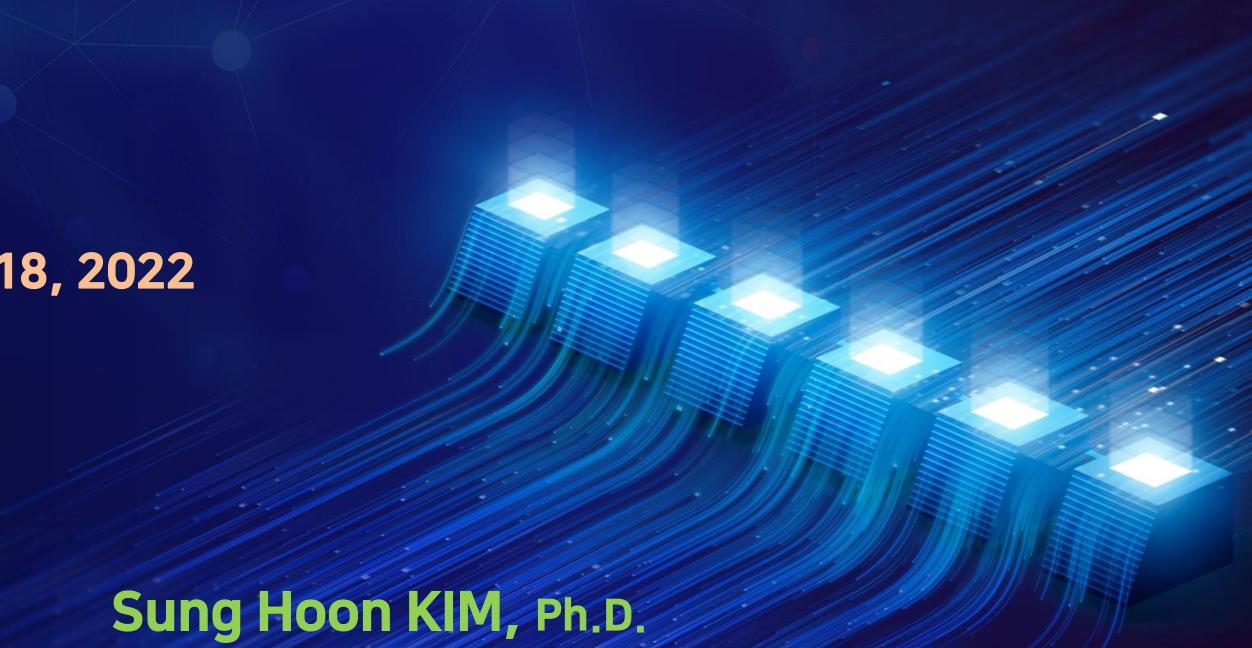


# K-water's Big Challenges for Digital Transformation in Smart Water Management

Aug 18, 2022



Sung Hoon KIM, Ph.D.

K-water Research Institute

01

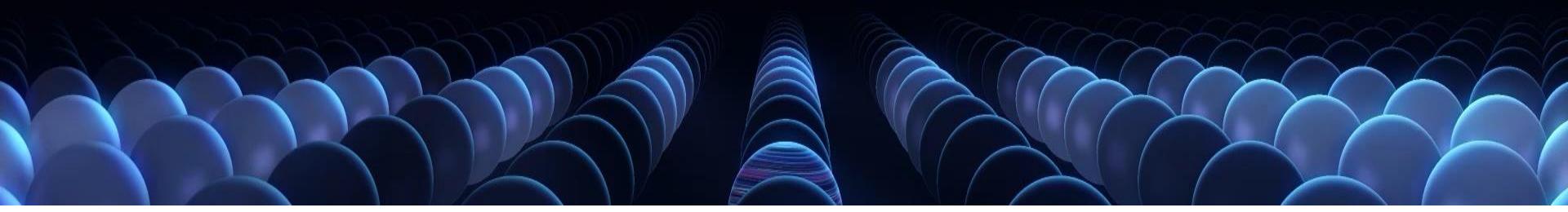
**Background**  
(Era of New Normal)

02

**K-water's Efforts**  
on Digital Transformation

03

**Future Directions**





[https://hedgersabroad.com/seomjin\\_river\\_cycling/](https://hedgersabroad.com/seomjin_river_cycling/)



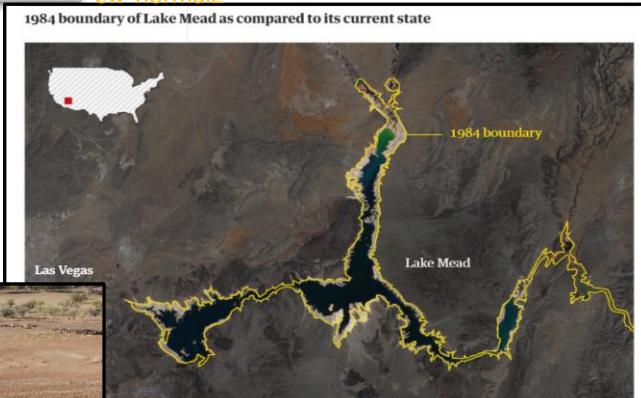
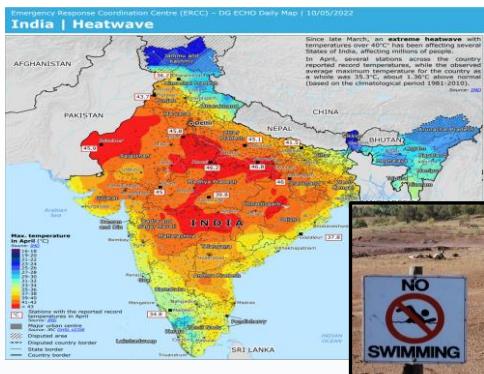
(Source):<https://montreal.ctvnews.ca>



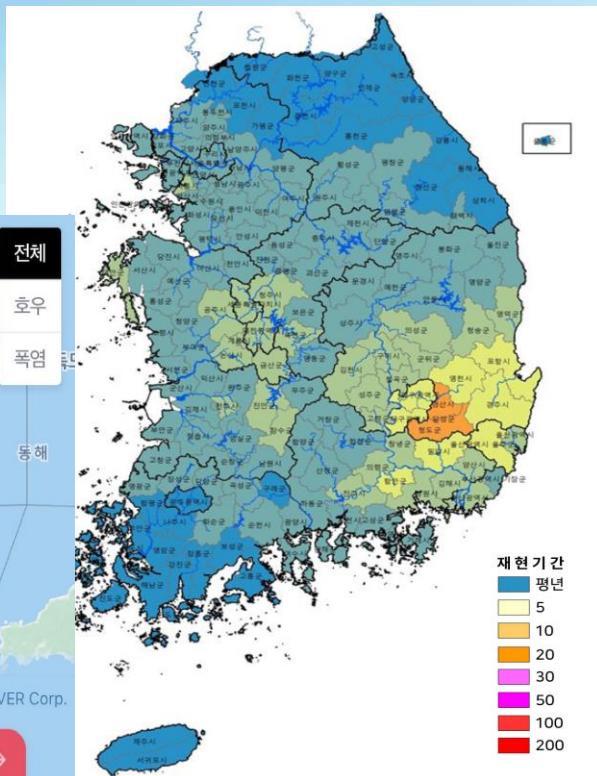
(Source)  
<https://www.samitivejhospitals.com/article/detail/new-normal2>



(Source)  
<https://edition.cnn.com/videos/weather/2015/06/18/climate-change-explainer-van-dam-cnni-nr-lklv.cnn>

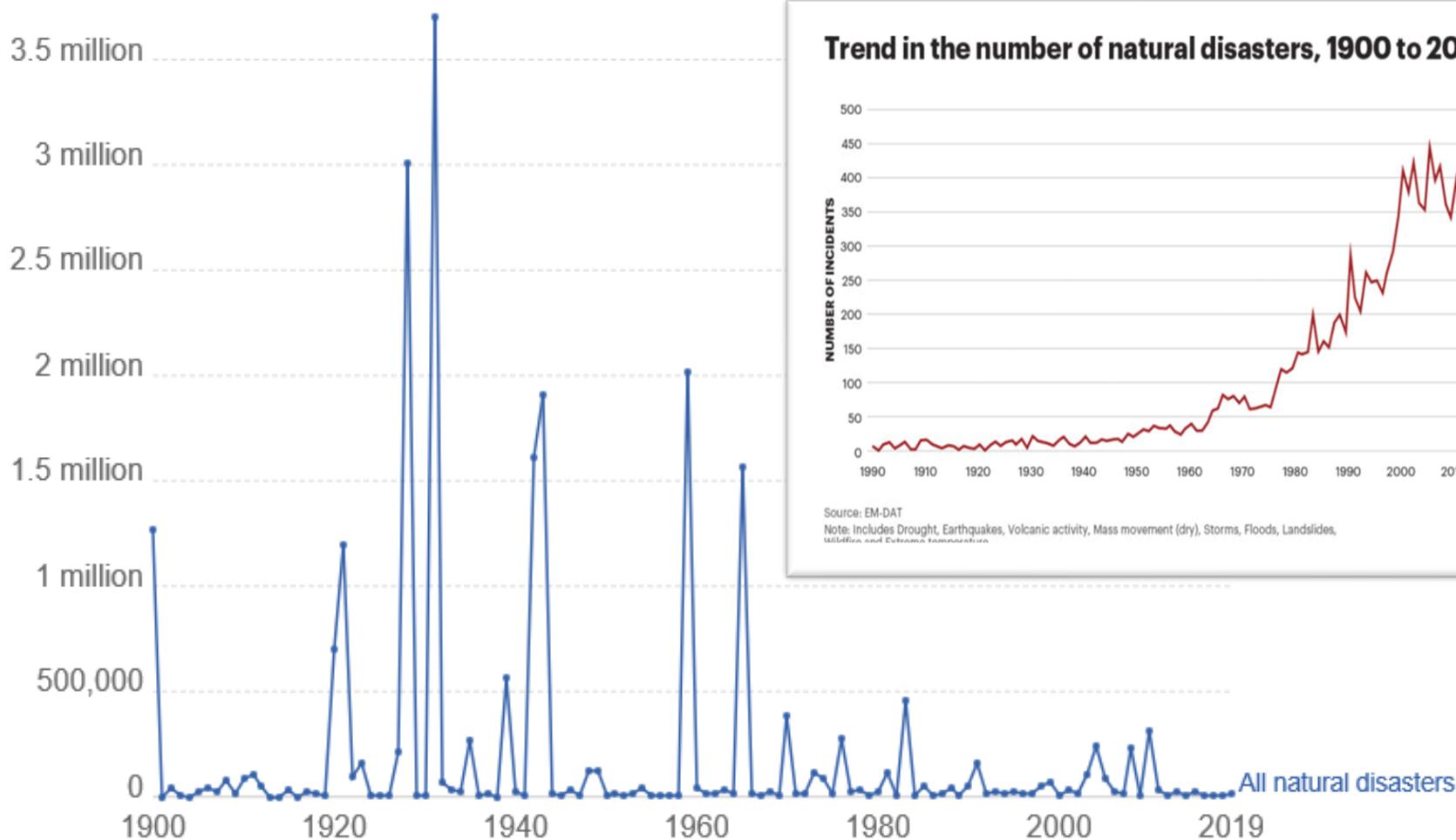


(Source) <https://www.theguardian.com/us-news/2021/jul/13/hoover-dam-lake-mead-severe-drought-us-west>



# Global deaths from natural disasters

Absolute number of global deaths per year as a result of natural disasters. "All natural disasters" includes those from drought, floods, extreme weather, extreme temperature, landslides, dry mass movements, wildfires, volcanic activity and earthquakes.



Source: EMDAT: OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium  
[OurWorldInData.org/natural-disasters/](http://OurWorldInData.org/natural-disasters/) • CC BY

# Background : CC, Net-Zero and DT

Water Problem caused by climate change :  
 the most complex and uncertain among global social issues  
 & the most pressing issue to be solved

## Climate Change

- Extreme weather events such as heat/cold waves and droughts
  - 1.8°C Increased in South Korea over last 100 years
- Extreme water disasters such as typhoons and heavy rains
  - 200K of flood victims, \$8.2B in economic loss over the last decade



## Net-zero

- Paris Agreement('16.11)
  - Obligated to reduce GHG emissions
- UNFCCC - COP25('19.12)
  - Net-zero by 2050
- UNFCCC - COP26('21.11)
  - 40% of NDC by 2030(South Korea)



## Digital Transformation (Accelerating DT)

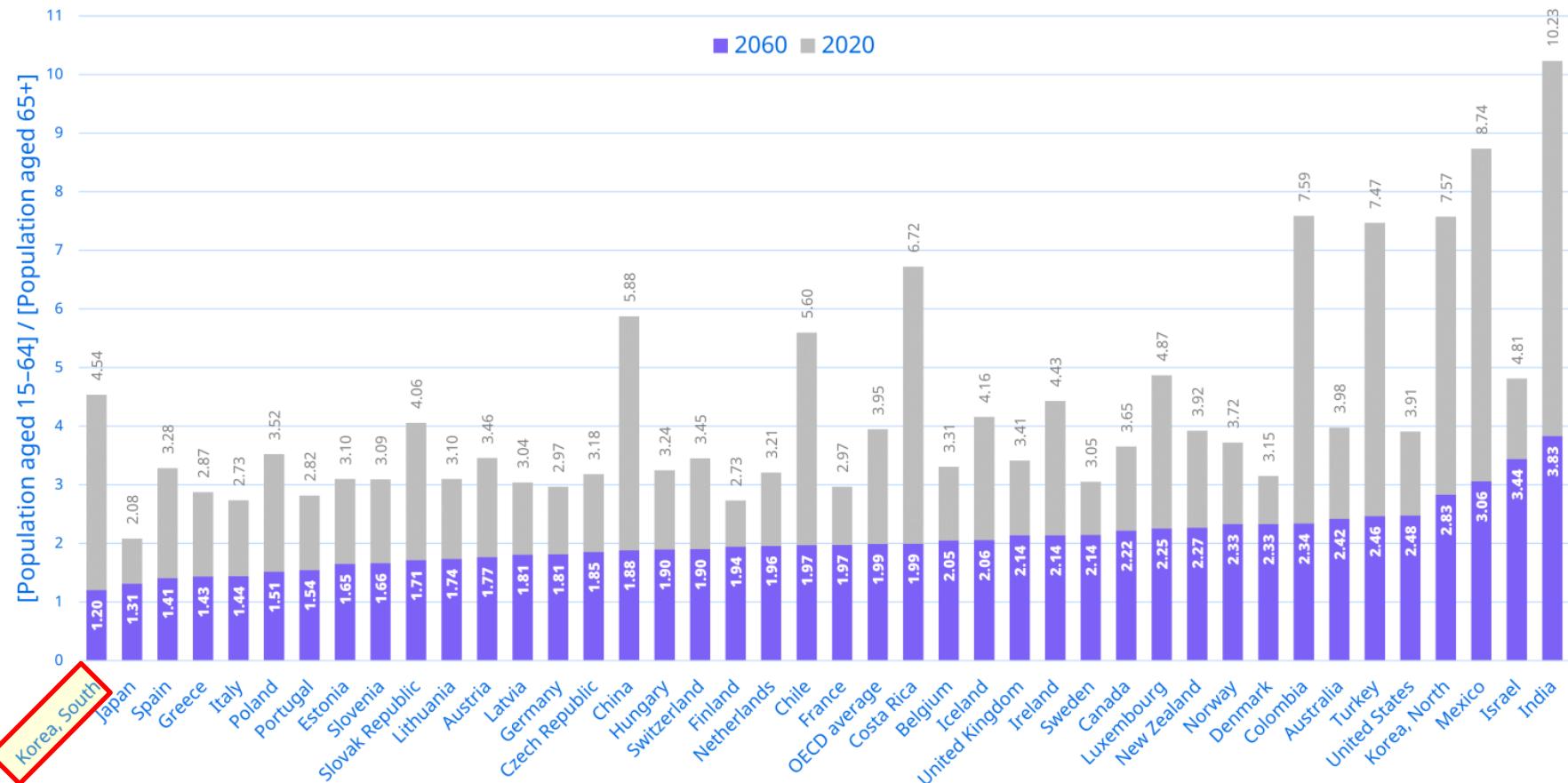
- Smart Innovation Technology
  - Rapid growth and evolution of AI, Data based technology
- Digital-based Platform
  - Development of tech. platforms

## Digital Water

Operational digital twins in the urban water sector: case studies

# Background : demographic change

## Old-Age Support Ratio in OECD and Some Asian Countries: Current and Projected



OECD. (2022). Society at a Glance: Asia/Pacific 2022. OECD Publishing.

