Ministry of the Interior and Safety
National Disaster Management
Research Institute

# Shaping the Future of Inundation Preparedness: The RAIN-X Series

National Disaster Management Research Institute

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Trusted by the Public

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# Contents

# 1. Introduction

## Changing Typhoon and Rainfall Patterns

- ✓ Climate change is intensifying typhoons and increasing extreme rainfall events.
- ✓ Short-duration, high-intensity rainfall has become more frequent, raising urban inundation risks.

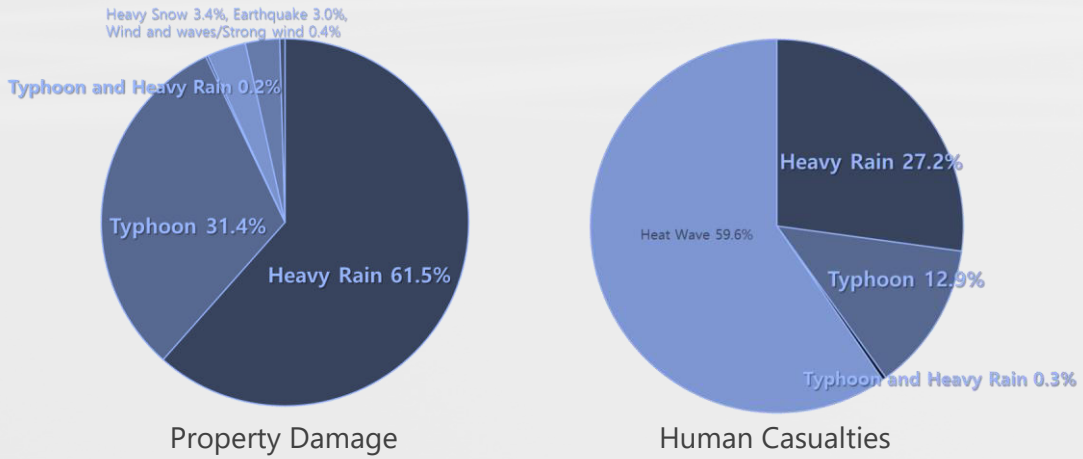
Global Extreme Weather Events and Impacts in 2024 (KMA, 2025)

| Nation | Date | Event | Damaged |
|---|---|---|---|
| Philipphine | 10.25. | Typhoon "TRAMI" | At least 85 deaths and 41 missing due to large-scale floods and landslides |
| Japan | 9.20. ~ 9.22. | Heavy Rainfall | 6 deaths and 498.5mm of rainfall in 48 hours |
| Vietnam | 10.27. | Typhoon "TRAMI" | 12 deaths and 7 injuries due to flooding |
| China | 6.21. | Heavy Rainfall | 47 deaths due to flooding in southern Guangdong Province |
| Thailand | 12.3. | Heavy Rainfall | 30 deaths and 660,000 homes inundated due to persistent heavy rainfall |
| Republic of Korea | 7.8. ~ 7.10. | Heavy Rainfall | 6 deaths and 2 missing due to inundation and landslides |
| | 9.19. ~ 9.22. | Heavy Rainfall | Record-breaking autumn rainfall in Changwon City: 397.7mm/24hrs and 104.9 mm/hr |

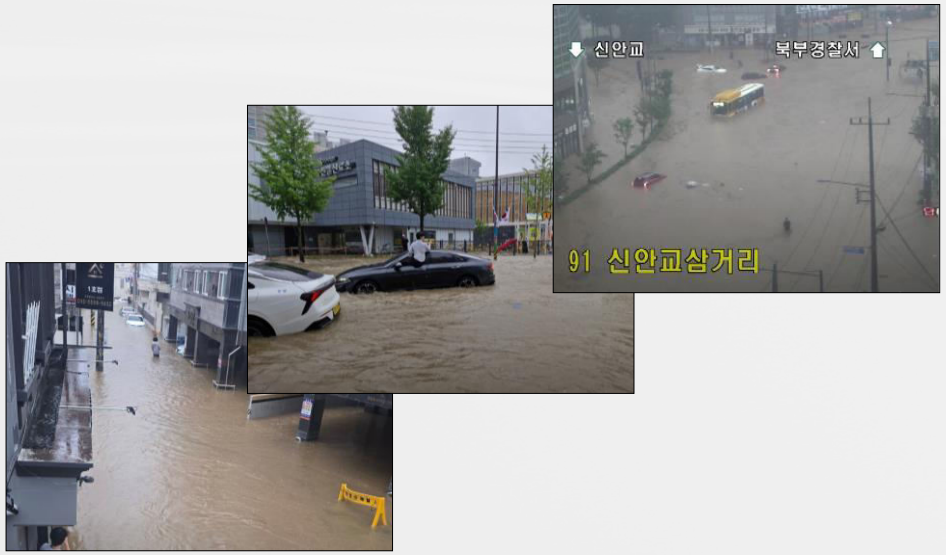
KMA "Abnormal Weather Report 2024" (2025)

## Increasing Inundation impacts in Korea

- ✓ **93.1% of property damage and 40.4%** of human casualties are due to **heavy rains and typhoons**, which account for most of the damage caused by natural disaster.
- ✓ Severe urban inundation events **occurred repeatedly**.
  - In 2022, Seoul suffered human casualties due to record-breaking heavy rainfall.
  - In 2023, 14 people died due to inundation of an underpass.
  - In 2024 and 2025, heavy downpours of over 100mm per hour and nearly 500mm in 24 hours caused Inundation of buildings and roads.




Proportion by Cause




Inundation in Gwangju, Korea (July, 2025)

## Need for Effective Inundation Response Information

| Current Issues | What We Need to Improve |
| --- | --- |
| **Uniform warning criteria nationwide** | Localized inundation risk criteria |
| **Lack of field-measured inundation data** | Real-time sensor-based measurement & Analysis |
| General non-specific alerts | Decision-support alerts at the local scale |

Practical and localized inundation information system is required.

# 2. RAIN-X Series Overview

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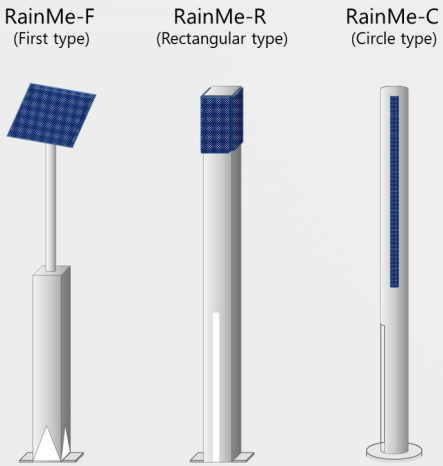
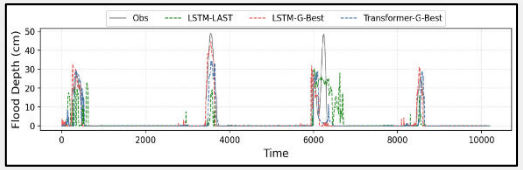
## RAIN-X Series and Expandability

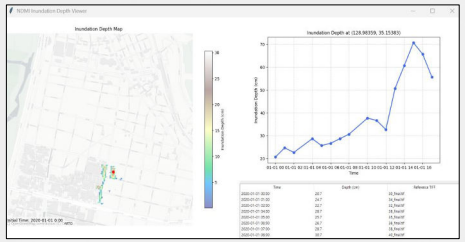
The RAIN-X Series is composed of two main components:

- ✓ **RAINSYS**, a web-based urban inundation monitoring system.
- ✓ **RainMe**, a sensor for measuring inundation depth in the field.
- ✓ **The RAIN-X Series** also represents **future expandability**, including prediction models and inundation mapping tools


