Developing Multi-Scale Decision-Making Support Tools for Urban Climate Resilience

—

: A Case Example of the Heatwave Assessment Tool.

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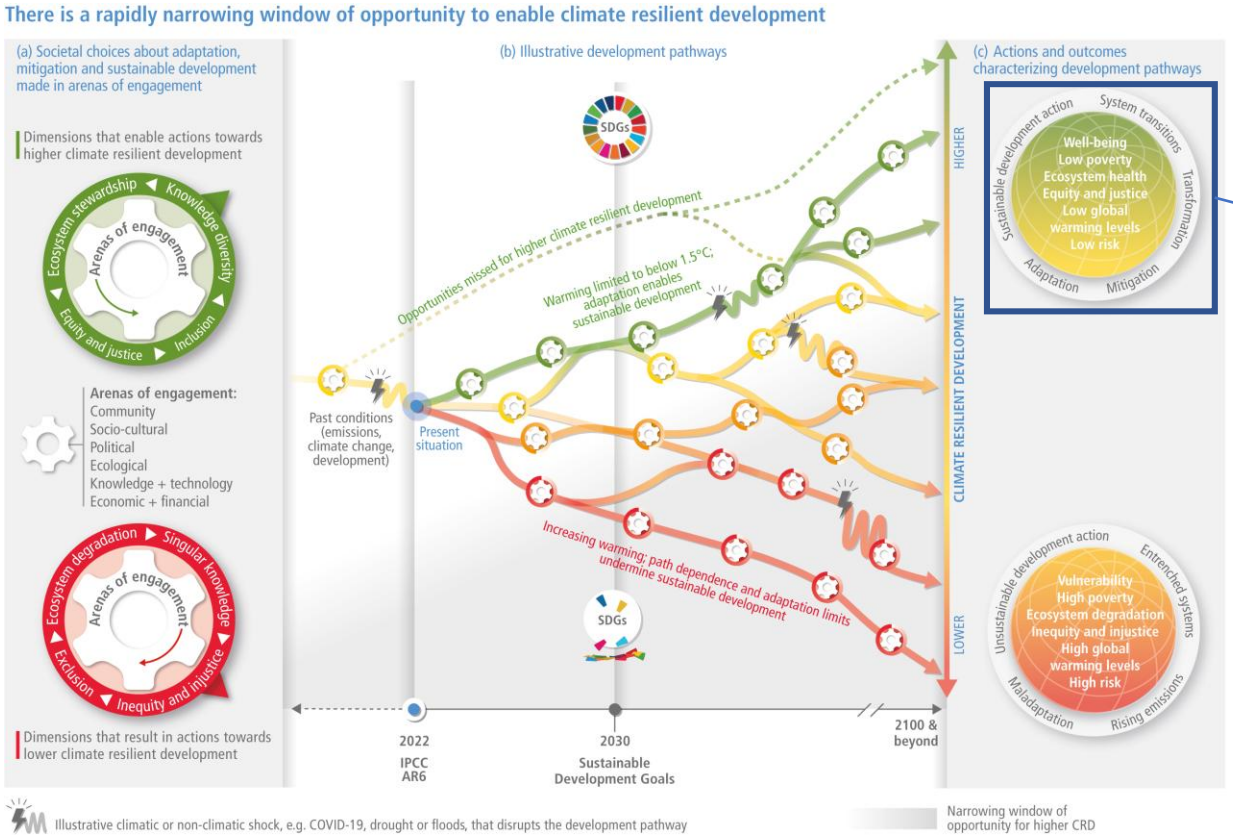
Background

The Importance of Climate Resilience



(IPCC AR6, 2022)

Higher climate resilience pathways

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improves a system's ability to recover from similar levels of climate risk.

Current policy decisions are critical for enabling this development pathway.