## Background : demographic change

### Trends in Working Age Population (x 10k)



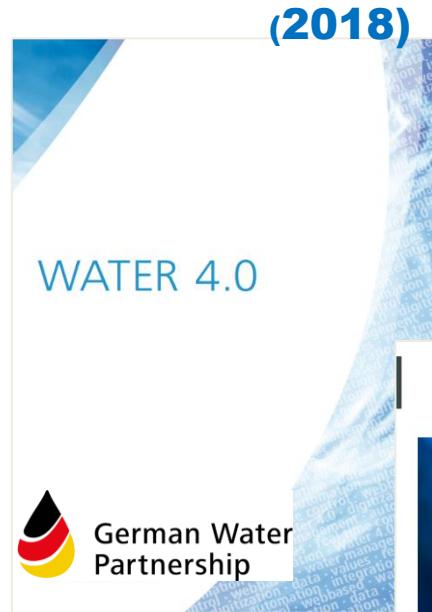
Korea National Statistical Office (2022)

# Background : water and digital

Leading countries are rapidly responding to digital transformation



(2016)



(2018)



(2019)



(2019)

# K-water : water and digital

Company Name	Korea Water Resources Corporation (K-water)
Establishment Date	November 16, 1967
Purpose of Establishment	Comprehensive development and management of water resources for the smooth supply of water for living, and to improve water quality to enhance the lives of the people and public welfare (Article 1 of the Korea Water Resources Corporation Act)
Institution Type	Quasi-market type public corporation
No. of Employees	6,498
Head Office Location	(34350) 200, Sintanjin-ro, Daedeok-gu, Daejeon, Korea
Organization	[Head Office] 1 Vice-President, 5 Divisions, 7 Headquarters, Institutes, Offices, 38 Departments, Teams, Centers [Local Business Site] 7 Head Offices, 20 Departments, Centers, 75 Branches, Offices (Sep. 2021)
Total Assets	KRW 22.9041 trillion (Dec. 2020)
Sales	KRW 3.7518 trillion (Dec. 2020)
Liabilities	KRW 13.8350 trillion (Dec. 2020)
Credit Rating	Korea: AAA, International: Moody's AA2 (Stable), S&P AA (Stable)
Shareholder Composition	ROK Government 93.49%, Korea Development Bank 6.43%, Local Government 0.08% (Sep. 2021)

# What K-water does...

## Renewable Energy Generation

- ◆ Capacity: 1,356MW → 13% of gross domestic capacity
- ◆ Hydropower 1,080MW → 60% of gross domestic hydro power capacity
- ◆ Annual Generation: 2,118GWh

Hydro Power



Tidal



Photovoltaic



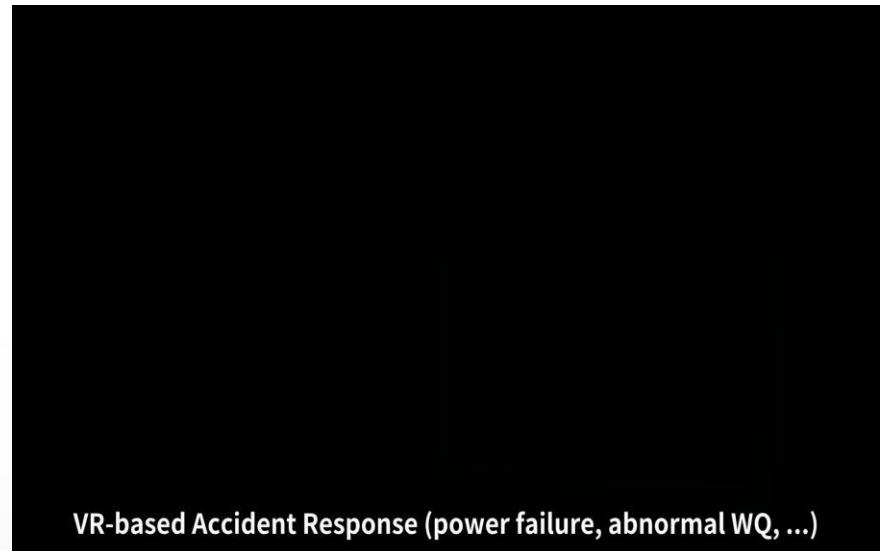
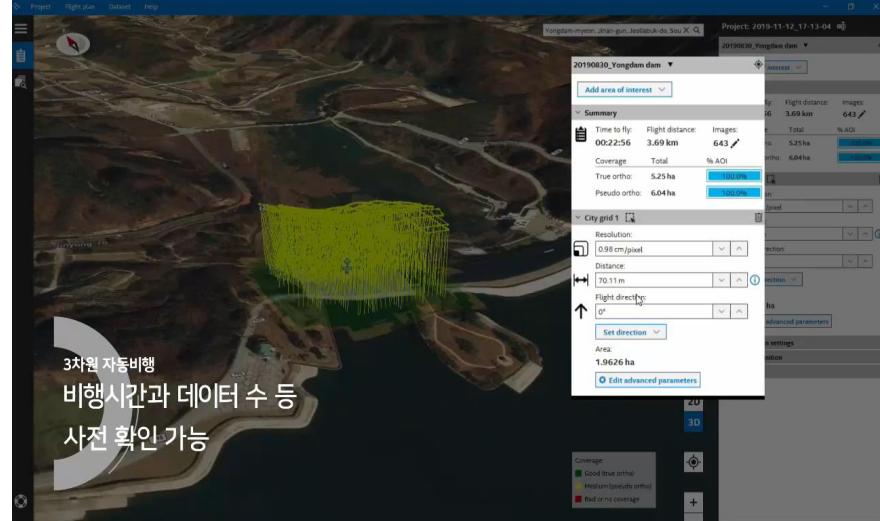
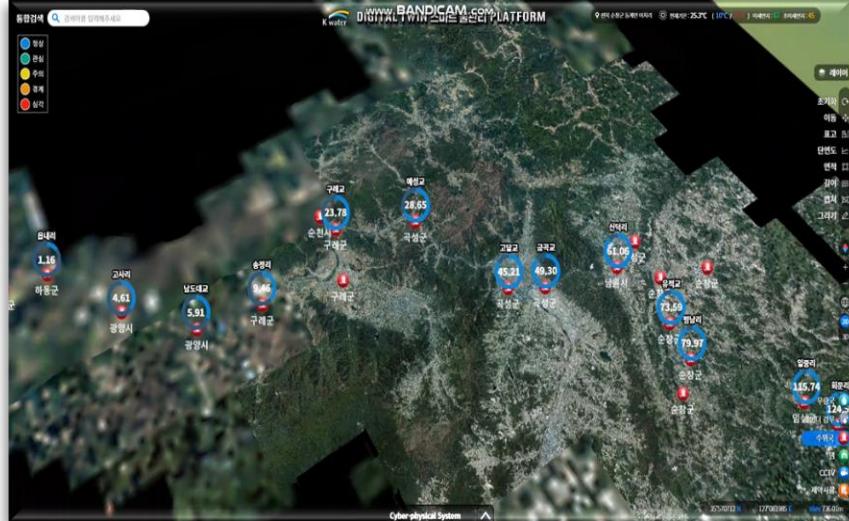
Hydrothermal



# K-water's efforts on Digital Twin Initiative



# K-water's efforts on Digital Twin Initiative



# K-water's effort on Digital Twin Initiative



- “Big Data + AI” based autonomous operation & virtual sensors
- Risk management ability ↑
- Facility inspection efficiency ↑



The image shows four digital twin applications:

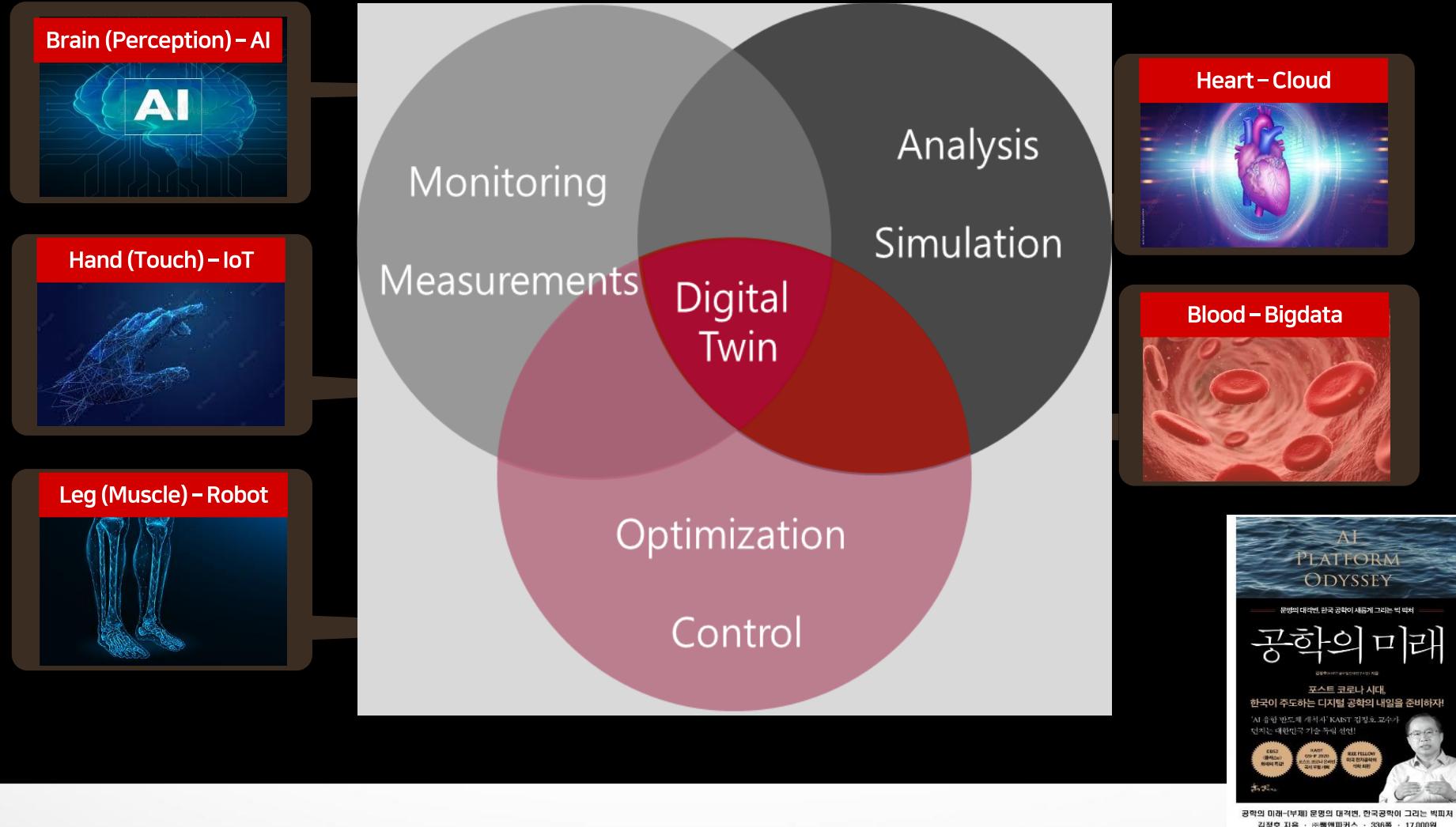
- Autonomous Operation:** Shows a profile of a person with AI icons above it, connected to a 3D model of industrial tanks.
- Smart EMS:** Displays a dashboard with various operational data and charts.
- Smart PMS:** Shows a pump unit with associated performance graphs.
- Com. Vision Safety Mgmt:** Illustrates a camera system with a safety monitoring interface.

# K-water's effort on Digital Twin Initiative

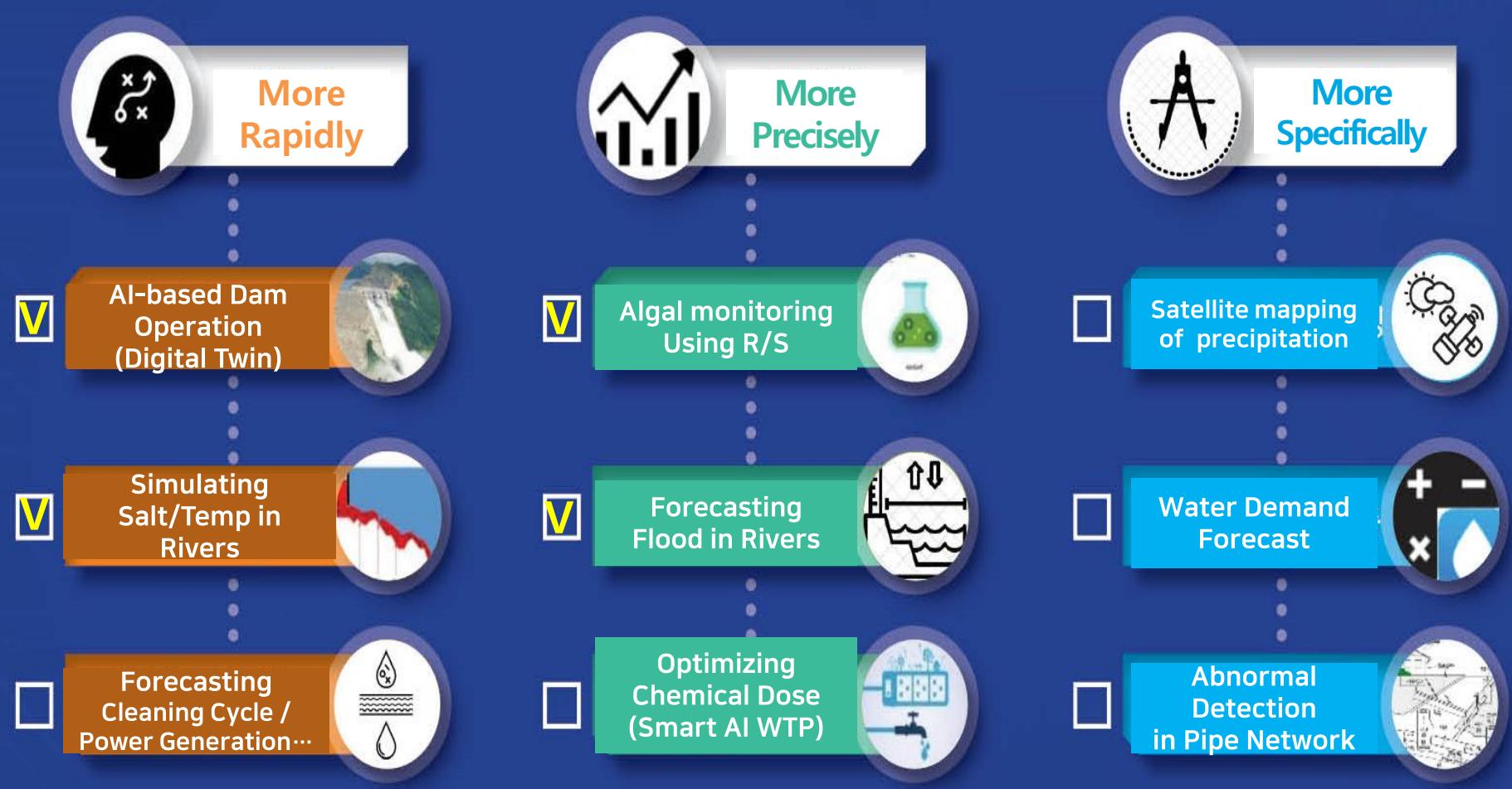
**VREW**

**3D Virtual Water Treatment Plant**

# ICBAM, DNA, Digital Twin...



# Research topics related to AI, ML



Keywords : Model Surrogate, Use of Remote-sensing, Data-Drive Model with Simulation