Prediction model based measuring depth data



Mapping program based prediction model

# 3. RAINSYS and Risk Criteria

RAINSYS
Real time Alert for Inundation System

# 3. RAINSYS and Risk Criteria

## RAINSYS: Real-time Alert for Inundation SYStem

✓ Web-based urban inundation monitoring system

* Trademark registered

# 3. RAINSYS and Risk Criteria

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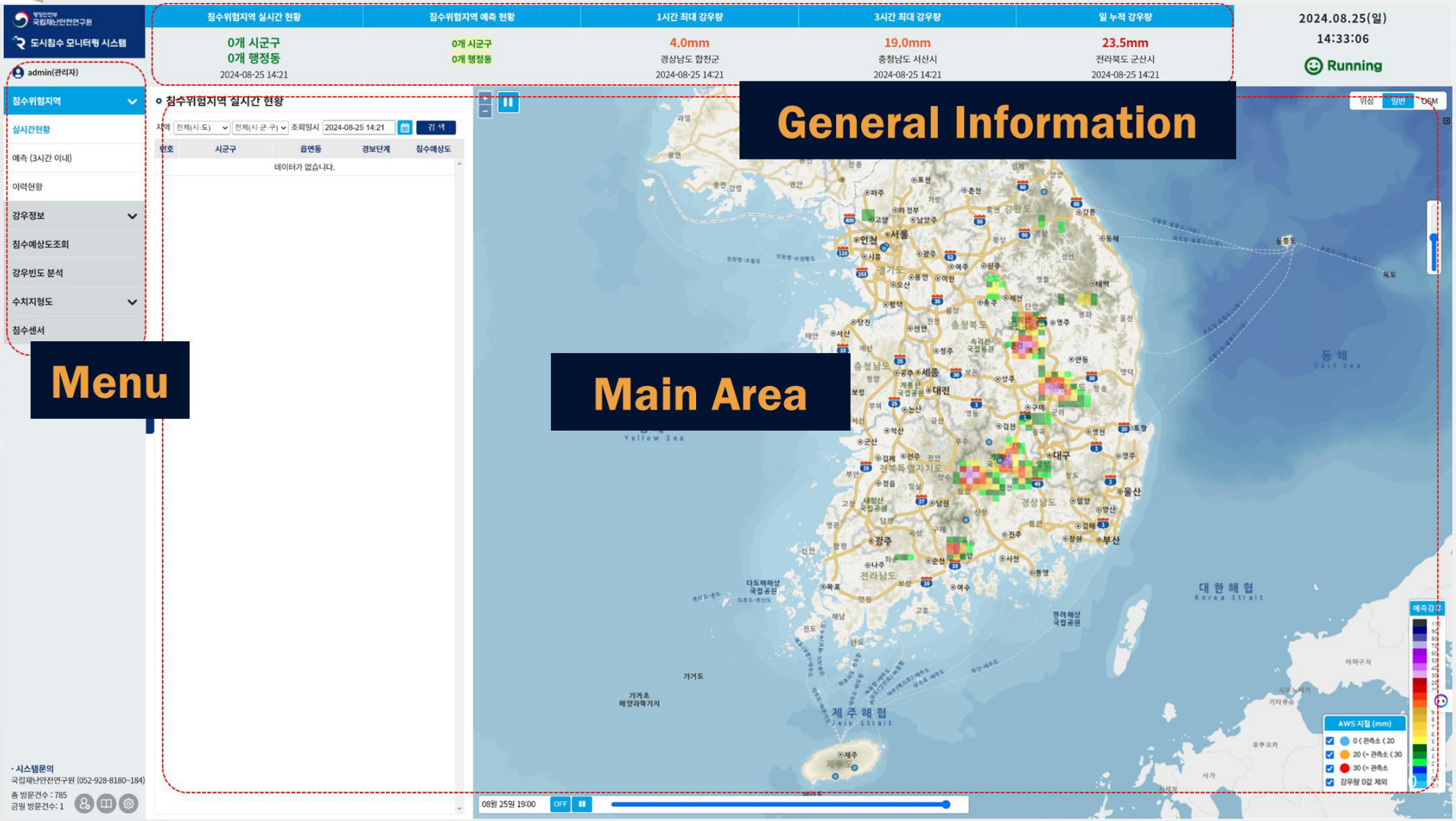
## RAINSYS Web Interface



# 3. RAINSYS and Risk Criteria

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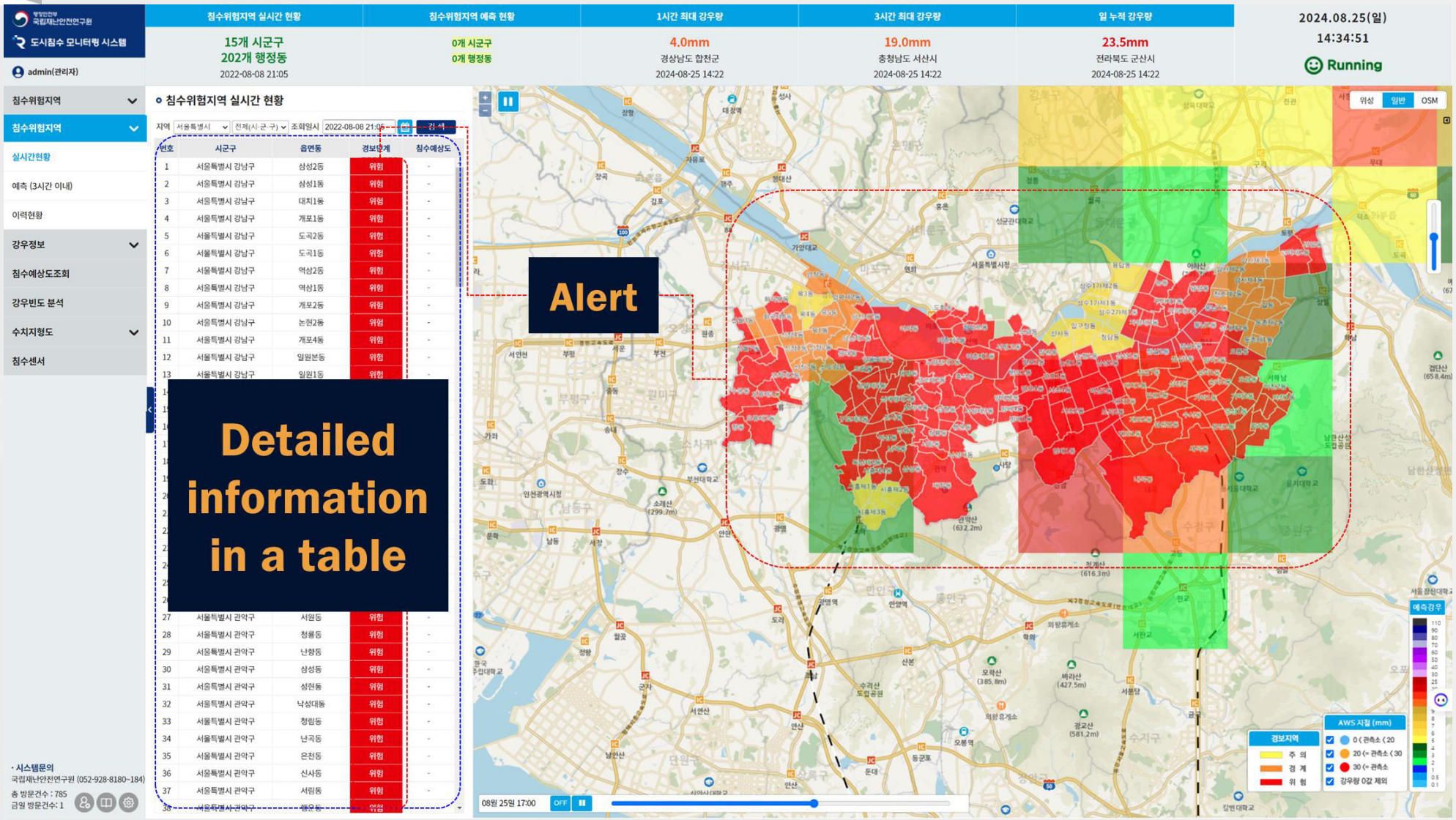
## RAINSYS Functions