- Climate Resilient Development (CRD) is a central concept in AR6, highlighting the integration of climate adaptation, mitigation, and sustainable development

The Importance of Climate Resilience

※ 자료: 환경부(보도자료)

- The 3rd National Plan for Strengthening Climate Crisis Adaptation (2023-2025) emphasizes the significance of climate resilience as a key concept in addressing the climate crisis

Problems

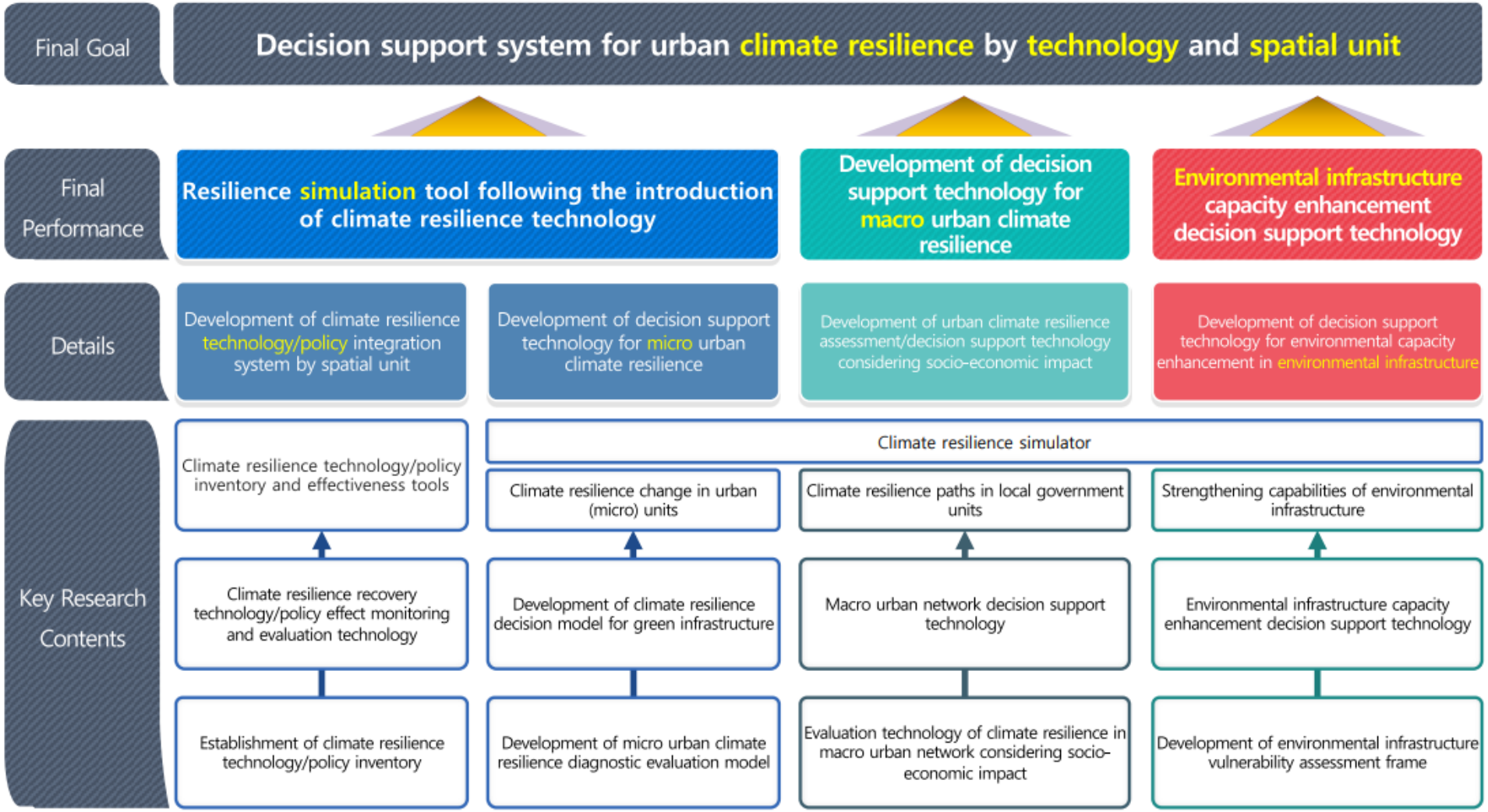
- Although climate resilience is emerging as an important concept both domestically and internationally, stakeholders involved in actual policy-making face several limitations:

1. Lack of Information on Effective Technologies and Policies
   - What technologies and policies are effective for addressing urban climate risks?
   - How do their quantitative impacts compare?
   - What are the installation and maintenance costs?