# AI Applications on Water Resource Management

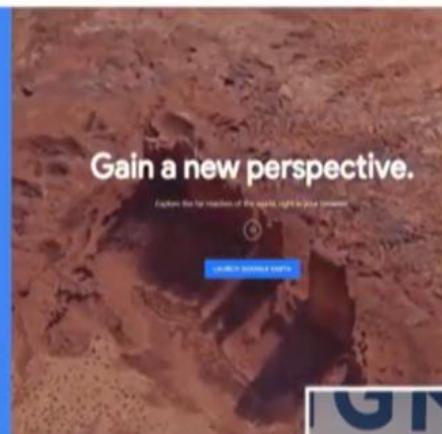
## The Google Flood Forecasting Initiative

### Why Google?

- Public-facing interfaces
- Computational resources
- Access to global data  
(Elevation, user-generated data, etc.)
- Scalability
- Machine learning expertise

### Why not (just) Google?

- Governmental mandate
- Hydrologic expertise
- Operational expertise
- Relationship with users



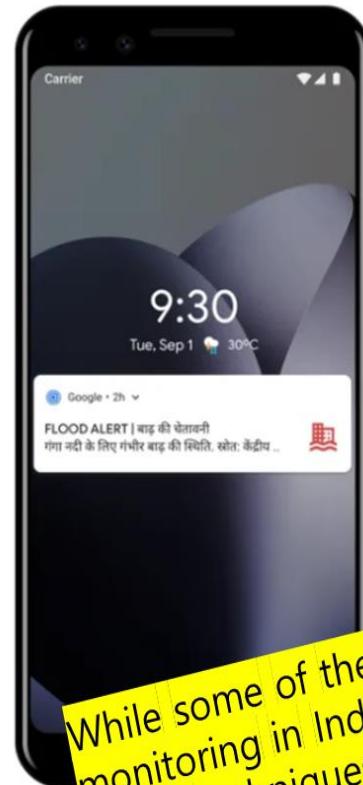
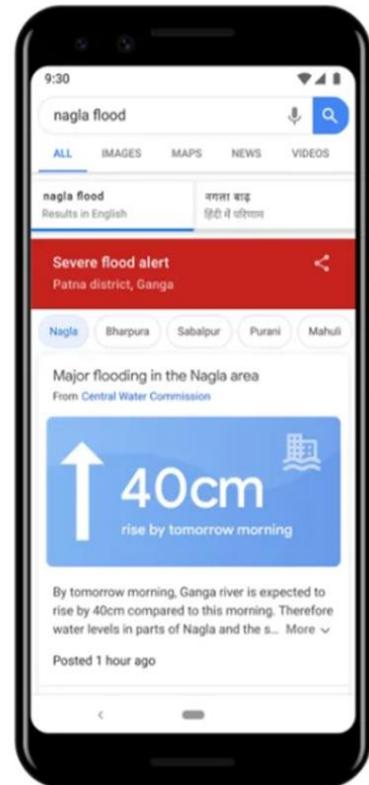
### Why Google?

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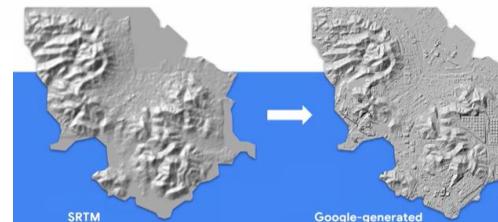
(Source) Global platform for disaster risk reduction, Geneva, Switzerland (2019)

# AI Applications on Water Resource Management

## Google's Flood Alerts



Elevation Map Example



Informing the Public



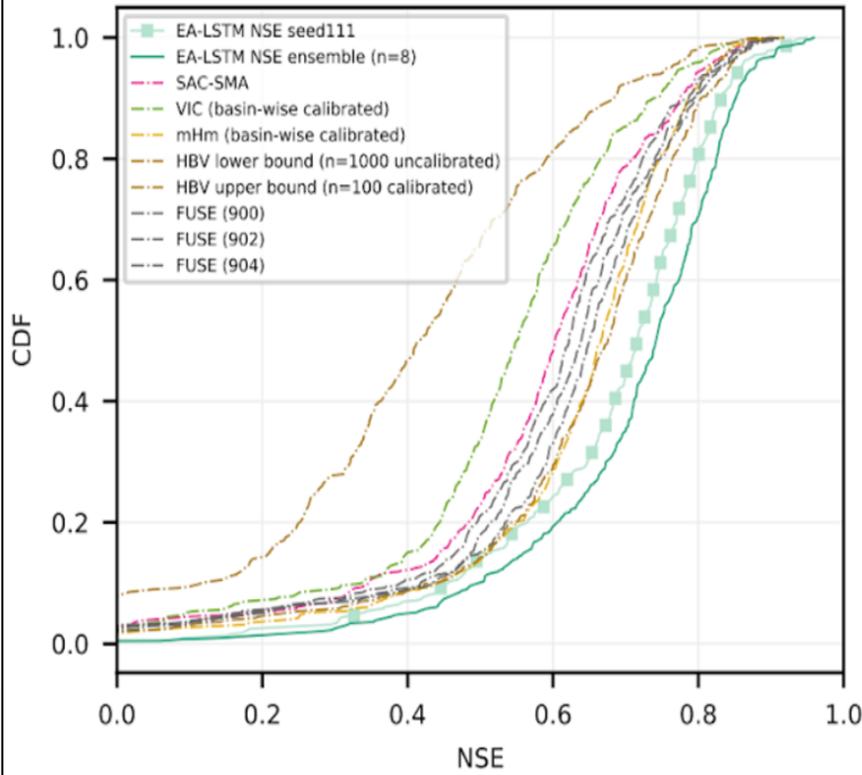
While some of these problems are specific to flood monitoring in India and other developing nations, some of the techniques Google has pioneered in India could change flood forecasting worldwide.

Google's new flood alerts offer information in some areas about the depth of the waters. | Image: Google

(source) <https://www.theverge.com/2020/9/1/21410252/google-ai-flood-warnings-india-bangladesh-coverage-prediction>

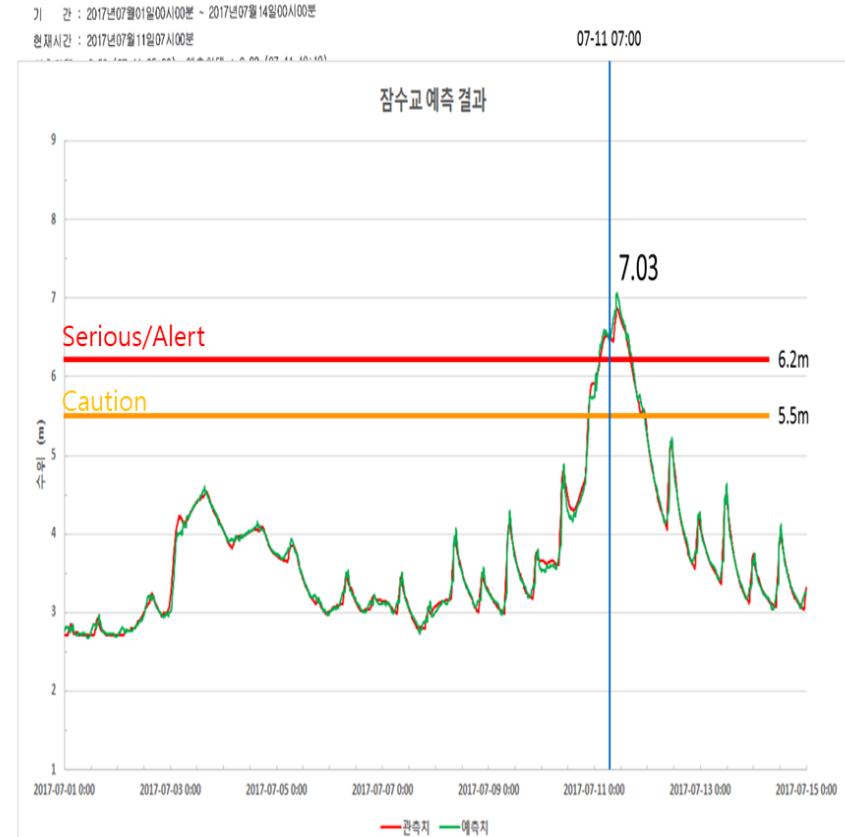
# AI Applications on Water Resource Management

Benchmarking vs. basin-wise calibrated models

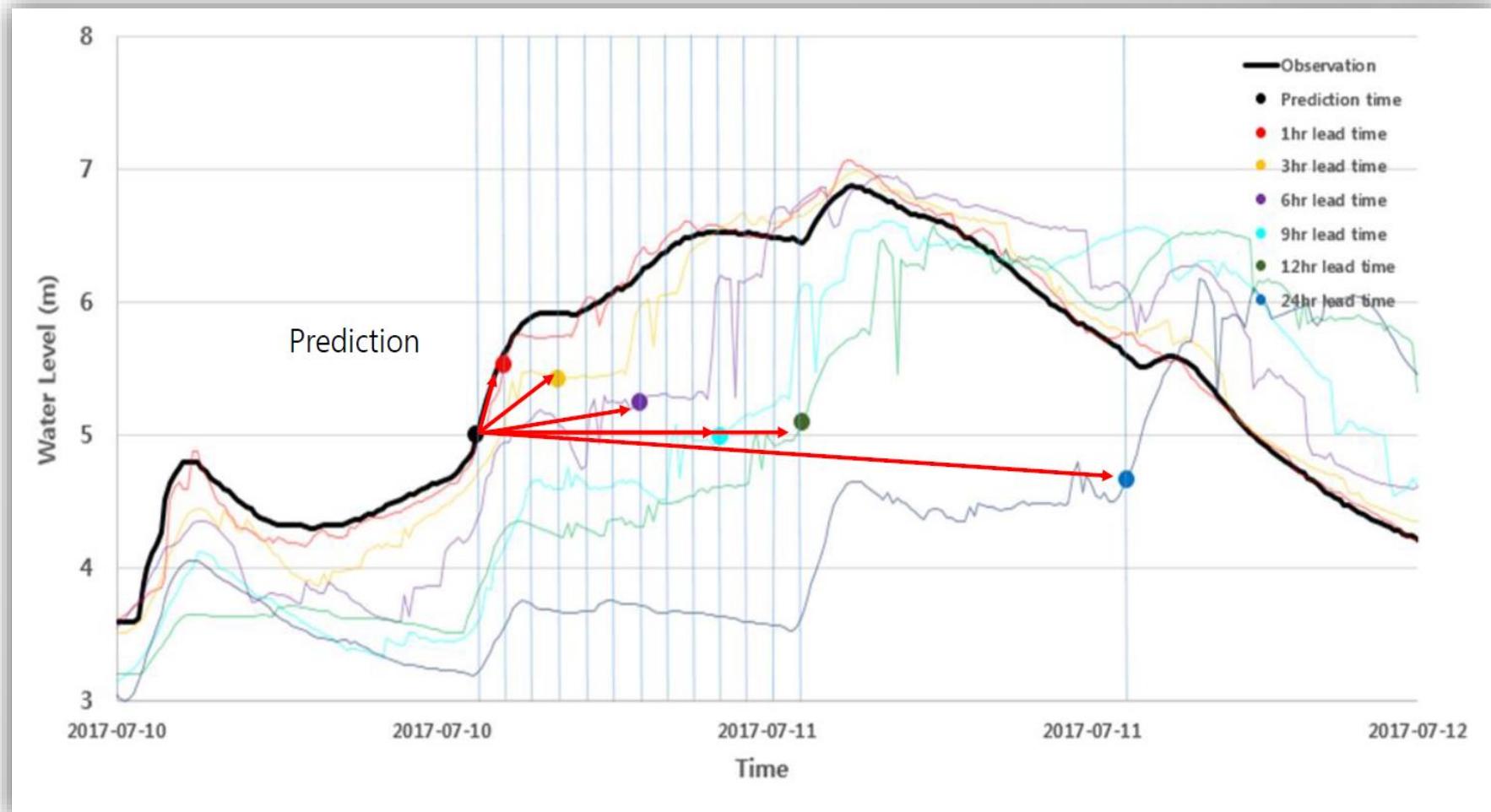


The distribution of NSE scores on basins across the United States for various models, showing the proposed EA-LSTM consistently outperforming a wide range of commonly used models.

Forecasted vs. Measured WL in Han River



# AI Applications on Water Resource Management



[ Forecast according to lead time ]

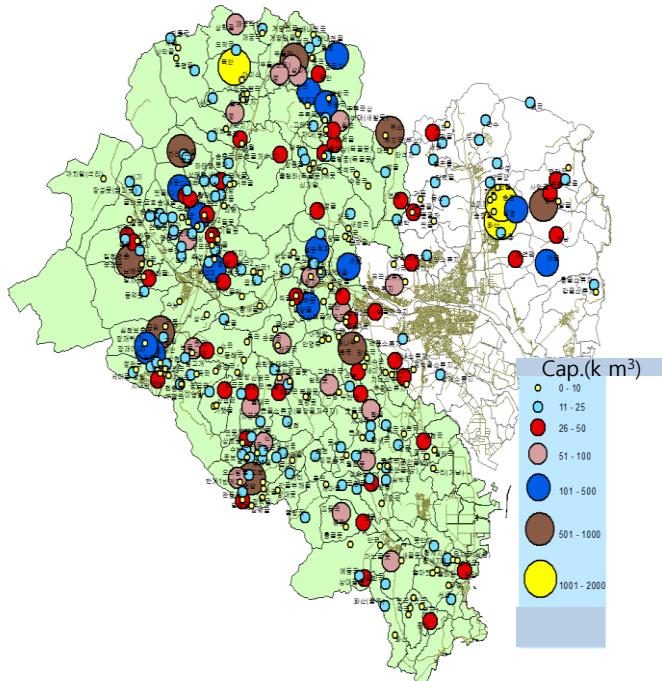
# AI Applications on Water Resource Management