# 3. RAINSYS and Risk Criteria

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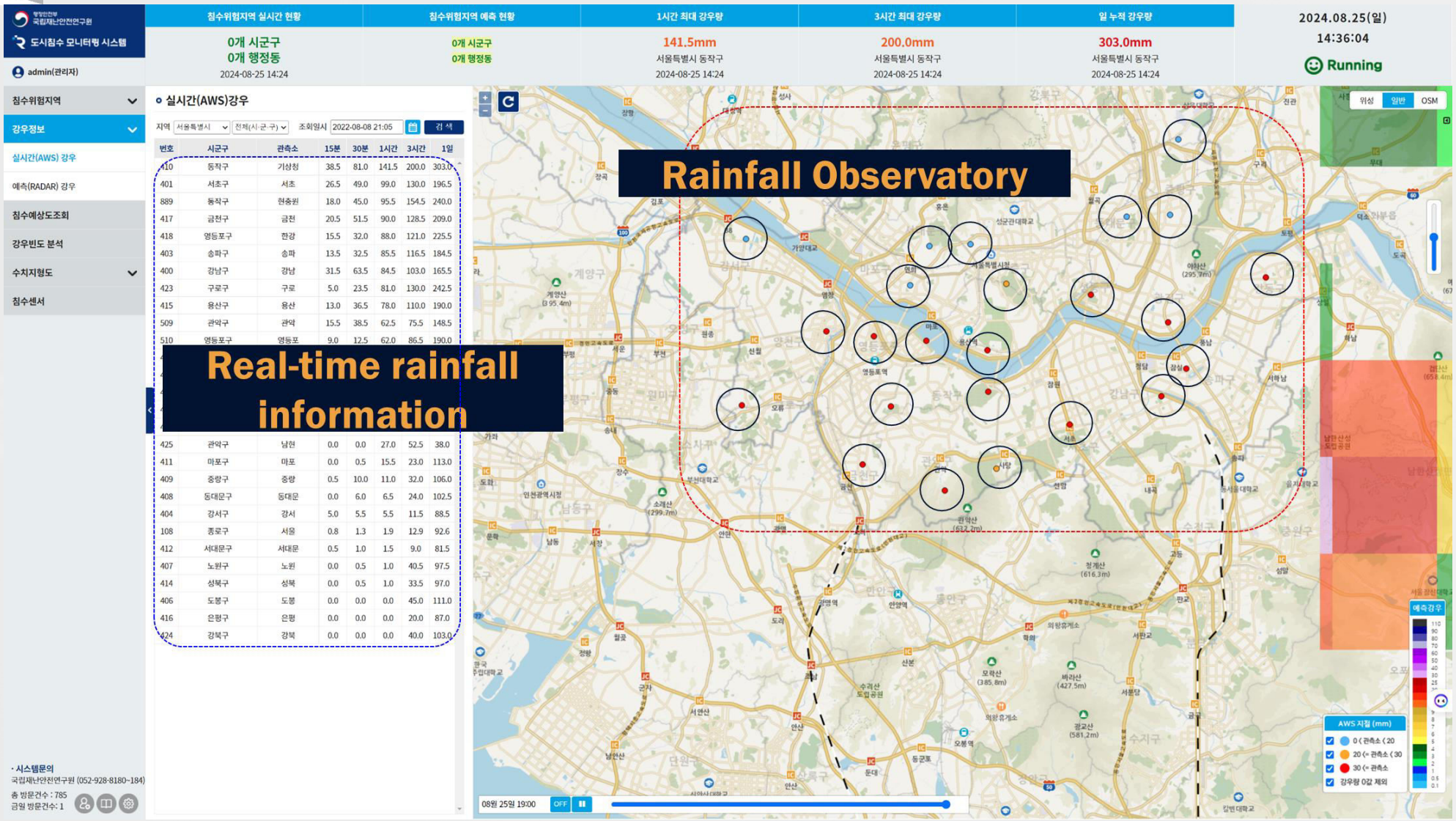
## RAINSYS Functions




| 번호 | 시군구 | 관측소 | 15분 | 30분 | 1시간 | 3시간 | 1일 |
|---|---|---|---|---|---|---|---|
| 410 | 동작구 | 기상청 | 38.5 | 81.0 | 141.5 | 200.0 | 303.0 |
| 401 | 서초구 | 서초 | 26.5 | 49.0 | 99.0 | 130.0 | 196.5 |
| 889 | 동작구 | 현충원 | 18.0 | 45.0 | 95.5 | 154.5 | 240.0 |
| 417 | 금천구 | 금천 | 20.5 | 51.5 | 90.0 | 128.5 | 209.0 |
| 418 | 영등포구 | 한강 | 15.5 | 32.0 | 88.0 | 121.0 | 225.5 |
| 403 | 송파구 | 송파 | 13.5 | 32.5 | 85.5 | 116.5 | 184.5 |
| 400 | 강남구 | 강남 | 31.5 | 63.5 | 84.5 | 103.0 | 165.5 |
| 423 | 구로구 | 구로 | 5.0 | 23.5 | 81.0 | 130.0 | 242.5 |
| 415 | 용산구 | 용산 | 13.0 | 36.5 | 78.0 | 110.0 | 190.0 |
| 509 | 관악구 | 관악 | 15.5 | 38.5 | 62.5 | 75.5 | 148.5 |
| 510 | 영등포구 | 영등포 | 9.0 | 12.5 | 62.0 | 86.5 | 190.0 |
| 425 | 관악구 | 남현 | 0.0 | 0.0 | 27.0 | 52.5 | 38.0 |
| 411 | 마포구 | 마포 | 0.0 | 0.5 | 15.5 | 23.0 | 113.0 |
| 409 | 중랑구 | 중랑 | 0.5 | 10.0 | 11.0 | 32.0 | 106.0 |
| 408 | 동대문구 | 동대문 | 0.0 | 6.0 | 6.5 | 24.0 | 102.5 |
| 404 | 강서구 | 강서 | 5.0 | 5.5 | 5.5 | 11.5 | 88.5 |
| 108 | 종로구 | 서울 | 0.8 | 1.3 | 1.9 | 12.9 | 92.6 |
| 412 | 서대문구 | 서대문 | 0.5 | 1.0 | 1.5 | 9.0 | 81.5 |
| 407 | 노원구 | 노원 | 0.0 | 0.5 | 1.0 | 40.5 | 97.5 |
| 414 | 성북구 | 성북 | 0.0 | 0.5 | 1.0 | 33.5 | 97.0 |
| 406 | 도봉구 | 도봉 | 0.0 | 0.0 | 0.0 | 45.0 | 111.0 |
| 416 | 은평구 | 은평 | 0.0 | 0.0 | 0.0 | 20.0 | 87.0 |
| 424 | 강북구 | 강북 | 0.0 | 0.0 | 0.0 | 40.0 | 103.0 |