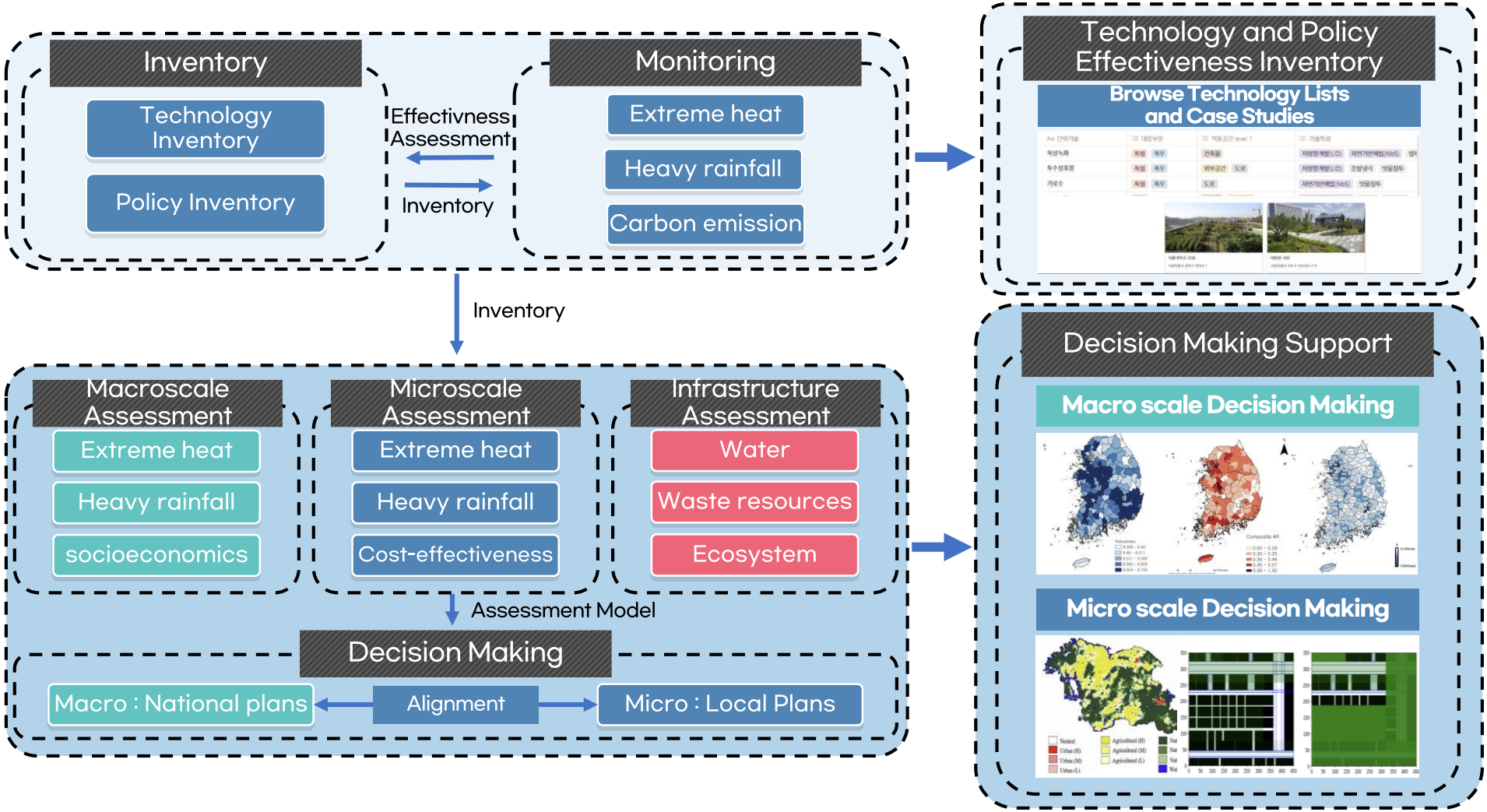
2. Lack of Decision-Support Tools for Spatial Planning
   - No scientific and quantitative models for assessing climate resilience at the national or local level
   - No micro-scale tools that can be integrated into real-world spatial planning

➢ In this context, this study aims to establish a system that supports the quantitative assessment, management, and planning of urban climate resilience