## Ulsan City

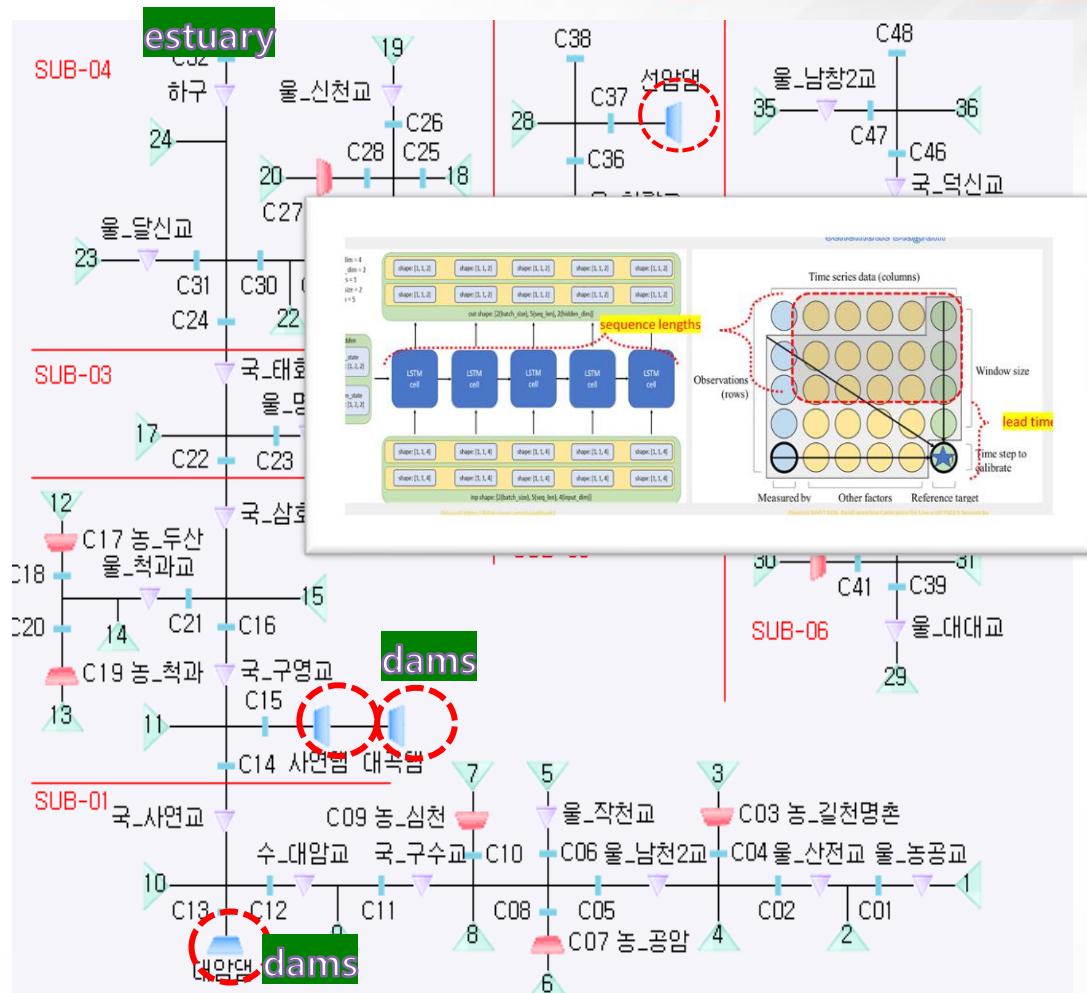
Watershed Area : 328 km<sup>2</sup>

Total Reservoir Capacity : 84,530K m<sup>3</sup>

Population : 1,178,907

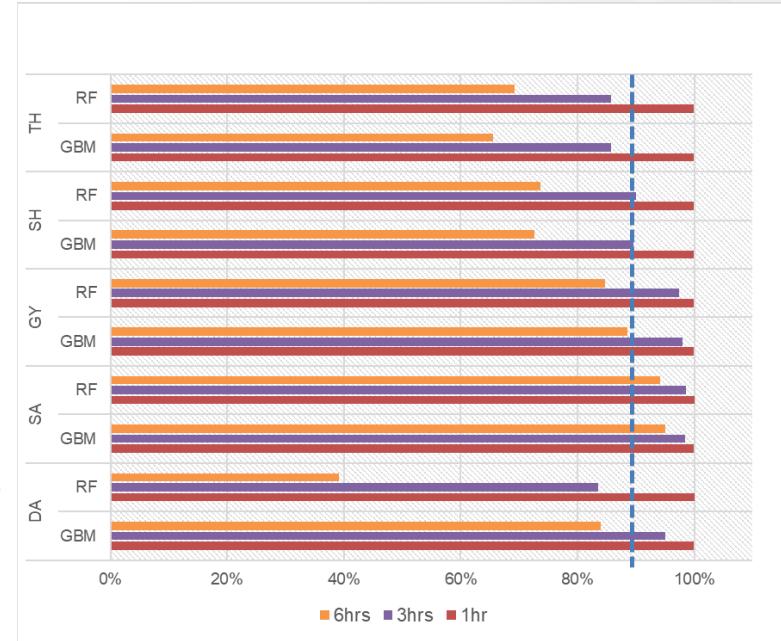


Status of spatial distribution in reservoirs



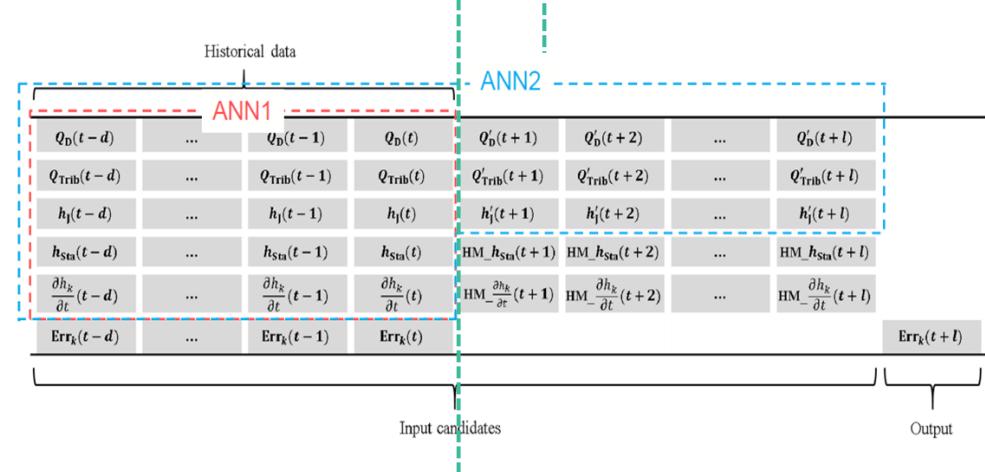
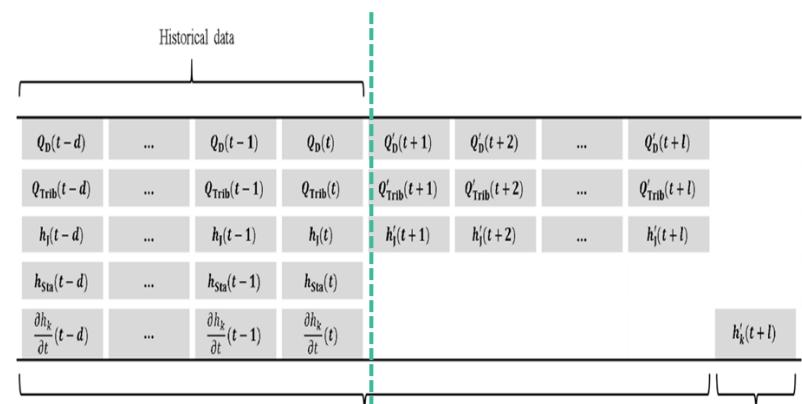
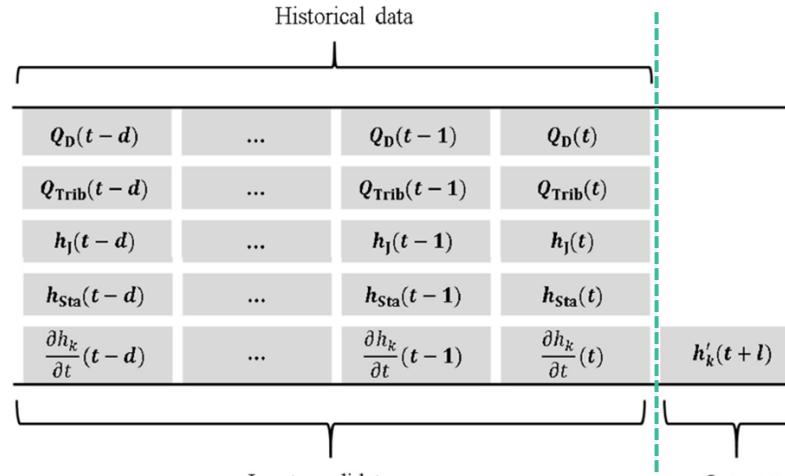
Schematic of river basin in target area

# AI Applications on Water Resource Management



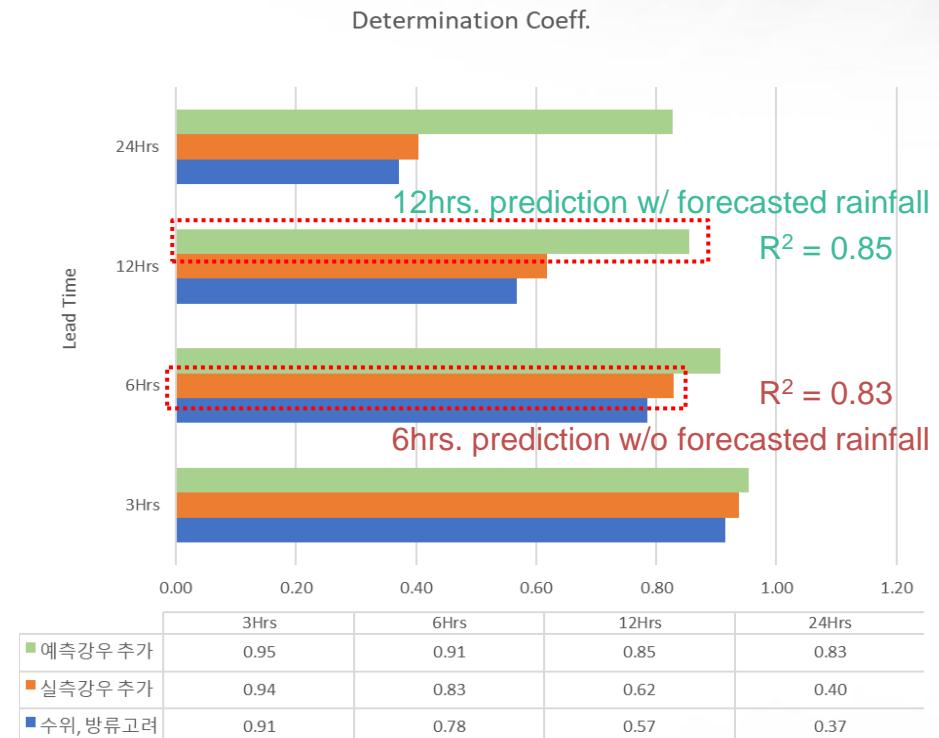
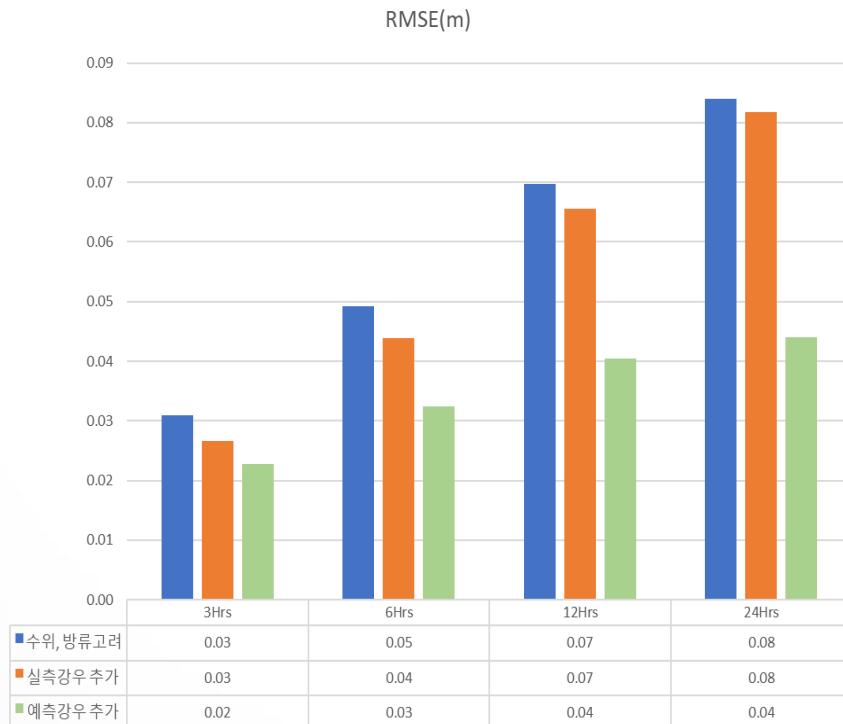
Predicted for	Sequence length	Case	Station	Characteristics	Forecasting Results		Remarks
					RMSE	Deter. Coeff. ( $R^2$ )	
3h	6h	various	DA	Upper	2.3cm	0.95	GBM > RF > BiL > LSTM
			SA	Middle	2.8cm	0.99	RF > GBM > BiL > LSTM
			GY	Middle	5.5cm	0.98	GBM > RF > BiL > LSTM
			SH	Middle	9.7cm	0.90	GBM~ > BiL > LSTM
			TH	Downstream (5km)	7.6cm	0.86	RF ~GBM > BiL > LSTM

# AI Applications on Water Resource Management



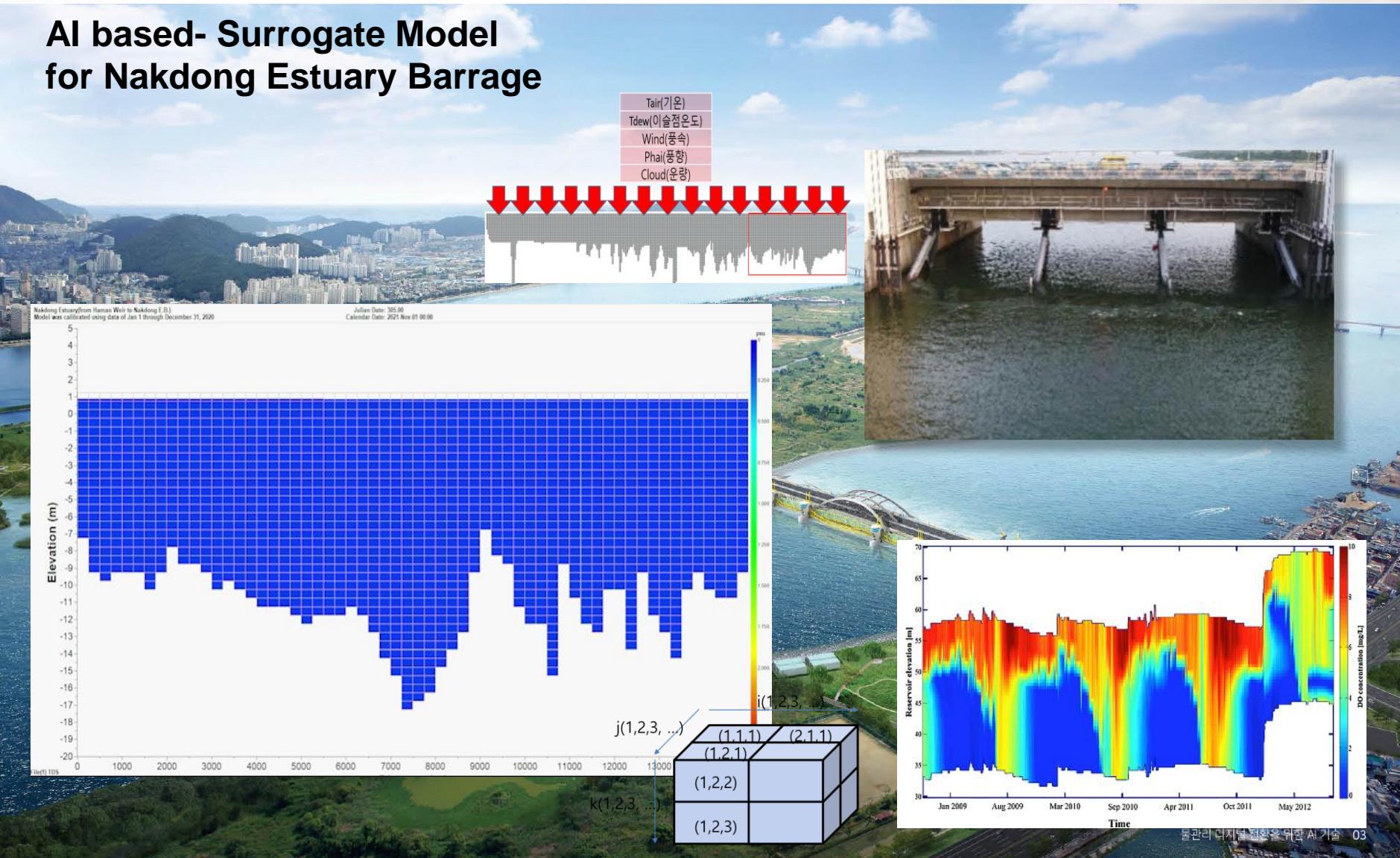
(source) Li and Jun (2018), A Hybrid Approach to Improve Flood Forecasting by Combining a Hydrodynamics Flow Model and ANNs