# 3. RAINSYS and Risk Criteria

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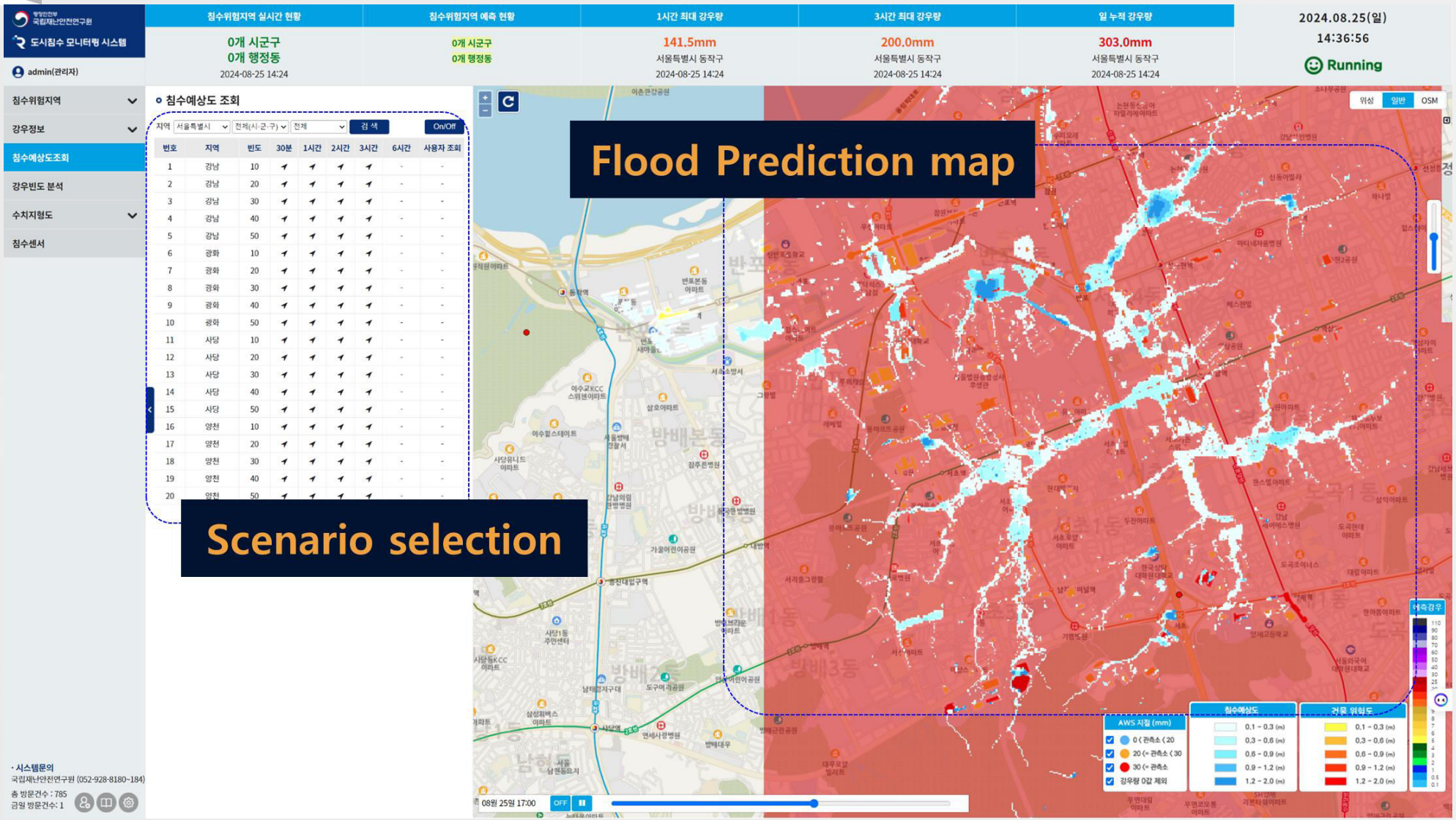
## RAINSYS Functions



# 3. RAINSYS and Risk Criteria

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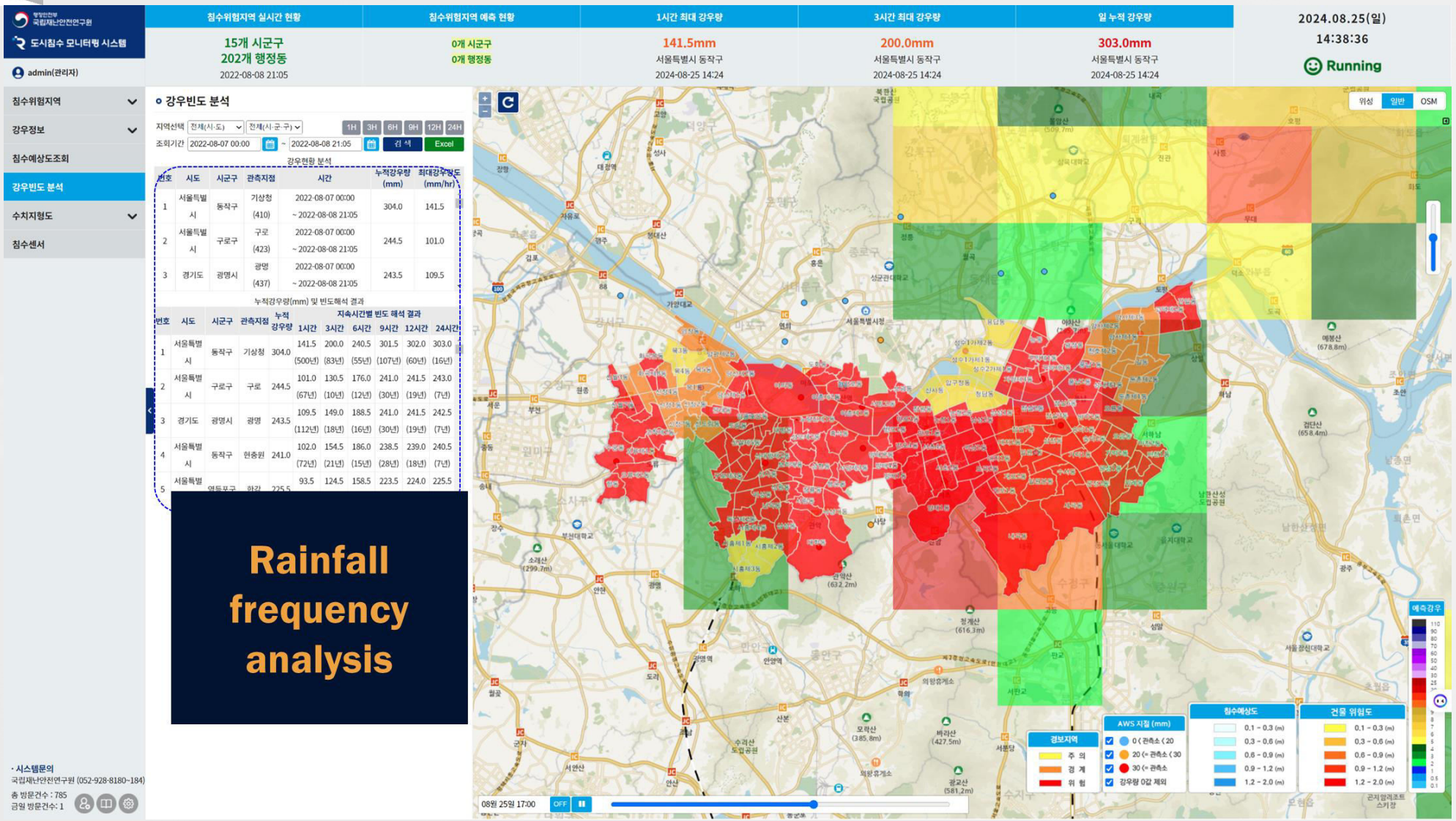
## RAINSYS Functions