Project Objectives



Overall Research Flow



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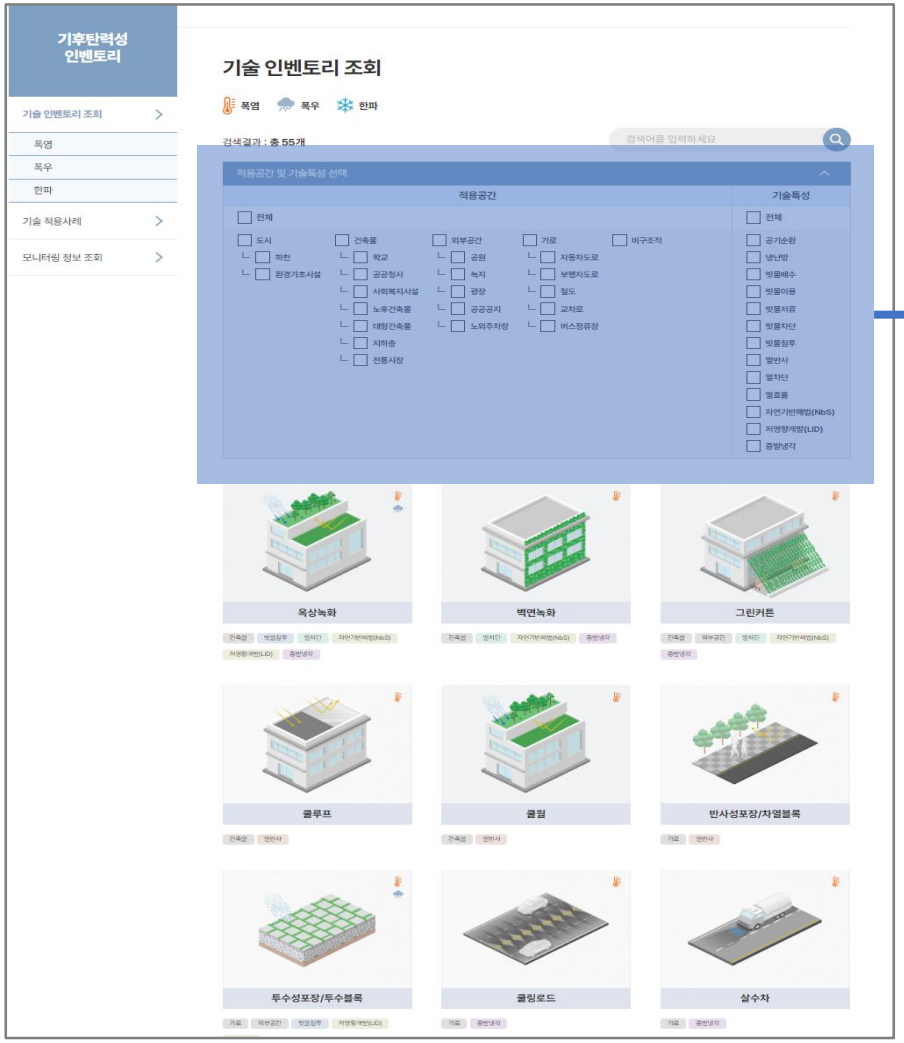
Technology and Policy Effectiveness Inventory

Technology and Policy Effectiveness Inventory



Categorization	
Fuction	Minimization of Building Heat Loss, Improvement of Energy Efficiency, Carbon Emission Reduction
Sector	Adaptation(Extreme heat, Heavy rainfall, …), Mitigation
Technology	green roofs, green walls, green curtains, thermal insulation, shading devices, heat-absorbing materials, cooling and irrigation systems, …
Policy/Projcet	Regional Support Program for Climate-Vulnerable Communities (Ministry of Environment), Residential Environment Improvement Program (Ministry of Environment, Ministry of Agriculture, Food and Rural Affairs), …
⋮	

- Development of a technology categorization system
  (functional categories, response sectors, technology types, and policies/programs, …)
- Currently, 52 technologies have been inventoried

