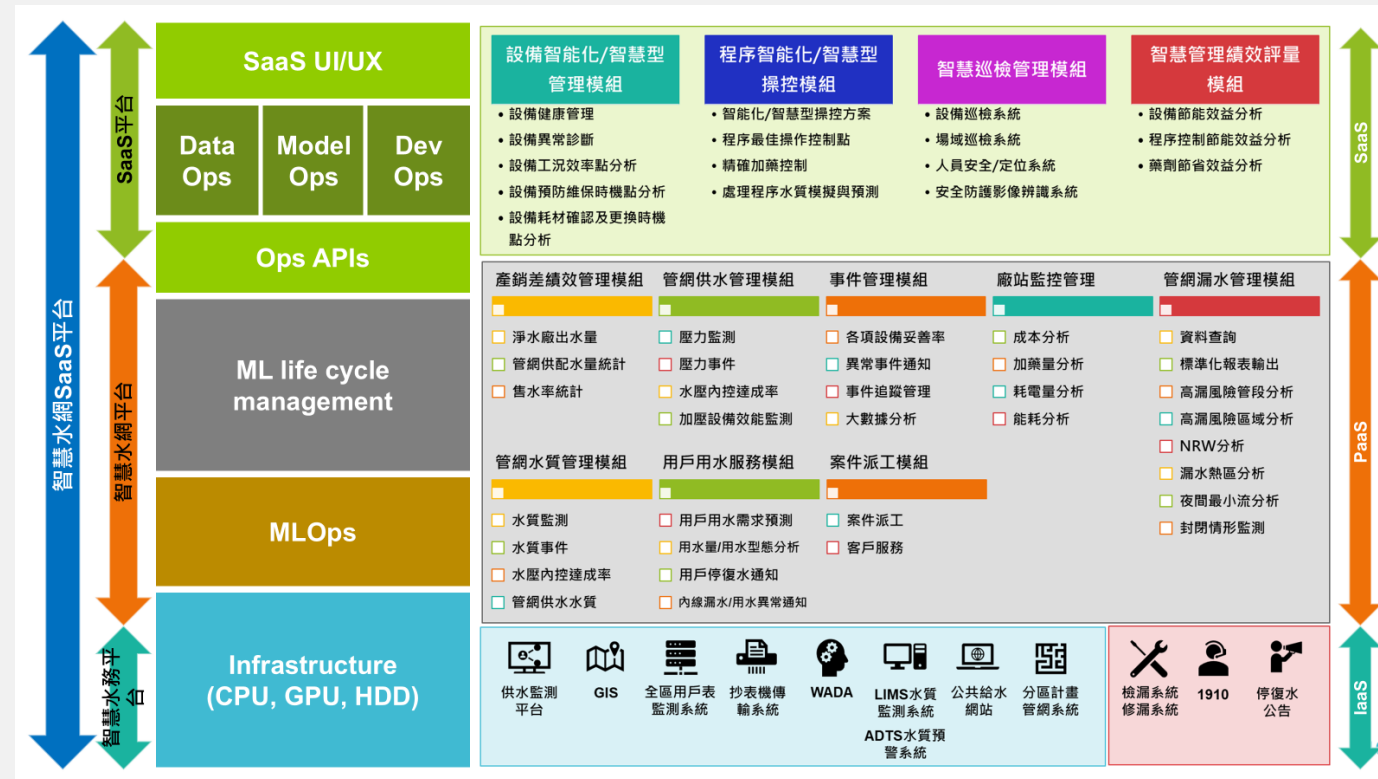
5. 行政管理與決策支援

Administrative Management and Decision Support

WaterOps智慧水務服務平台

WaterOps Smart Water SaaS Platform

- 為提供智慧水務領域免編程（No-Coding）、快速上手的AI機械學習維運平台。透過此平台可以帶來維護AI模型生命週期與DevOps的改善速度與敏捷性。
- WaterOps平台具備網頁式的簡易操作介面，並整合多種數學與統計學工具以及演算法（表9.5），透過機器學習AutoML、深度學習與專家系統等強大數據資料處理與分析功能，使用者無須開發程式，即可迅速精準構建專屬AI模型，並可生成各類直觀的資料統計分析圖表，作為決策的參考。