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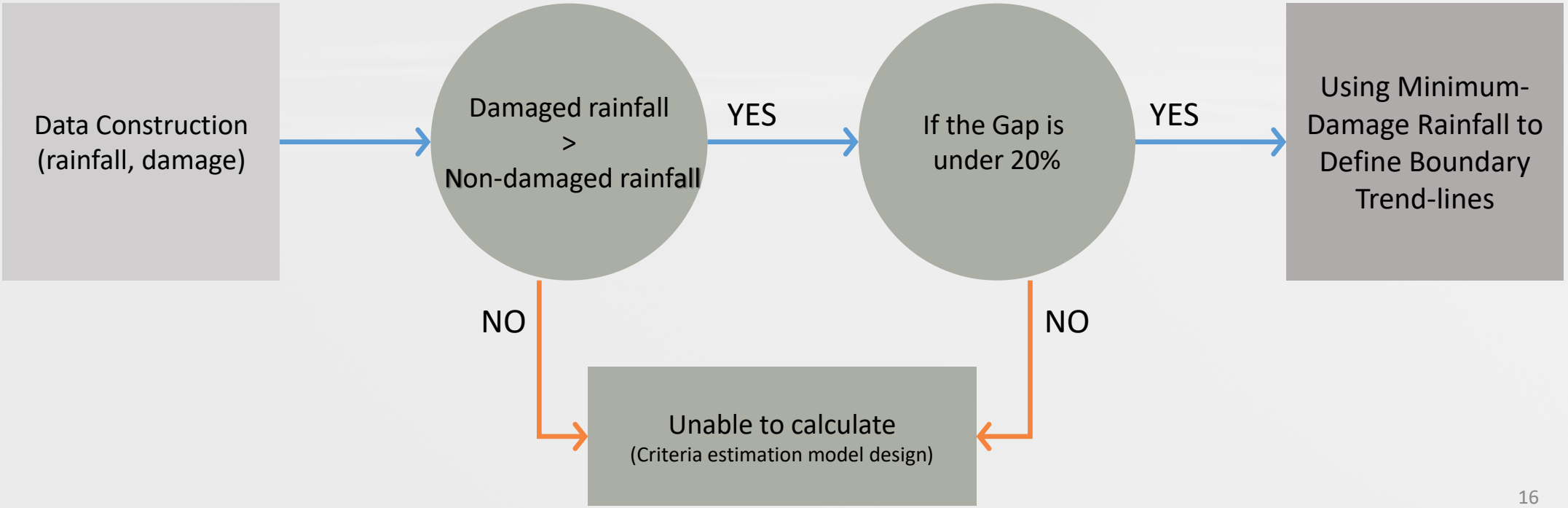
## Urban Inundation Risk Criteria

### How to make Risk Criteria

- ✓ We introduced the concept of **Threshold Rainfall** which represents the rainfall amount that can cause urban inundation.
- ✓ It is determined based on **curb(kerb) height (approximately 25 cm)** and is a key input for developing **inundation risk criteria**.



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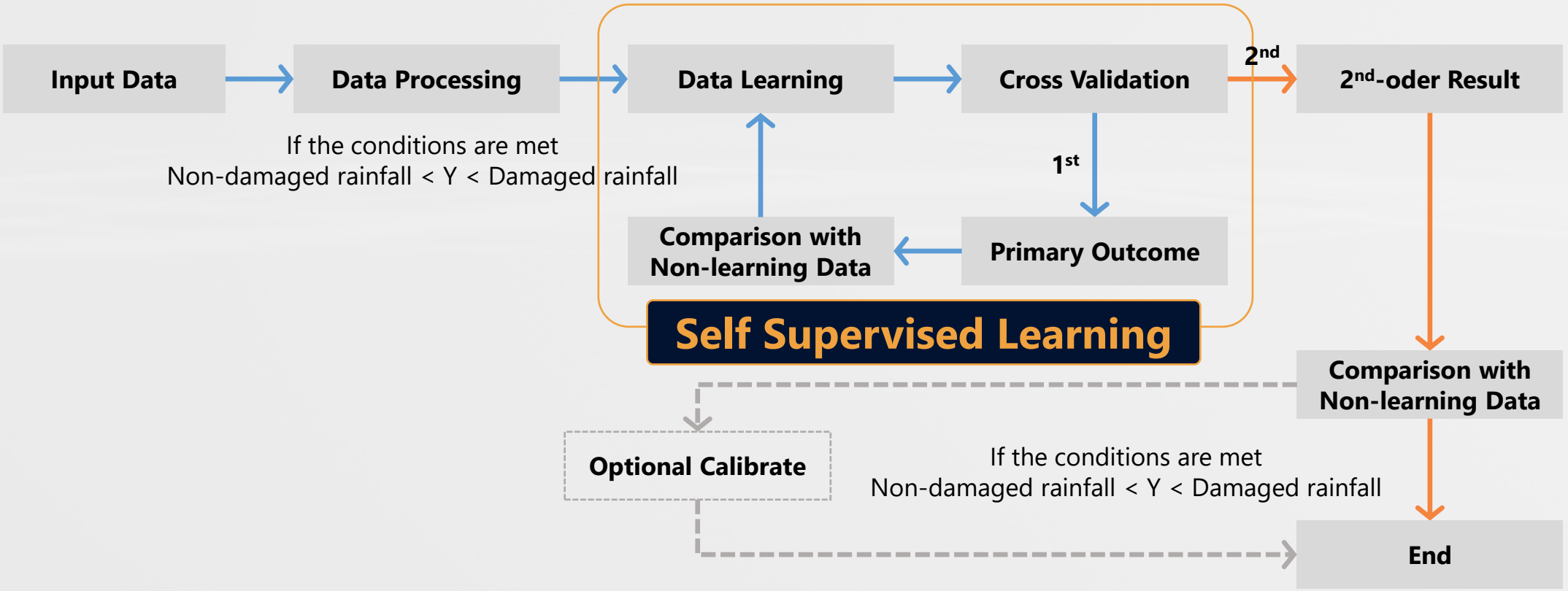
## Urban Inundation Risk Criteria

### Assistance from Deep Learning

✓ Since the proportion of training data was only 20%, we increased the amount of training data to about 60% through self supervised learning.