# AI Applications on Water Management



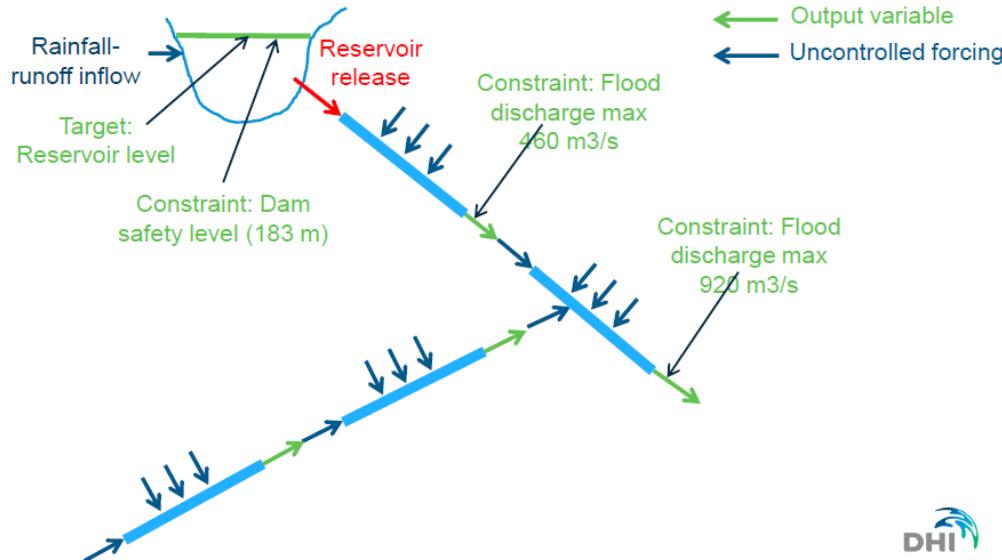
# AI Applications on Water Management

## AI based- Surrogate Model for Nakdong Estuary Barrage



# AI Applications on Water Management

## Surrogate model



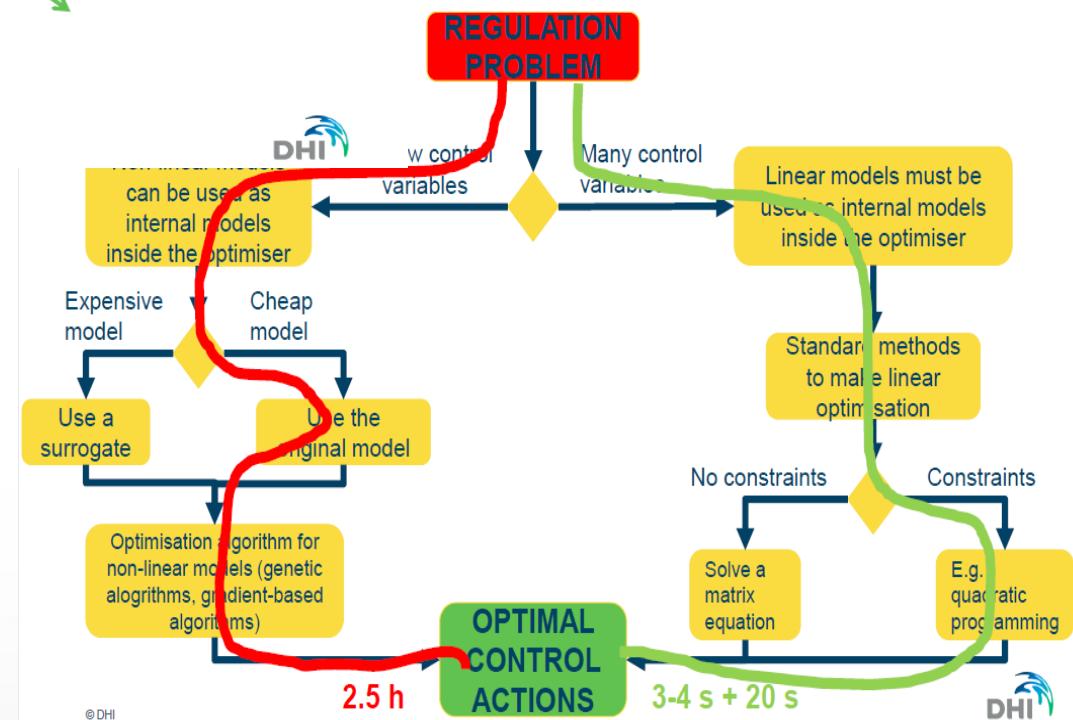
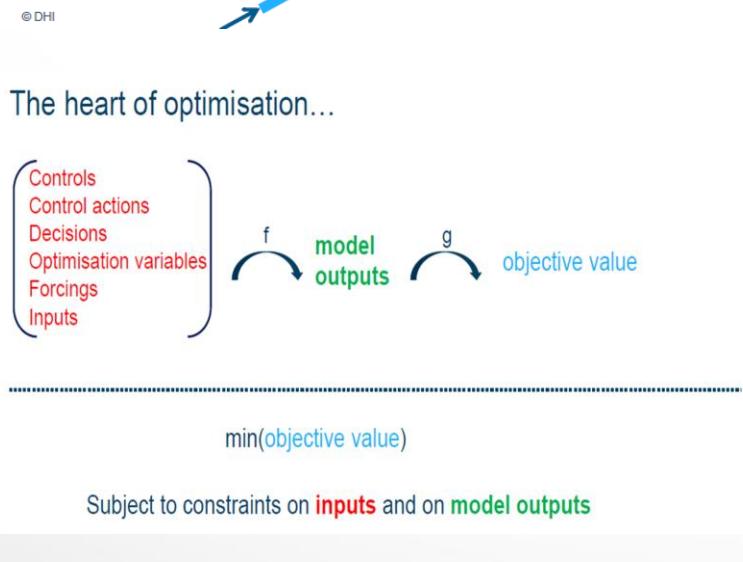
What is control...

"Control is about choosing the input that gives the desired output"

$$f(\text{control actions}) = \text{model output}$$

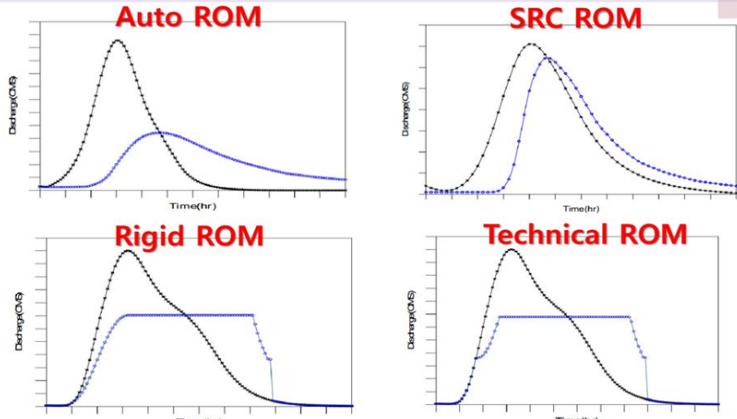
Entire forecast horizon

"control actions =  $f^{-1}(\text{model output})$ "

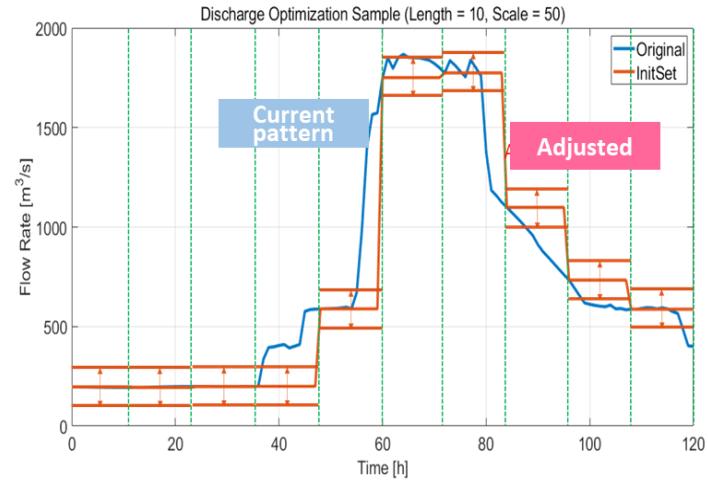
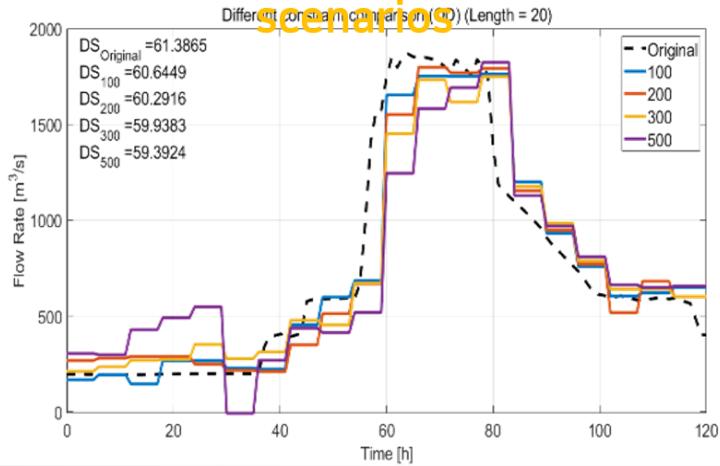


# AI Applications on Water Management

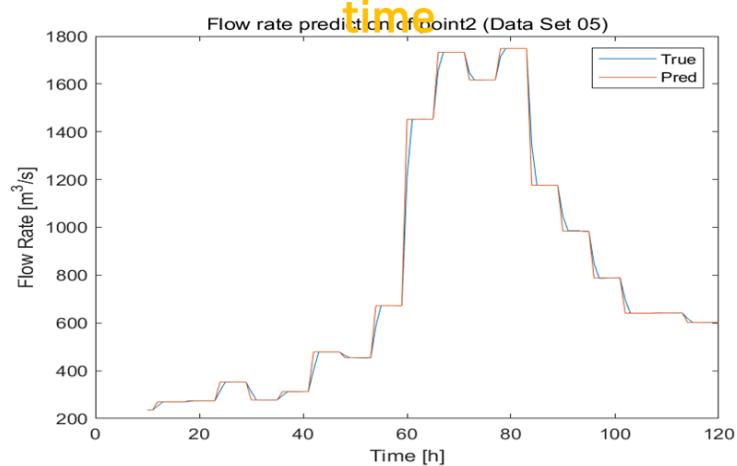
## Dam Gate Operation (PoC)



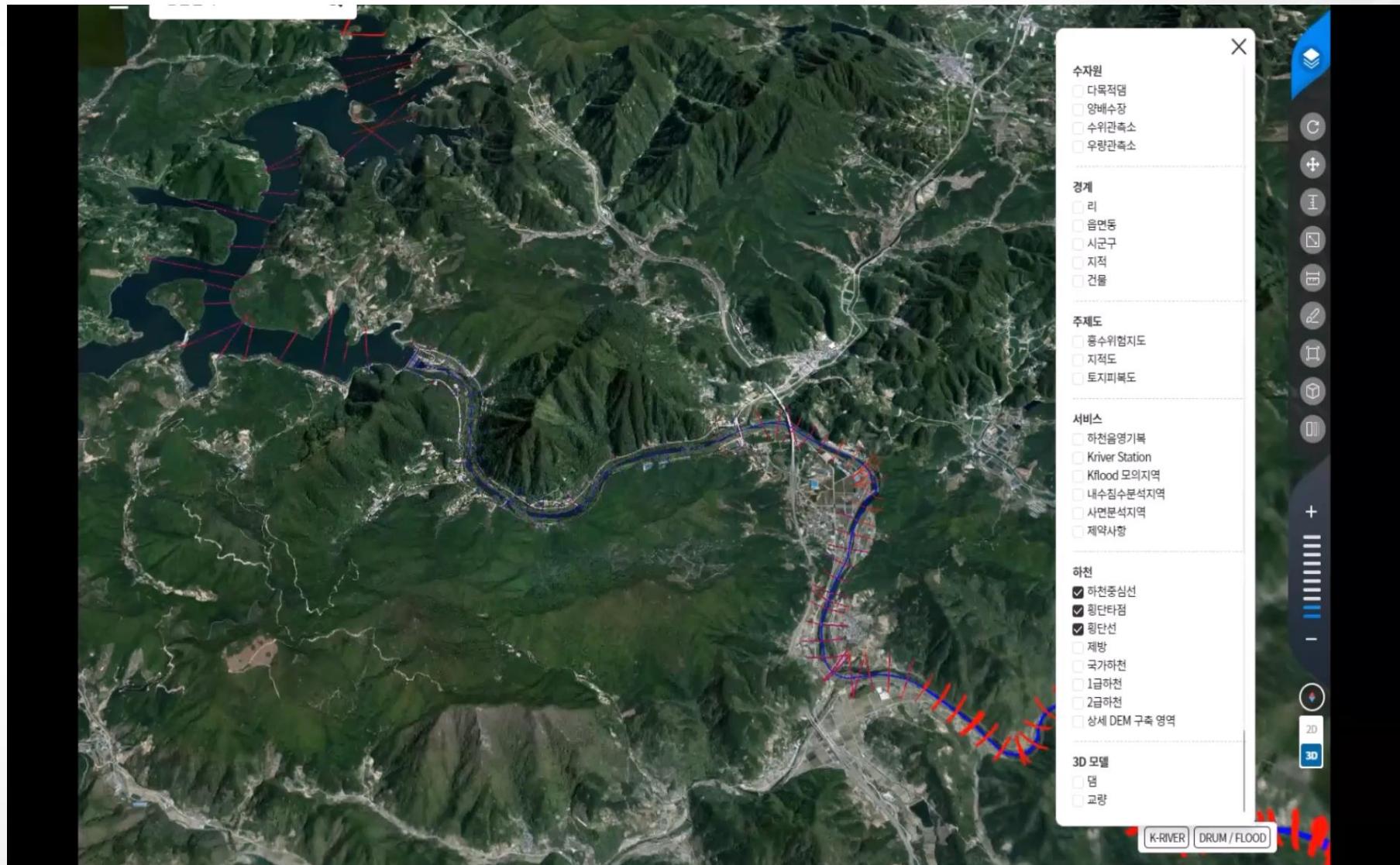
Possible dam discharge scenarios



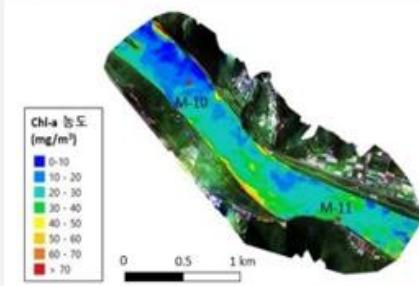
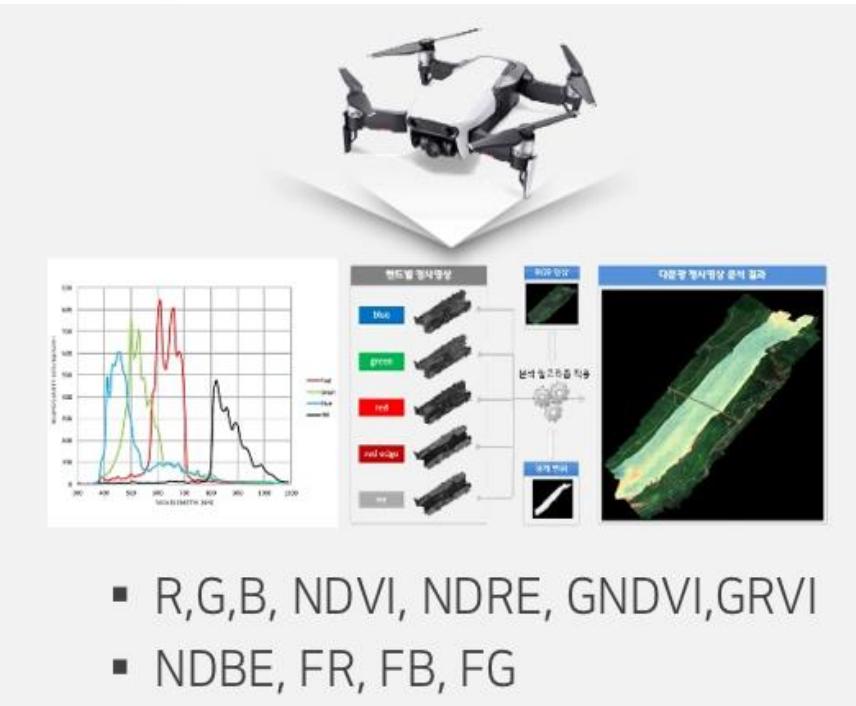
Optimized scenario at the current time