Technology and Policy Effectiveness Inventory

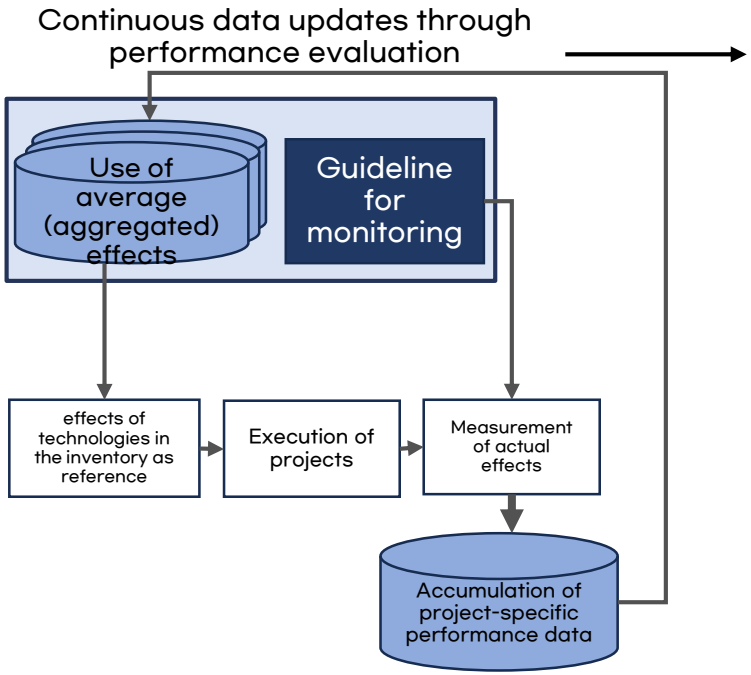
- For each technology, users can access real-world application cases and detailed technical information
- The detailed information includes the definition, operating principles, and effectiveness of the technology
- Application cases provide information on actual implementation sites, budget, and other relevant details

Technology and Policy Effectiveness Inventory

- Policies have also been reviewed and categorized through a similar process
- Particular emphasis has been placed on aligning policies with the Sustainable Development Goals (SDGs)
- Each policy is linked to relevant technologies and associated SDGs, allowing for integrated display and retrieval

Practical Applications for Policy Decision-Makers - Inventory

Structuring a Monitoring System

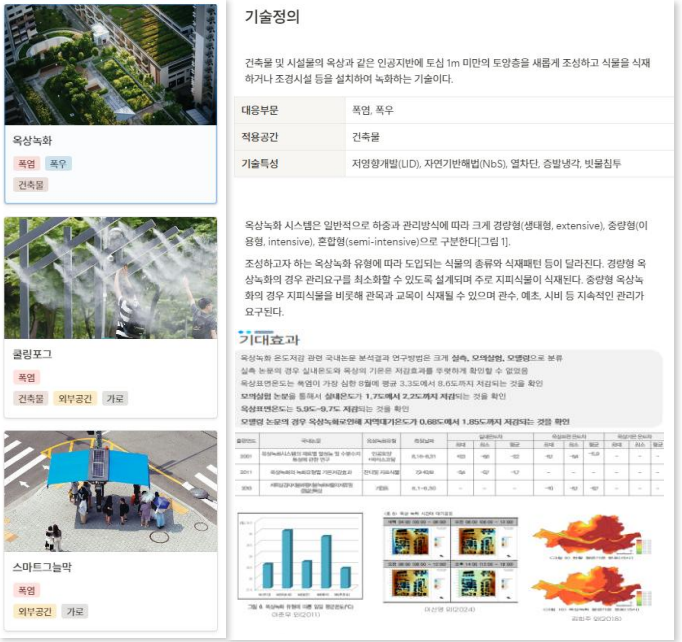


Technology Inventory Access

Inventory List

단위기술	대응부문	적용공간	기술특성
옥상녹화	폭염, 폭우	건축물	빗물침투, 열차단,
벽면녹화	폭염	건축물	열차단, NbS, 증
그린커튼	폭염	건축물, 외부공간	열차단, NbS, 증
쿨루프, 쿨페	폭염	건축물	열반사
반사성포장	폭염	도로	열반사
투수성포장	폭염, 폭우	도로, 외부공간	빗물침투, LID, 증
쿨링로드, 살수차	폭염	도로	증발냉각
쿨링포그	폭염	건축물, 도로, 외부공간	증발냉각
그늘막(차양막)	폭염	도로, 외부공간	열차단
가로수	폭염, 폭우	도로	빗물침투, 열차단,
지표면녹화	폭염, 폭우	외부공간	빗물침투, NbS, 증
바람길	폭염	도시	공기순환
무더위쉼터, 이동식쉼터	폭염, 한파	도로, 외부공간	냉난방, 열차단
냉온열벤치	폭염, 한파	도로, 외부공간	냉난방
외부차양	폭염	건축물	열차단
내부차양	폭염	건축물	열차단
단열개선	폭염, 한파	건축물	열효율
히트펌프	폭염, 한파	건축물	열효율
건물에너지관리시스템(B	폭염, 한파	건축물	열효율
공기순환시스템	폭염	건축물	공기순환
나무여과상자	폭우	외부공간	빗물침투, LID
빗물통	폭우	건축물	빗물이용, LID
식물재배화분	폭우	도로, 외부공간	빗물침투, LID
식생수로	폭우	도로, 외부공간	빗물침투, LID
식생여과대	폭우	외부공간	빗물침투, LID
식생체류지, 빗물정원	폭우	외부공간	빗물침투, LID
침투측구	폭우	도로, 외부공간	빗물침투, LID
침투통	폭우	건축물, 외부공간	빗물침투, LID
침투트렌치	폭우	건축물, 외부공간	빗물침투, LID
빗물받이, 집수정	폭우	도로	빗물저류
빗물저류조	폭우	건축물, 외부공간	빗물저류