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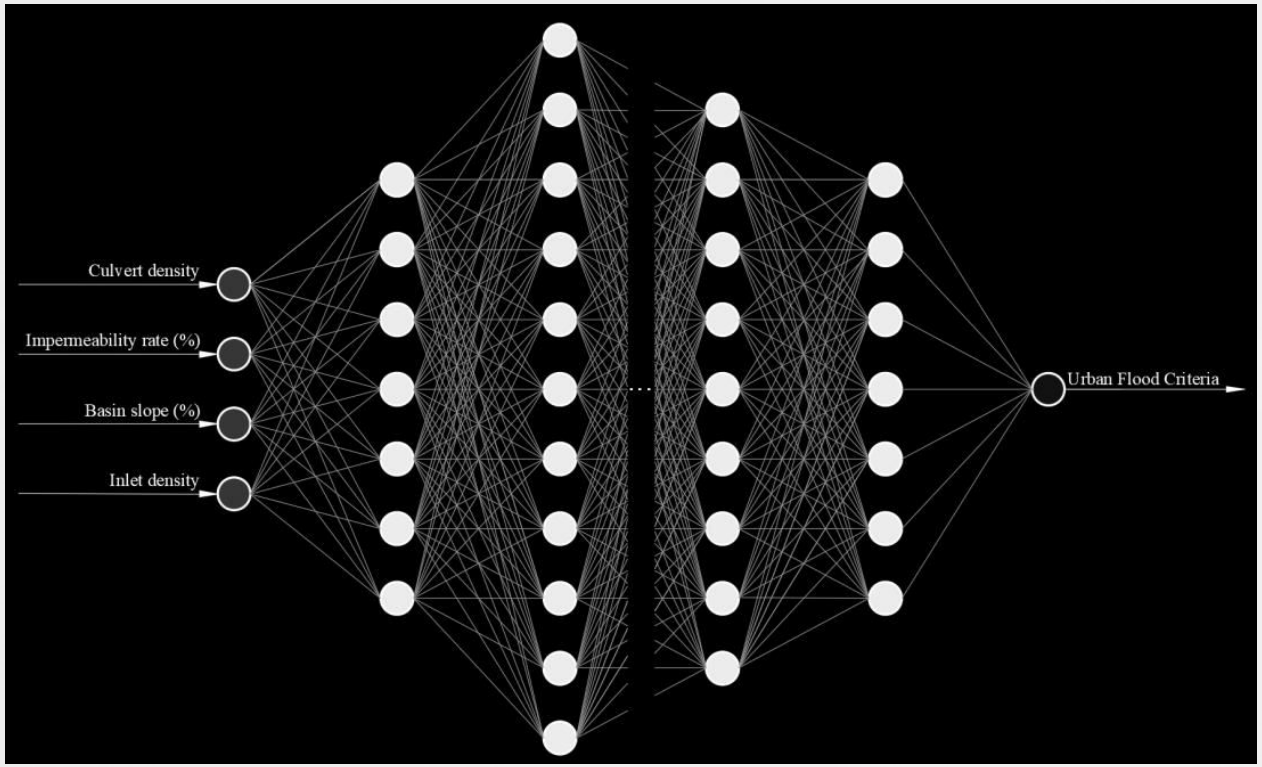
## Urban Inundation Risk Criteria

### Development of DL Model

- ✓ Rainfall data: more than 3 billion
- ✓ Damage data: more than 10,0000
- ✓ Geospatial data: slope, elevation, river network, Percentage of Impervious areas and etc.




* Patent registered

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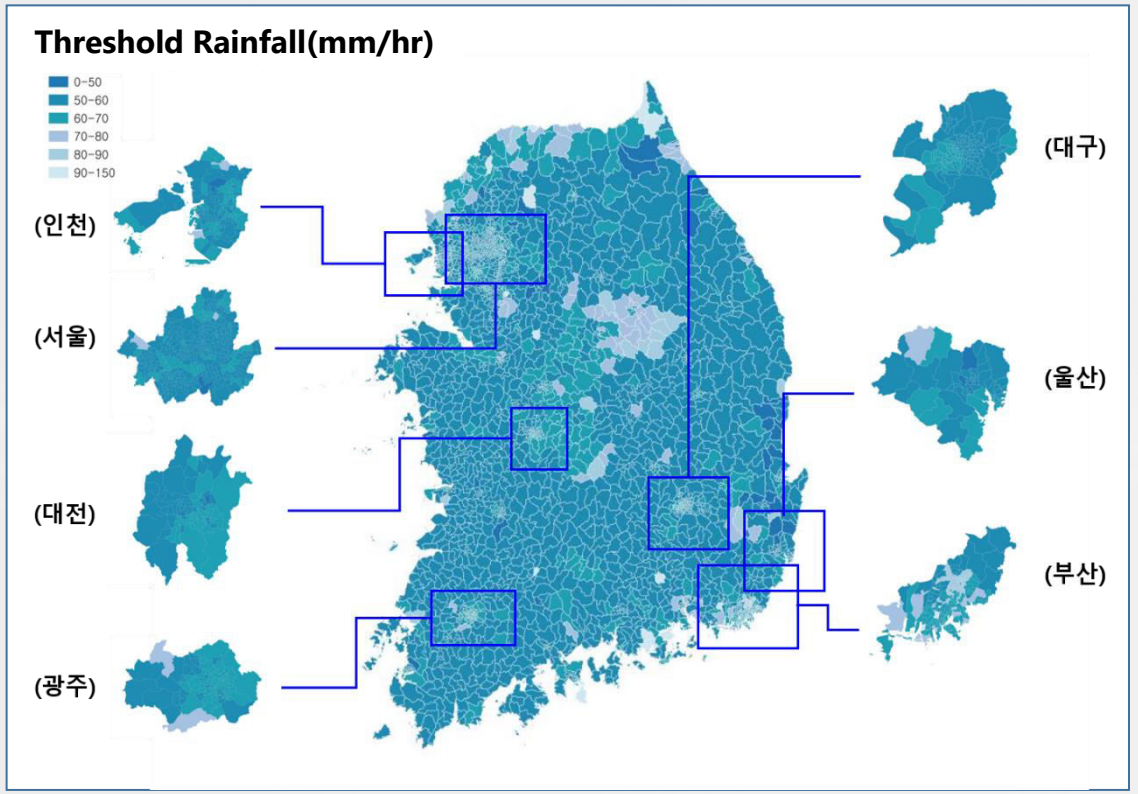
## Urban Inundation Risk Criteria

### Urban Flood Risk Criteria

- ✓ Using this developed model, we calculated the threshold rainfall for 3,390 administrative Dong, excluding island regions.
- ✓ In order to provide a alert at least 10 minutes to 1 hour before inundation, the risk criteria was set in stages from 50% to 80% of the threshold rainfall.



# 4. RainMe and Application

RainMe

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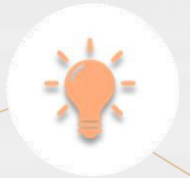
## Development History

✓ **RainMe has evolved** through field testing and design improvements to provide reliable real-time inundation depth measurements.

2018
First Installed
Bollard type

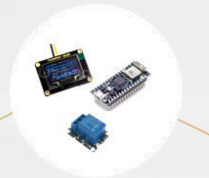
2019
Rectangular column type
with Solar panel

2020
Add water detection
sensor



**2021**
**Attempt**
**self-development**

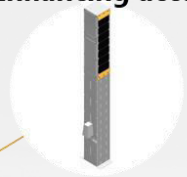
2022
First product
- Ultrasonic sensor
- Create a variety of type



**2023**
**Second product**
**- Improvement of structure and code**

**2024**
Development of RainMe
and Field Installed

**2025**
**RainMe-R type**
**- Expanding measurable water-depth range**
**- Enhancing accuracy**

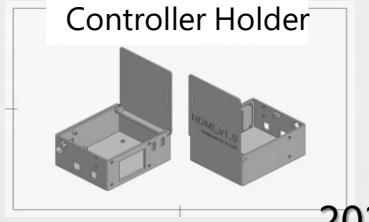


## Development of the Control Unit: WMeT

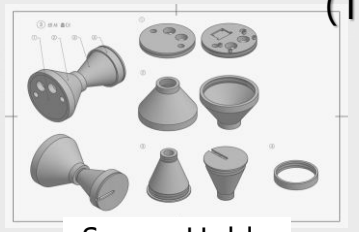
- ✓ **WMeT**: compact control unit embedded in RainMe
- ✓ Collects, stores, and transmits data to a server (RAINSYS)
- ✓ Supports more sensor types than existing units
- ✓ Low-power PCB design
- ✓ Patent, trademark, and design registered