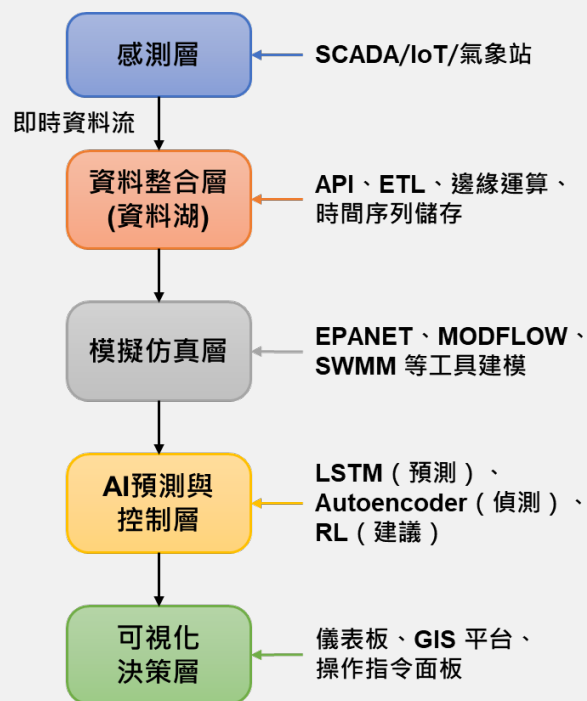
數位孿生與模擬控制技術

Digital Twin and Analog Control Technology

- 數位孿生 (Digital Twin) 技術，透過即時資料驅動與虛實系統同步，建構可模擬、可預測、可控制的虛擬映射場景，成為智慧水務轉型的重要基礎設施。

- 數位孿生是一個「資料 + 模型 + 模擬 + 控制」的整合平台，其價值在於：

- 即時監控，提升透明度；
- 虛擬模擬，預測未來狀況；
- 決策支援，優化行動方案；及
- 自動控制，關鍵參數即時反應等。



WaterOps平台與數位孿生技術之應用

Applications of WaterOps SaaS Platform and Digital Twin's Technology

- **自動化決策支援系統**：將水情數據轉換為即時報表與決策建議。
Automated decision support systems: Converting water situation data into real-time reports and actionable recommendations.
- **NLP 與智慧客服**：處理民眾查詢與諮詢，提高服務效率。
NLP and smart customer service: Handling public inquiries and consultations, improving service efficiency.
- **知識管理**：將專家經驗與操作案例納入 AI 系統，縮短人員培訓時間。
Knowledge management: Incorporating expert experiences and operational cases into AI systems to shorten staff training time.

對行政管理與決策支援任務之效應

Effects on administrative management and decision support tasks.

提升政策透明度與民眾互動效率

Improve policy transparency and public interaction efficiency.

政策意義與未來展望

Policy Implications & Future Outlook

政策價值

Align with global policy goals



支援SDG 6、SDG 13

SDG 6 – Clean Water and Sanitation
SDG 13 – Climate Action



符合ESG與淨零碳排目標

Net Zero Carbon Reduction targets



實現效率、韌性與永續治理

Achieve efficiency, resilience, and sustainability of water governance.

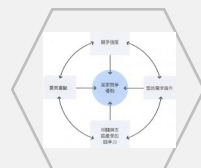
未來方向

Future Directions



AI為水資源治理的新基礎設施

AI becomes a new infrastructure for water governance.



建立跨國合作與國際標準

International collaboration for sharing AI models and standards.



AI倫理與資料治理保障

Data governance and AI ethics to ensure trust.



讓我們攜手以AI點亮水資源的未來，共創智慧水務新時代。

Let us work together to illuminate the future of water resources with AI and create a new era of smart water services.



基士德科技股份有限公司 台灣分公司
GSD Technologies Co., Ltd. Taiwan Branch
基士德環科股份有限公司
GSD Enviro-Tech (Taiwan) Co., Ltd.

Thanks for Your Attention