Technology Inventory



- By linking **climate resilience policies, technologies, effects, and the technology inventory**, the platform effectively supports **decision-making by central and local governments** during project implementation
- Building an **Effect Estimation Guideline** and linking it to the inventory database enables more **accurate evaluation** of each project
- Currently, this system is being connected to **support programs for climate-vulnerable and disadvantaged regions** (since 2021), helping to improve operational efficiency and project effectiveness through administrative integration

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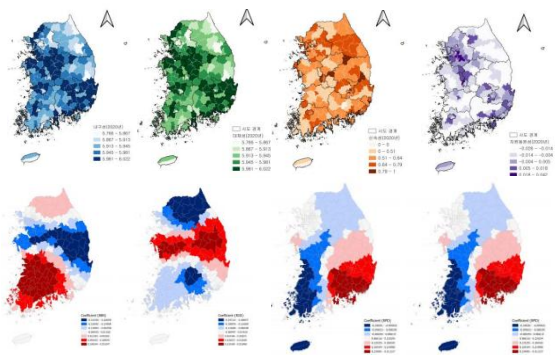
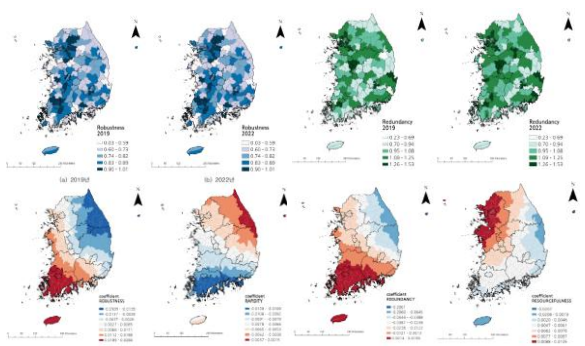
Decision Making Support

Macroscale Assessment

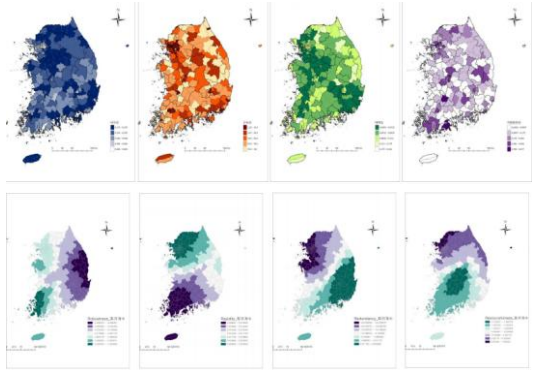
Socioeconomics



Extreme heat



Heavy rainfall



- Climate resilience was assessed nationwide at the provincial (si-do) level across the socio-economic, heatwave, and heavy rainfall sectors
- The assessment of climate resilience was based on the 4Rs framework

Robustness : The ability to withstand climate-related disturbances without significant degradation
- Proportion of Vulnerable Population, Green Space Ratio