2025 (4rd)

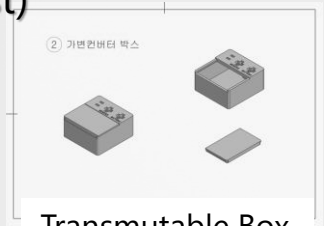

Controller Holder



2022 (1st)

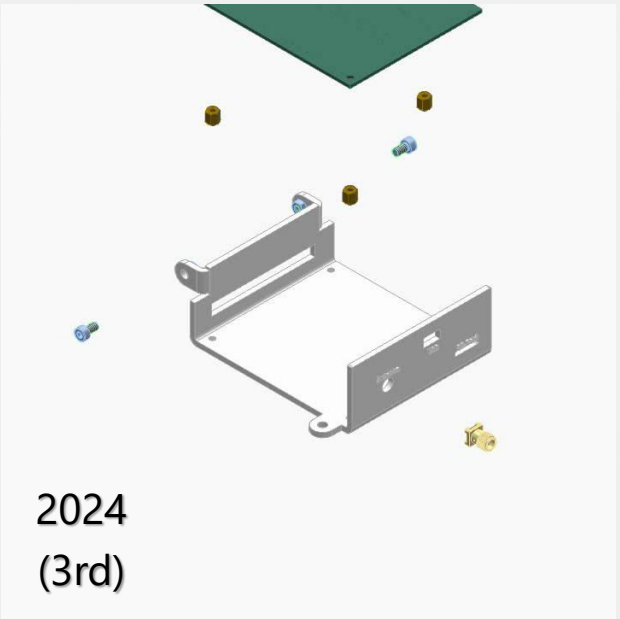


Sensor Holder



Transmutable Box

2023 (2nd)



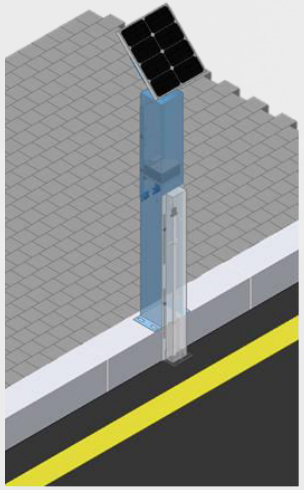
2024 (3rd)

## Field Installation: RainMe

- ✓ The device can be installed on the road surface or on curbs.
- ✓ For curb installation, sensors are placed on both the inside and outside to measure inundation depth

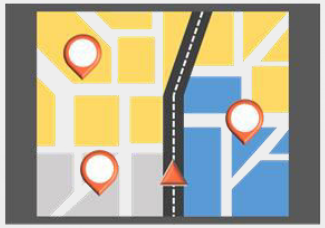

## Availability of RainMe

✓ Sensor data enable alerts, traffic control, navigation support, and facility safety management.

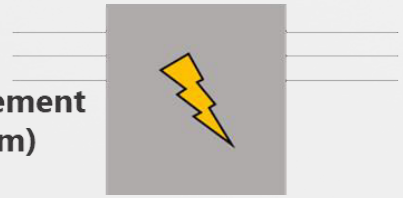



Risk Information Message
MMS, SNS(KakaoTalk, Line)

Traffic Control
(Underpass or Riverside road)



Navigation
(Guide to avoiding flooded areas)



Dangerous Facility Management
(Power or gas supply system)

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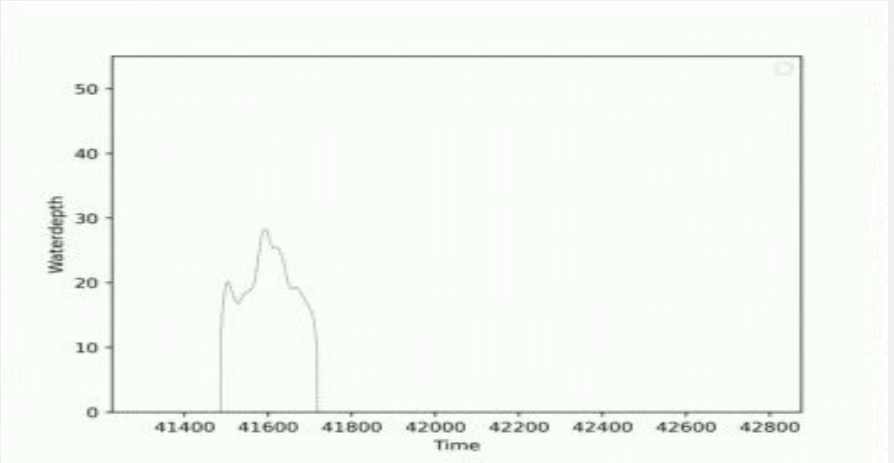
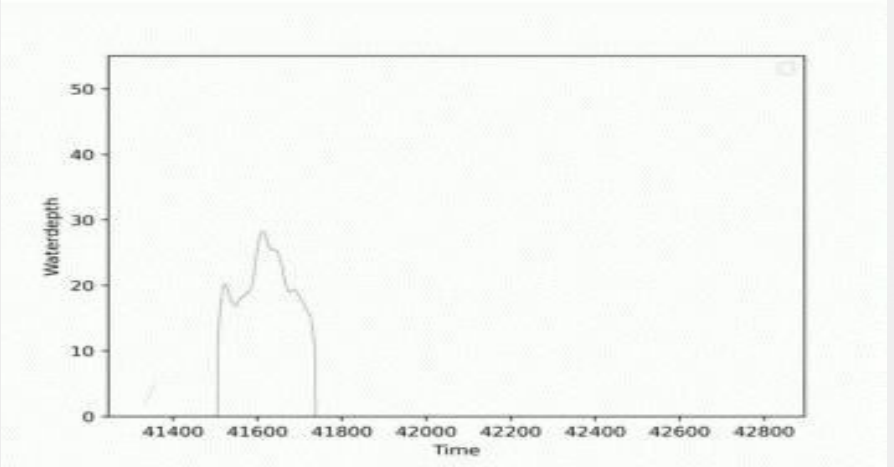
## Application of RainMe Data: Inundation Prediction Model

- ✓ Measured inundation data are used as training inputs for our prediction models.
- ✓ We developed LSTM-based models that learn flooding behavior from historical measurements.
- ✓ Although peak values show some errors, the model captures overall inundation patterns effectively.