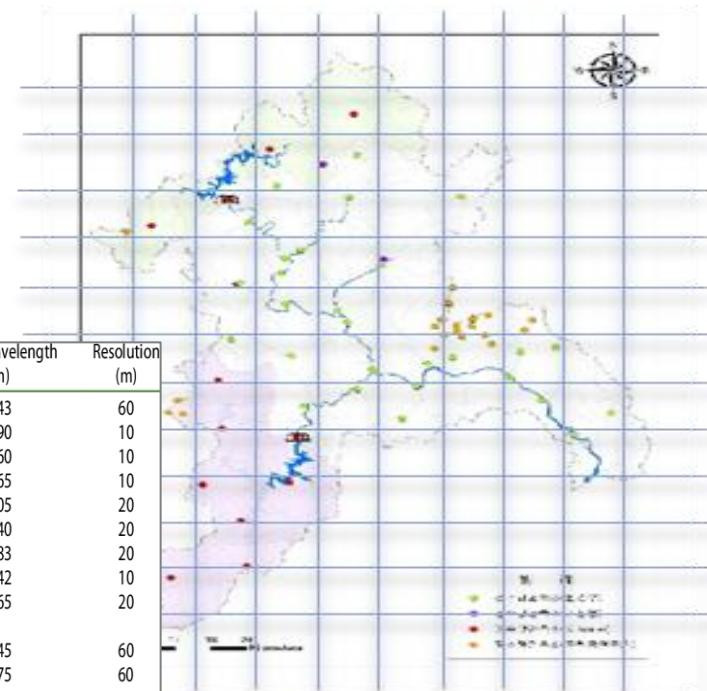
# AI Applications on Water Management



# AI Applications on Water Resource Management

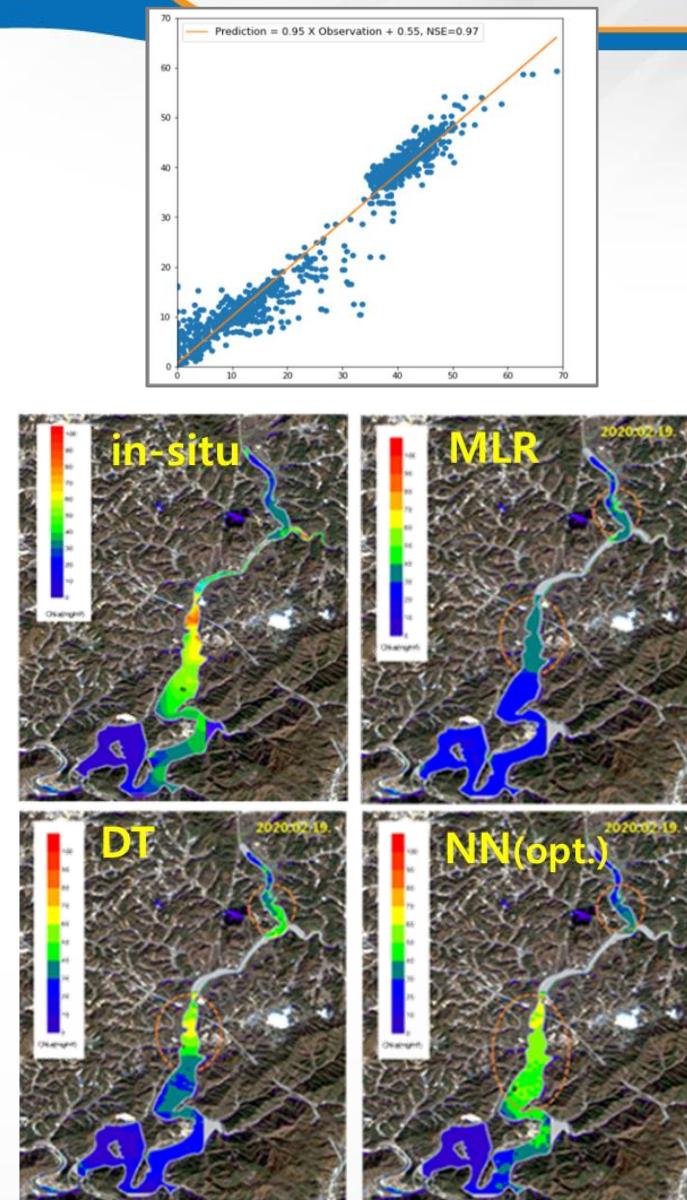


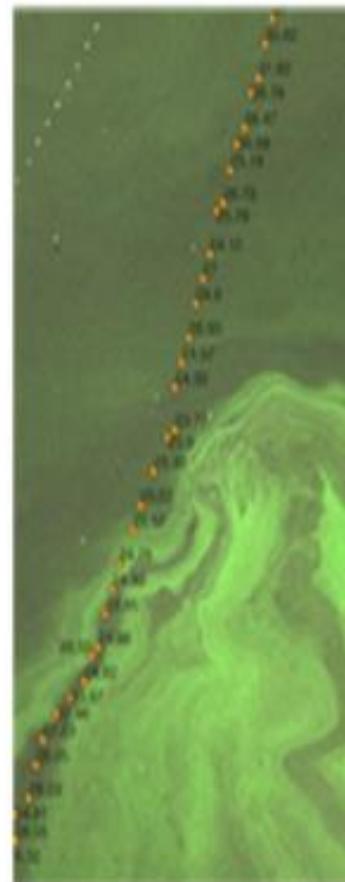
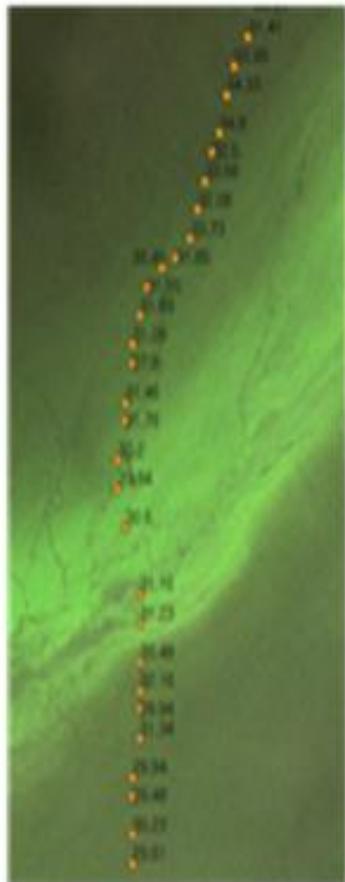
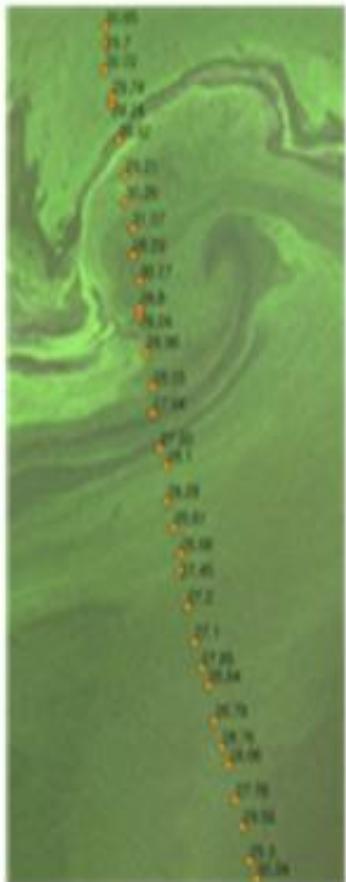
Sentinel-2 bands	Central wavelength (μm)	Resolution (m)
Band 1 – Coastal aerosol	0.443	60
Band 2 – Blue	0.490	10
Band 3 – Green	0.560	10
Band 4 – Red	0.665	10
Band 5 – Vegetation red edge	0.705	20
Band 6 – Vegetation red edge	0.740	20
Band 7 – Vegetation red edge	0.783	20
Band 8 – NIR	0.842	10
Band 9 – Vegetation red edge	0.865	20
Band 9 – Water vapour	0.945	60
Band 10 – SWIR – Cirrus	1.375	60
Band 11 – SWIR	1.610	20
Band 12 – SWIR	2.190	20



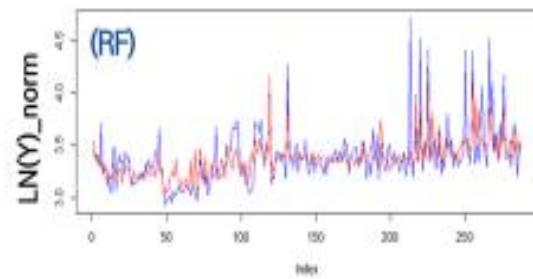
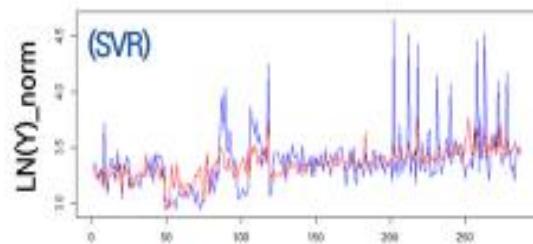
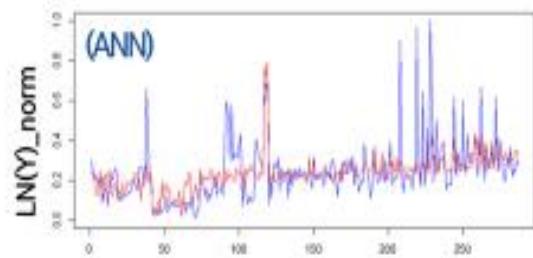
# AI Applications on Water Management

	Train/ Test	Accu. Index	Total Chl-a	Blue- Green	Diatom
MLR	Train	R <sup>2</sup>	0.28	0.63	0.60
		RMSE	17.6	11.8	10.9
	Test	R <sup>2</sup>	0.27	0.64	0.59
		RMSE	17.6	11.6	10.9
DT	Tran	R <sup>2</sup>	0.44	0.62	0.78
		RMSE	15.6	11.9	8.1
	Test	R <sup>2</sup>	0.43	0.62	0.77
		RMSE	15.6	11.8	8.2
NN1	Train	R <sup>2</sup>	0.63	0.77	0.90
		RMSE	13.5	10.3	5.8
	Test	R <sup>2</sup>	0.64	0.78	0.88
		RMSE	13.2	10.1	6.2
NN2	Train	R <sup>2</sup>	<b>0.74</b>	<b>0.84</b>	<b>0.92</b>
		RMSE	<b>10.6</b>	<b>7.8</b>	<b>4.8</b>
	Test	R <sup>2</sup>	<b>0.69</b>	<b>0.82</b>	<b>0.9</b>
		RMSE	<b>11.5</b>	<b>8.12</b>	<b>5.5</b>





무인항공 영상 vs Chl-a



# AI Applications on Water Management



# AI Applications on Water Management

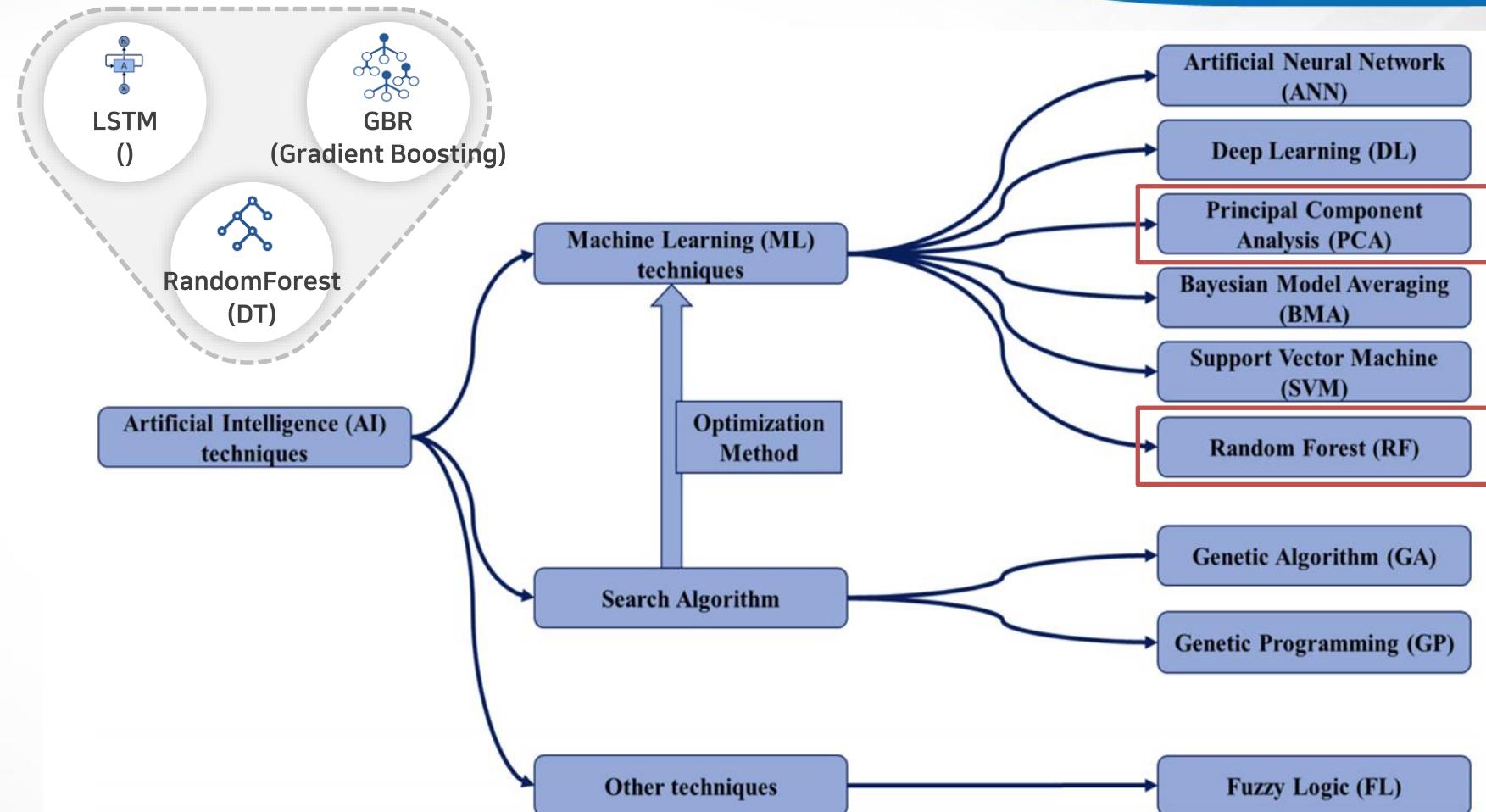
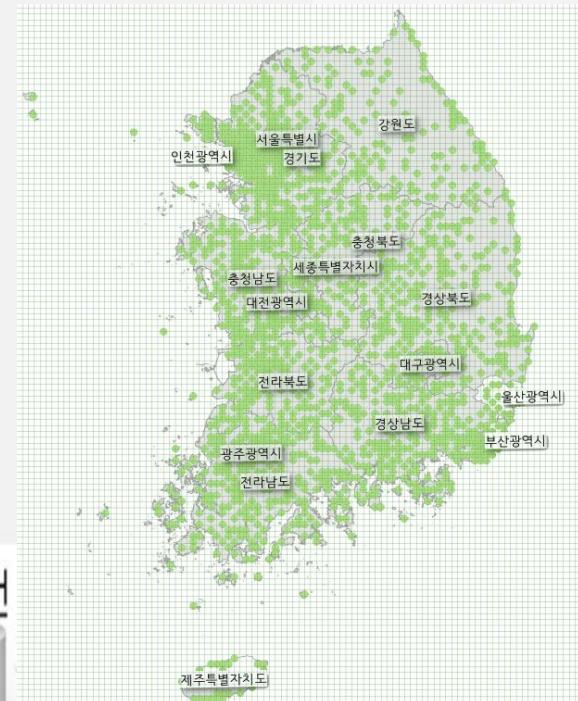
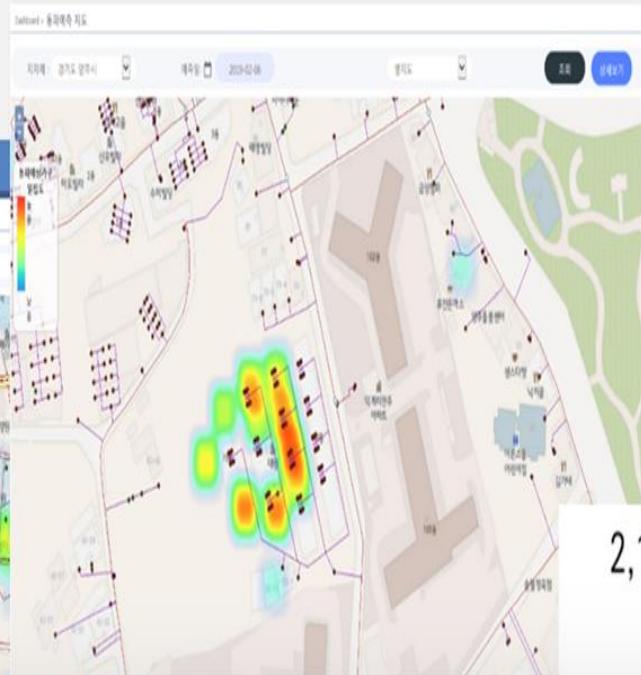
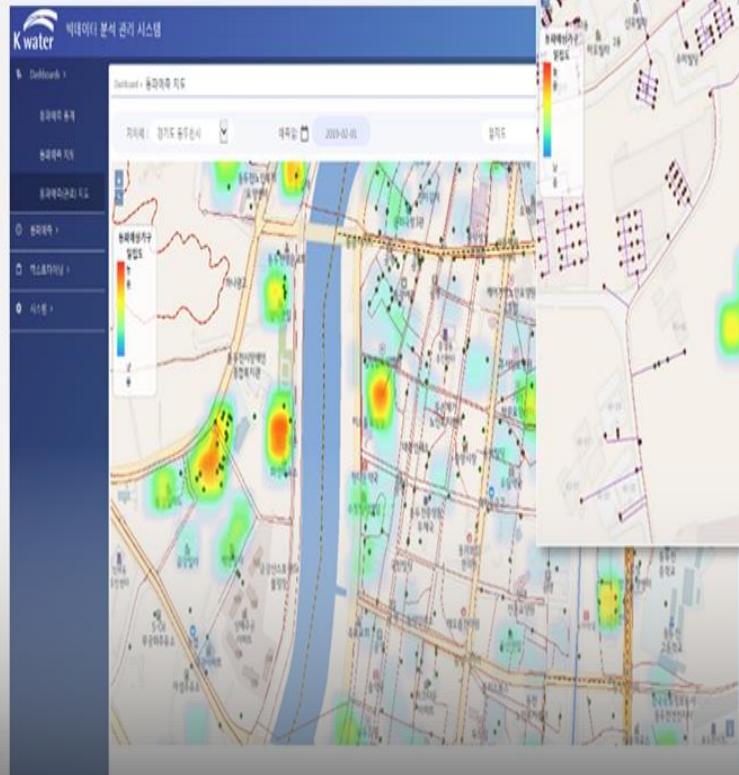


Fig. 1 A classification table of AI and ML techniques useful in the water systems

(Source) Maria Teresa Gaudio, et. al., "Artificial Intelligence-Based Optimization of Industrial Membrane Processes", Earth Systems and Environment 5(2):3 (2021)

# AI Applications on Water Management

<동파 예상 수용가 추정 및 시각화>



2,130건

'17년 겨울

동파민원수

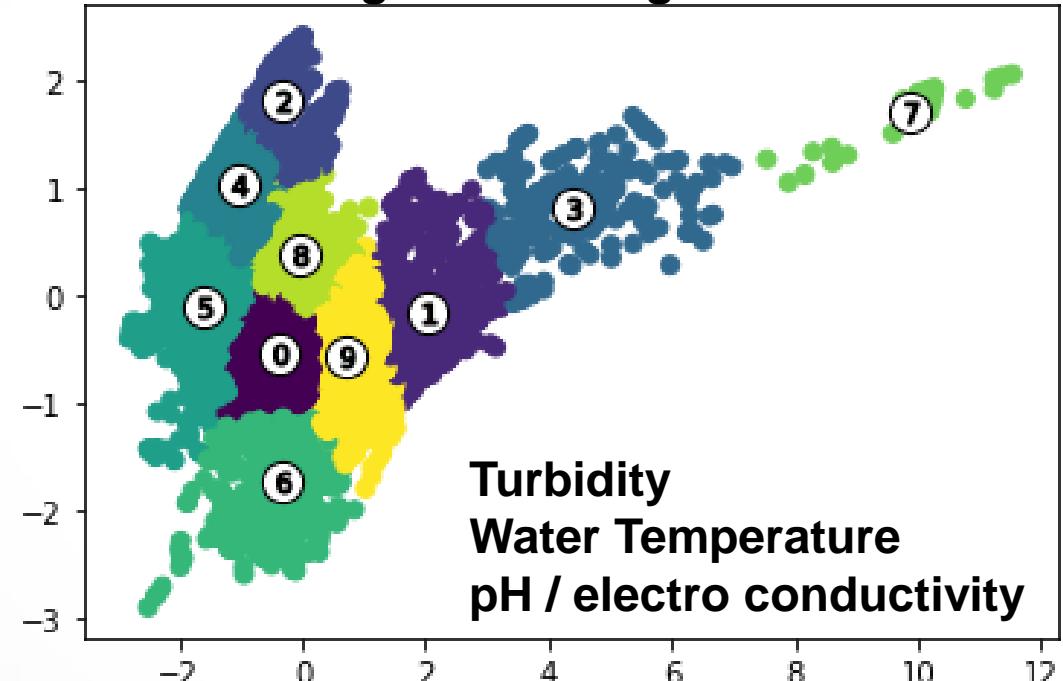


예측결과를 반영한 SMS안내 및 홍보 실시

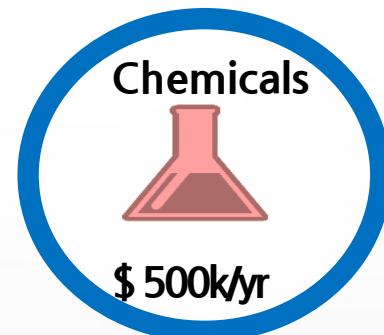
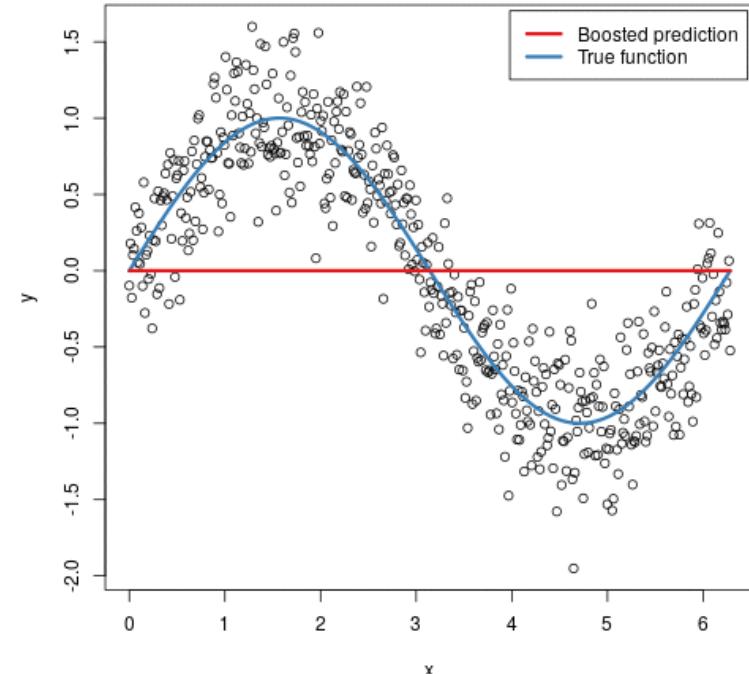
→ 동파 민원 90% 감소

# AI Applications on Water Management

## Clustering considering inflow WQ



## Gradient Boosting Regressions

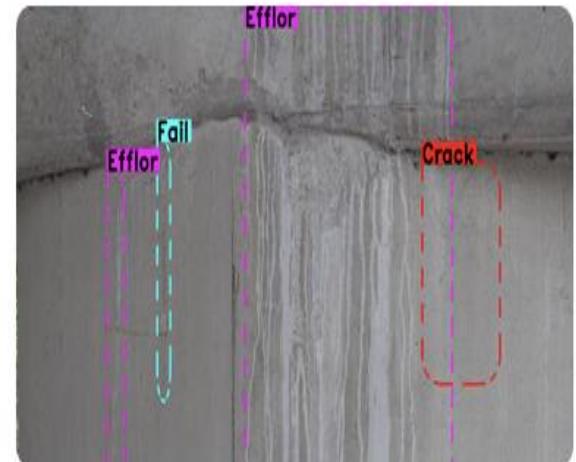
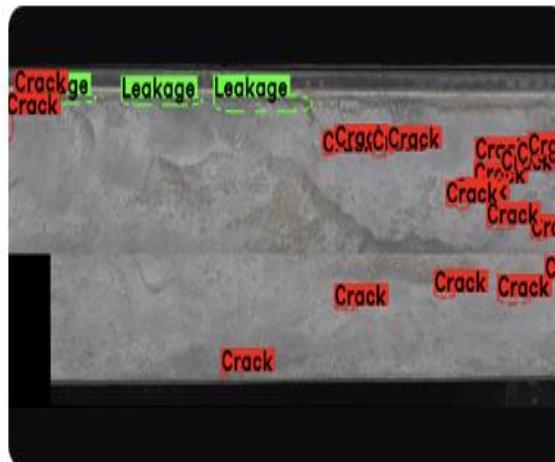


# AI Applications on Water Management

## CV application

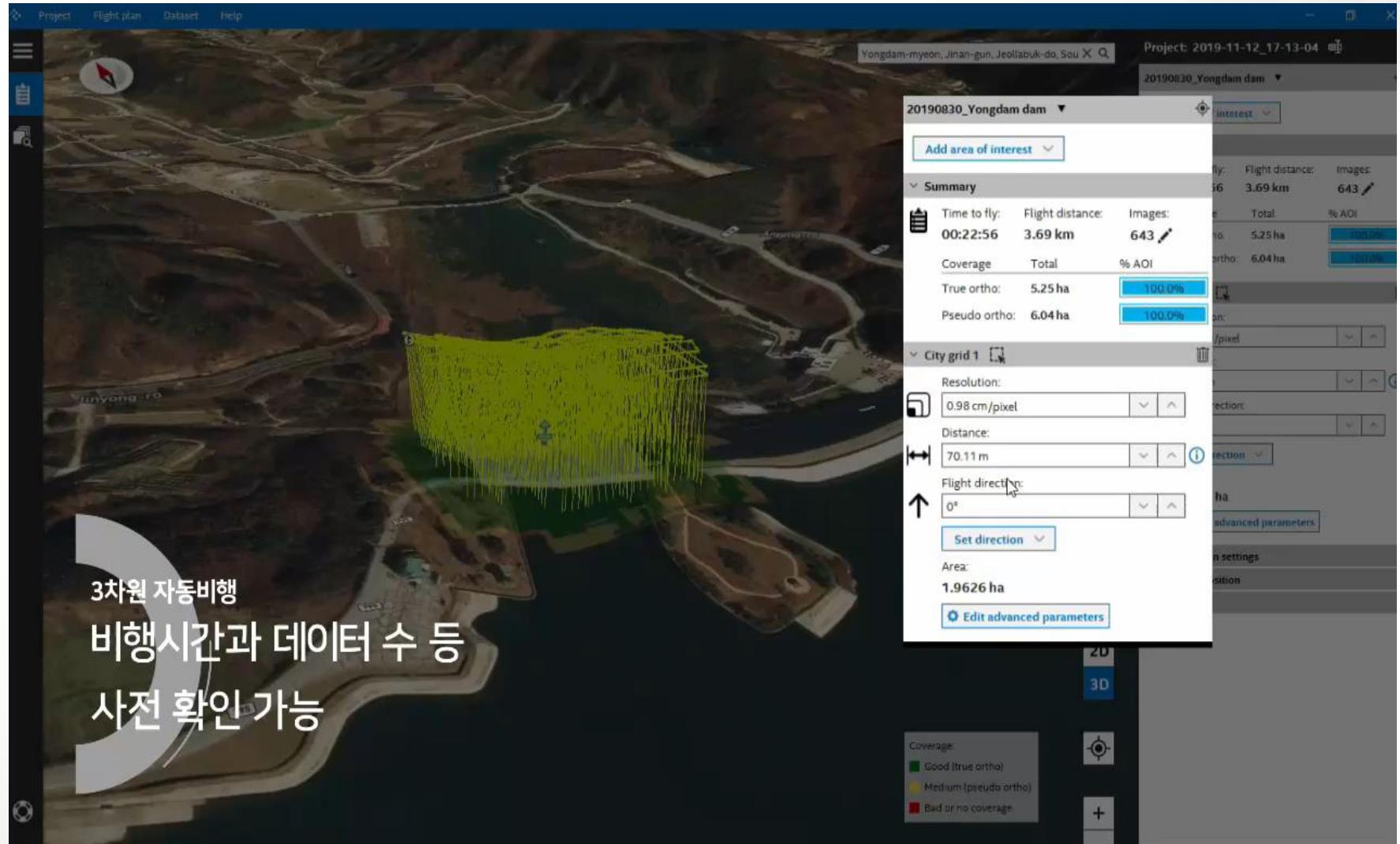


## For concrete surface

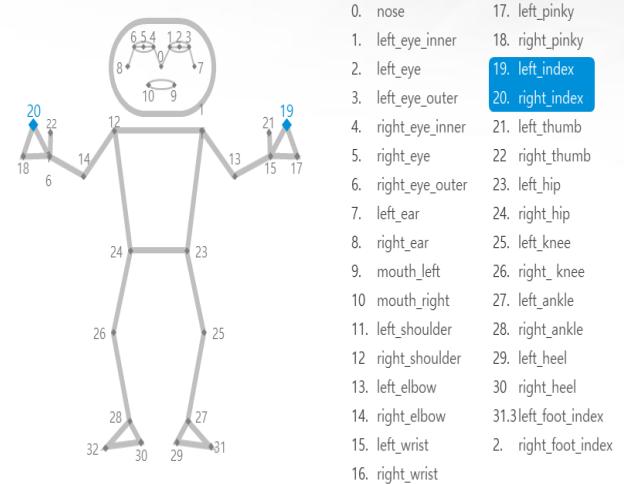


(Source) K-water Consortium – Deep Inspection, “ Digital Twins : Water Management Platform in SeomJin River Basin” (2021)