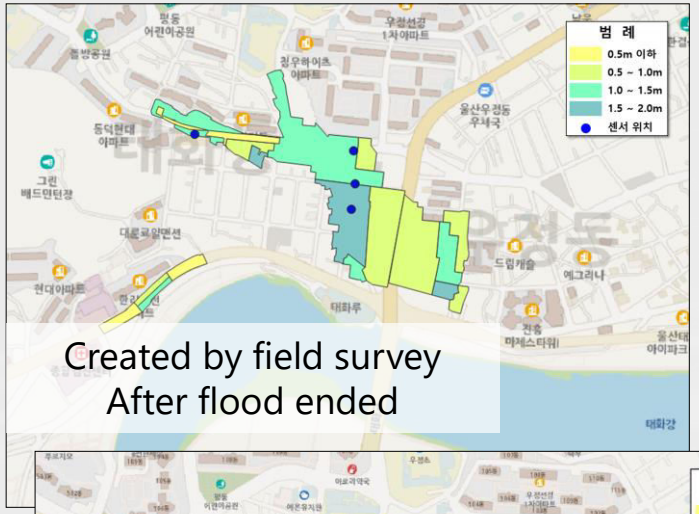


# 4. RainMe and Application

## Application of RainMe Data: Inundation Map

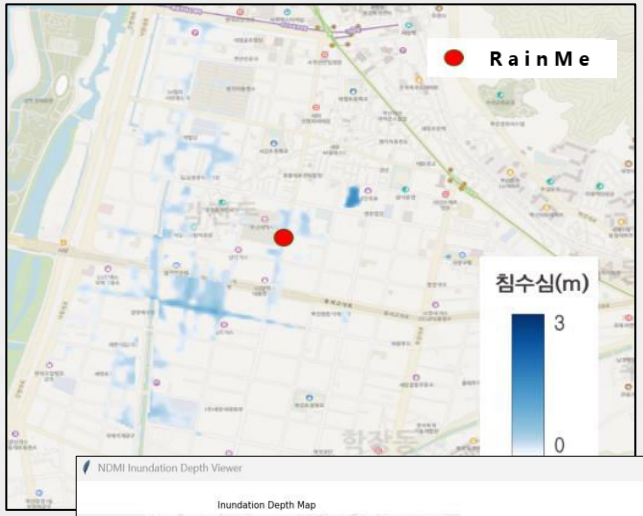
✓ Replace traditional inundation trace maps

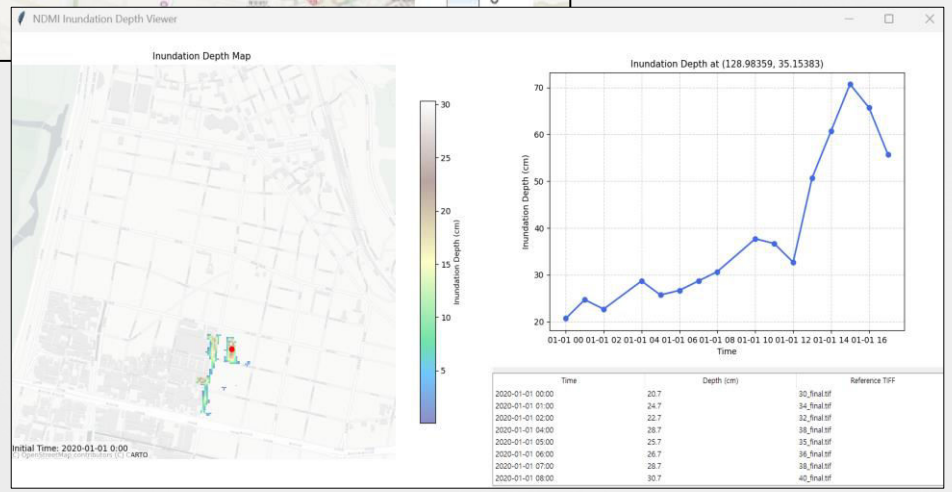



Created by field survey
After flood ended


Real-time Created by measuring data

✓ Generate forecast inundation maps




**More cost-effective, efficient and accurate**

# 4. RainMe and Application

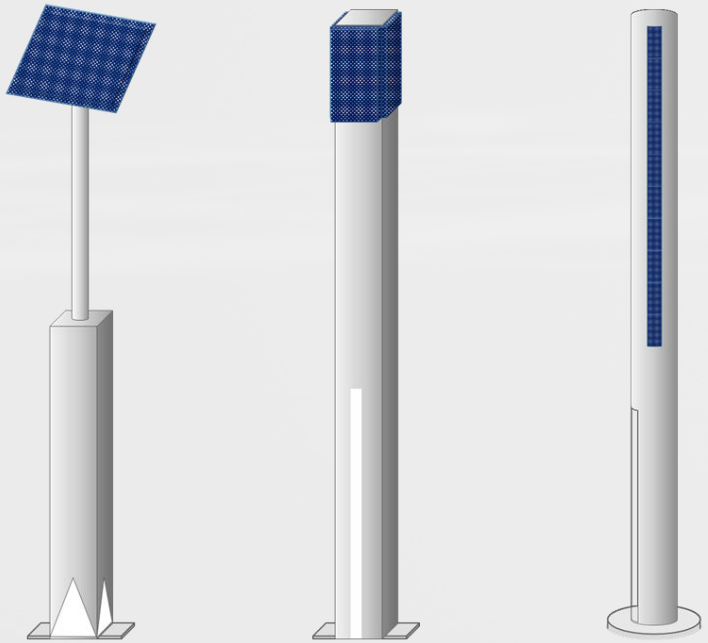
## Expansion of RainMe

✓ Multiple RainMe models have been developed, and more will follow

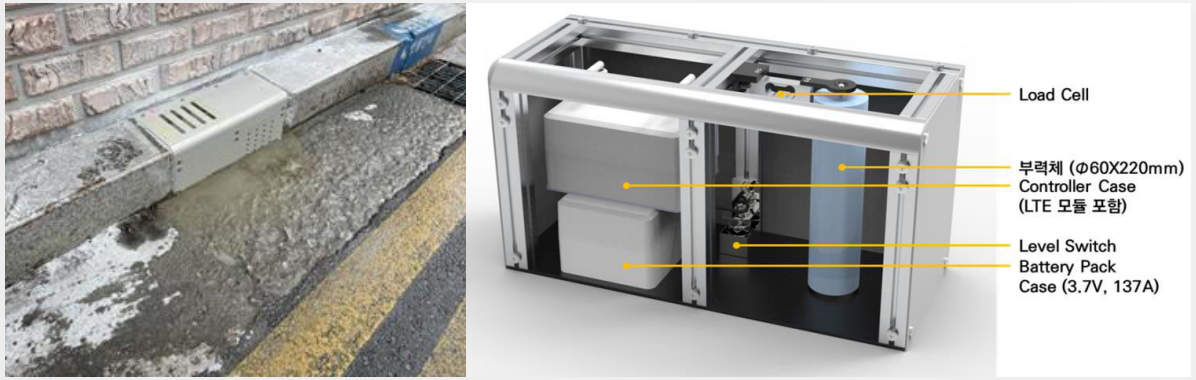
RainMe-F
(First type)

RainMe-R
(Rectangular type)

RainMe-C
(Circle type)



NDMI RainMe
* Patent, trademark, and design registered


Currently under R&D development

# 5. Future Vision and Conclusion

# 5. Future Vision and Conclusion

## Future Vision

The RAIN-X Series will continue to evolve beyond monitoring and measurement, expanding into real-time analysis, forecasting models, and interconnected response systems.
Our vision is to establish a fully integrated framework that supports rapid, data-driven decisions for urban inundation resilience.

## Conclusion

We do not yet know what the next “RAIN-X” will be.
But the direction is clear: continuous innovation, expand capabilities, and stronger support for cities facing intensifying typhoon and inundation risks.

# 5. Future Vision and Conclusion

## Acheivement

**The first time in Korea!**
**And the world!**


Over 30 domestic and international patents and software copyrights registered

# 5. Future Vision and Conclusion

## Acheivement

with RAIN X Series

Ministry of the Interior and Safety

Cooperation

Korea Meteorological Administration

K water

Ministry of Environment
Han River Flood Control Office

Ministry of Environment

KEPCO KOREA ELECTRIC POWER CORPORATION

KOGAS KOREA GAS CORPORATION

Service

Local Autonomous Entity

UNPOG UNITED NATIONS PROJECT OFFICE ON GOVERNANCE

ADB ASIAN DEVELOPMENT BANK

KLID 한국지역정보개발원

울산대학교 UNIVERSITY OF ULSAN

Ministry of the Interior and Safety
National Disaster Management
Research Institute

# Thank you!

Q&A

hyejin0402@korea.kr

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