# AI Applications on Water Management



# AI Applications on Water Management



# Future directions : on-going government-funded projects

## AI Convergence Regional Specialized Industry Support Project

Project summary

M of S/ICT  
NIPA

Appx. 3M  
'22.5~'23.5

K-water  
Daejeon  
DICIA

Main Theme

Development of water-specialized AI solutions  
for companies in demand

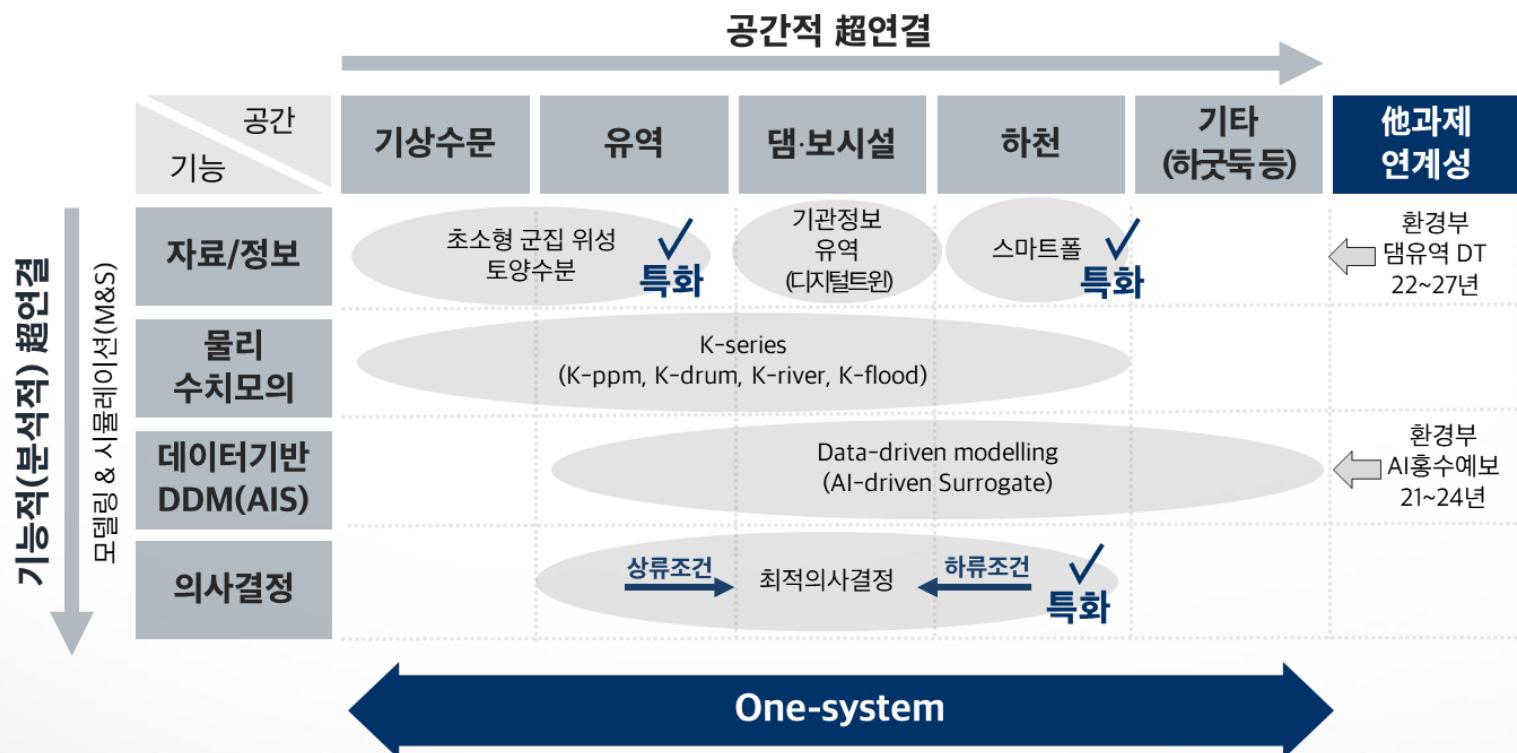
Digital Demonstration Lab (700k, WPT)  
→ (to-be) ICT demonstration sandbox



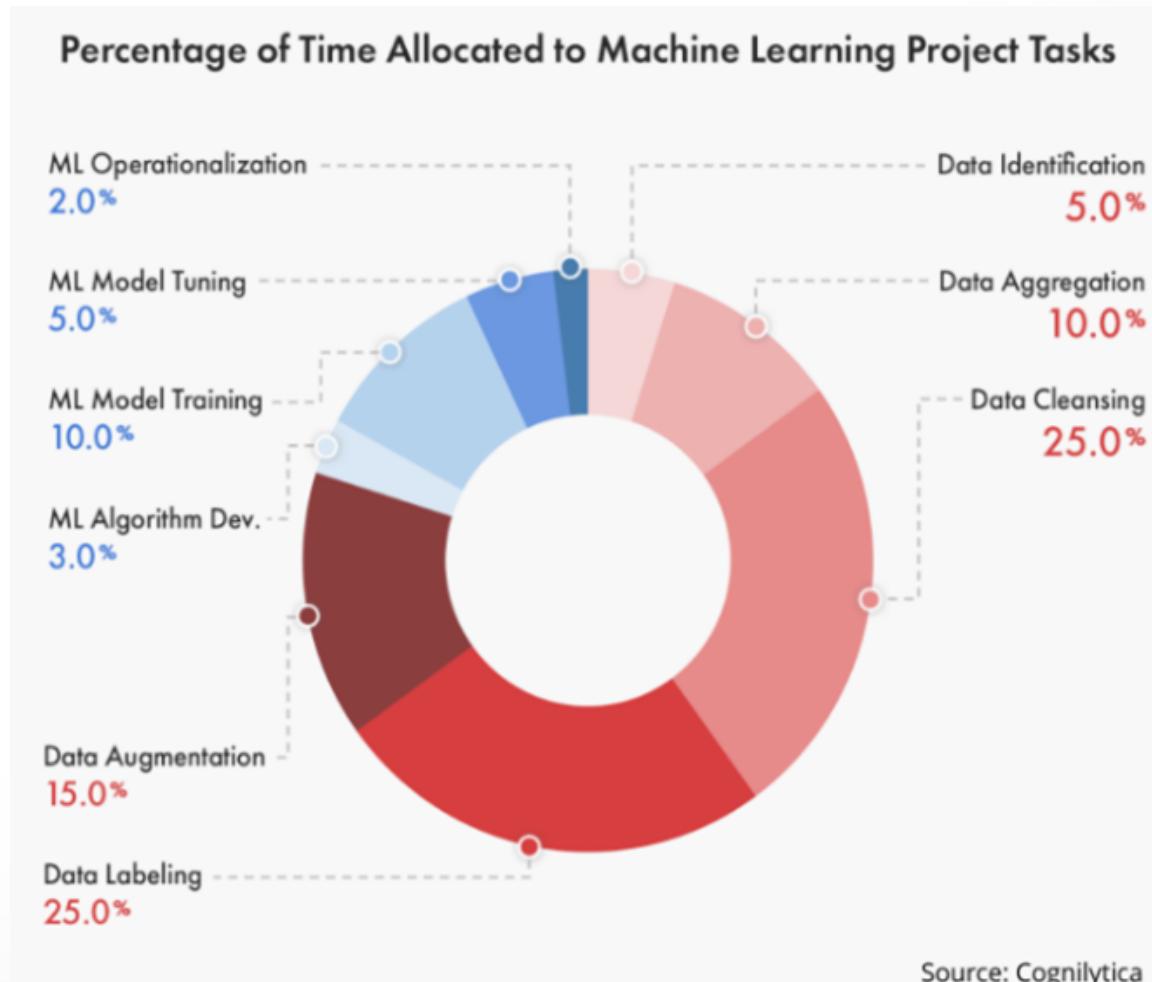
# Future directions : on-going government-funded projects

## Decision Support System to cope with Extreme Event (M of Env) (6M)

- Digital Twin :**
- 물리적 대상과 이를 모사한 디지털 대상을 (준)실시간으로 동기화하고 다양한 목적에 따라 상황을 분석하고 모의결과를 기반으로 예측하여 물리적 대상을 최적화하기 위한 지능형 기술 플랫폼
  - 3D모델링과 IoT기반의 관제기술



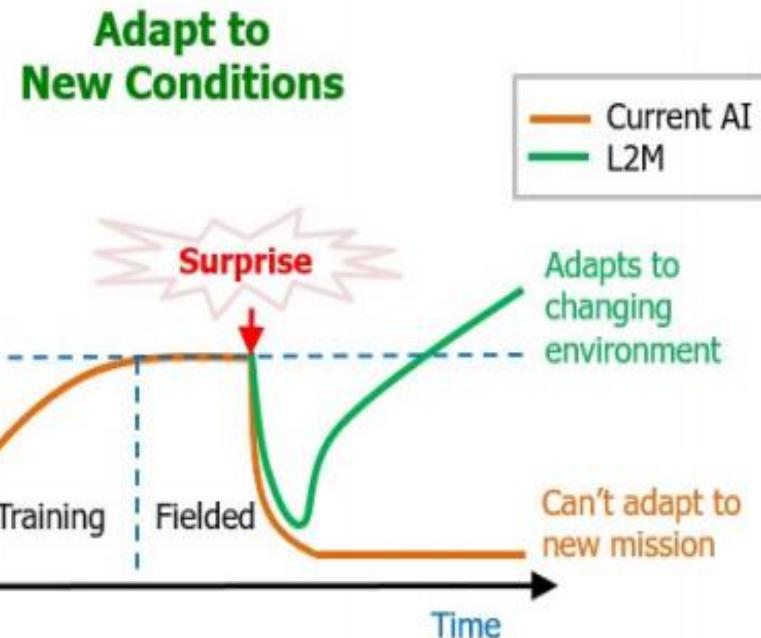
# Future directions : data matters



# Future directions : suggestions



Current machine learning is based on large datasets;  
DoD data may be scarce



Situation may change  
after training and fielding  
(external, internal)

(Source) DARPA, Microsystems Technology Office, Broad Agency Announcement, Lifelong Learning Machines(L2M), HR001117S0016 (2017)

To share knowledge and collaborate K-water AI LAB

## K-water AI Research Lab : GitHub

<https://github.com/Kwater-AILab>



Kwater-AILab  
Kwater-AILab



Overview    Repositories 7    Projects    Packages    Stars

Kwater-AILab / README.md

K-water AI Lab GitHub에 오신 것을 환영합니다. 🙌

이곳은 K-water AI Lab에서 개발한 다양한 AI Source Code를 공유하는 곳입니다. 앞으로 물 관리 전분야에 대한 다양한 코드를 공유할 예정입니다. 많은 관심 부탁드립니다.

💡 Research 분야 😊

- 💻 Digital Twin과 연계한 AI 기술 개발 (In progress)
- ⚡ 댐안전관리 플랫폼 개발을 위한 인공지능 알고리즘 선정평가 연구 (In progress)
- 💻 AI기반 위성영상 활용한 강우자료 신뢰도 개선 (In progress, Launch Jupyter notebook [Launch binder](#))
- 😊 AI기반 녹조 광역 모니터링 기술 개발 ([https://github.com/Kwater-AILab/algae\\_monitoring](https://github.com/Kwater-AILab/algae_monitoring))
  - Launch Jupyter notebook [Launch binder](#) Launch Web App [Open in Streamlit](#)
- ▣ 정수장 유입 수질(망간 등) 예측 알고리즘 개발 (In progress)
- ▣ 막여과공정 AI 운용모델 개발 (In progress)
- ⚡ 물수급 분석 생활用水 수요량 예측 알고리즘 개발 (In progress)

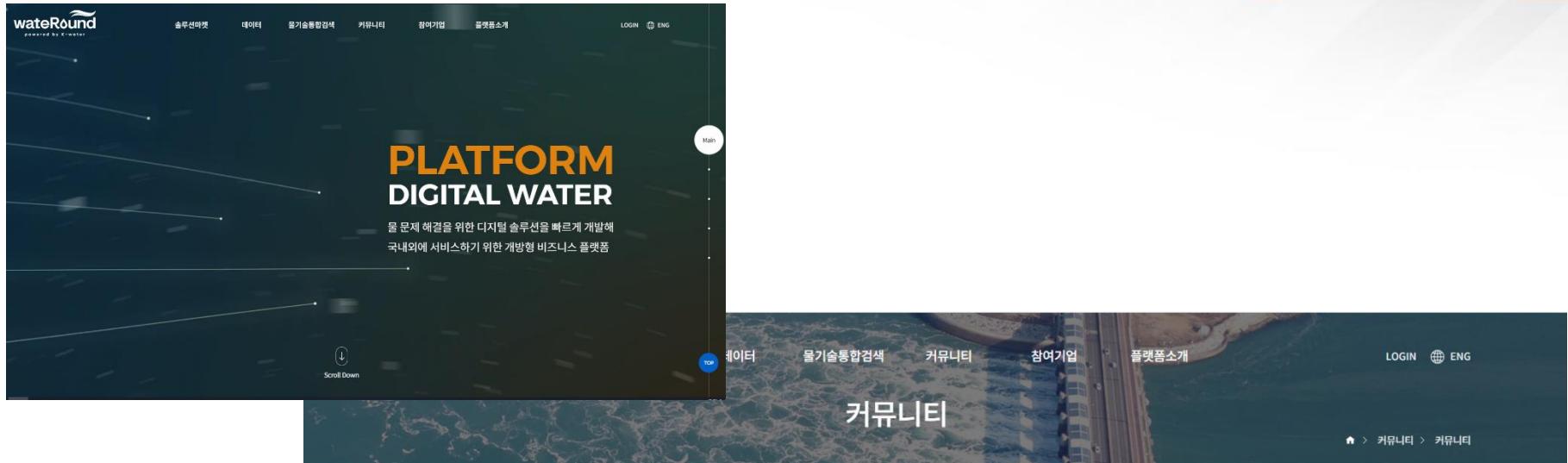
💡 Conference 발표 😊

- 💻 2022년 한국수자원학회 학술발표회 (22.5.19~20)
  - (주제) 온라인 저작소, 클라우드 기반 jupyterHub와 모델 APIs를 활용한 수자원모델링의 재현성 개선 (최영돈) [발표자료](#)
  - Launch Jupyter notebook: [Launch binder](#)

문의사항: K-water AI Lab에 문의사항이 있으시면 언제든지 아래의 이메일을 이용해주세요.

- K-water 연구소 AI Lab 김성훈 센터장 ([sunghoonykim@kwater.or.kr](mailto:sunghoonykim@kwater.or.kr))
- K-water 연구소 AI Lab 최영돈 책임연구원 ([choiyd1115@kwater.or.kr](mailto:choiyd1115@kwater.or.kr))

# K-water's Open Platform



내가 가입한 커뮤니티

전체 커뮤니티 목록

제목

검색어를 입력하세요.

+ 커뮤니티 개설하기

전체 4 건 | 현재 페이지 1/1

제목	작성자	등록일	회원수
<a href="#">Digital 커뮤니티 기초부터 세계로 ↗</a>	#Digital Governor #시뮬인터넷 #스마트 관리	등록일 2021.12.14	회원수 55명
<a href="#">물분야 AI기술 활용예제 ↗</a>	#AI기술 #물분야 #LSTM #플랑크론	등록일 2022.01.27	회원수 42명
<a href="#">OpenAPI를 활용한 수문데이터 수집 ↗</a>	#OpenAPI #WAMIS #강수량 #수위 #기상	등록일 2022-02-01	회원수 22명
<a href="#">공간데이터 분석 및 시각화 ↗</a>	#SHP #공간정보 #도형정보 #좌표 변환	등록일 2022-02-15	회원수 18명

가입완료

가입완료

가입하기

가입하기

« < 1 > »

↑

# Thank You.