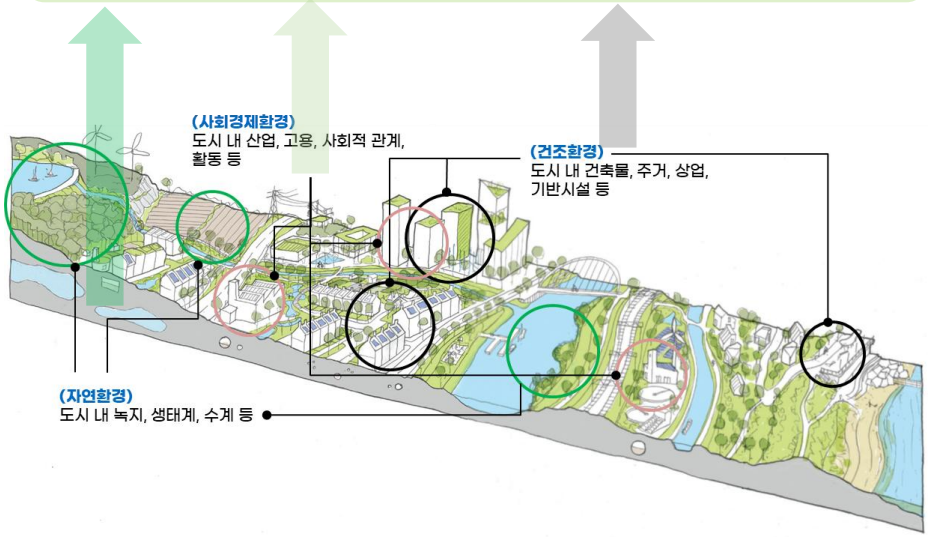
Rapidity : The speed at which a system can recover and restore functionality after a disturbance
- Number of Emergency Medical Facilities, Average Distance to Emergency Medical Facilities

Redundancy : The presence of backup systems or alternatives that can take over when primary systems fail
- Number of Workers in Related Industries

Resourcefulness : The capacity to mobilize resources and respond effectively during disruptions
- Local Budget for Disaster Management and Civil Defense

Practical Applications for Policy Decision-Makers - Macroscale Assessment

Science-Based Climate Resilience Modeling, Future Outlook, and Policy Scenarios & Systems



Scientific Forecast → Policy Target Setting → Policy/Project Design → Implementation & Monitoring → Feedback

(Scientific Forecast)
Climate change and demographic shifts may soon lower climate resilience (e.g., from 30 to below 25)

(Policy Target Setting)
To maintain resilience at 30 in the face of heatwave risk, assume a 20% improvement is required in area A — this becomes a policy target

(Policy/Project Design)
Design intervention plans using climate resilience technologies and the policy inventory
(→ Integrated with technology database and tools)

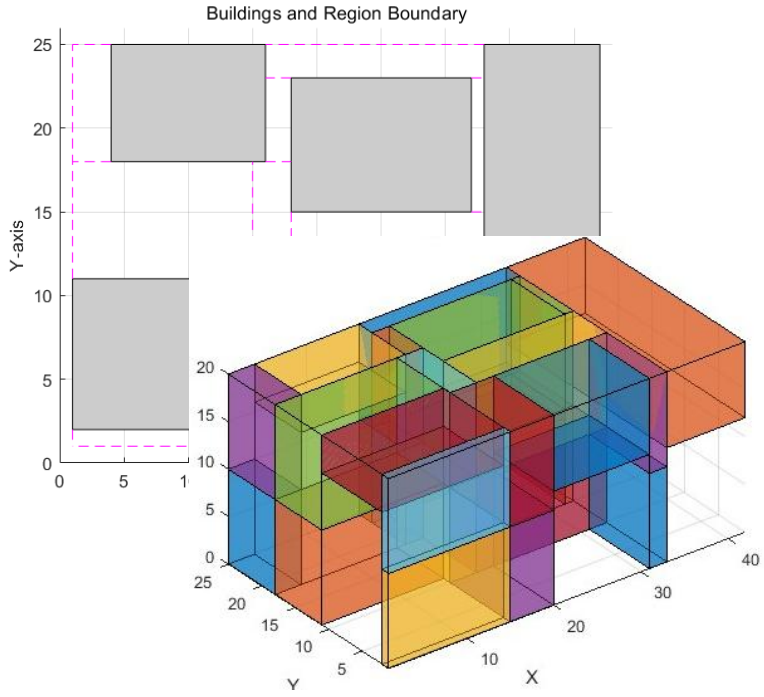
(Monitoring & Implementation)
Track progress toward policy targets in area A using B, C, and D indicators (→ Integrated monitoring system)

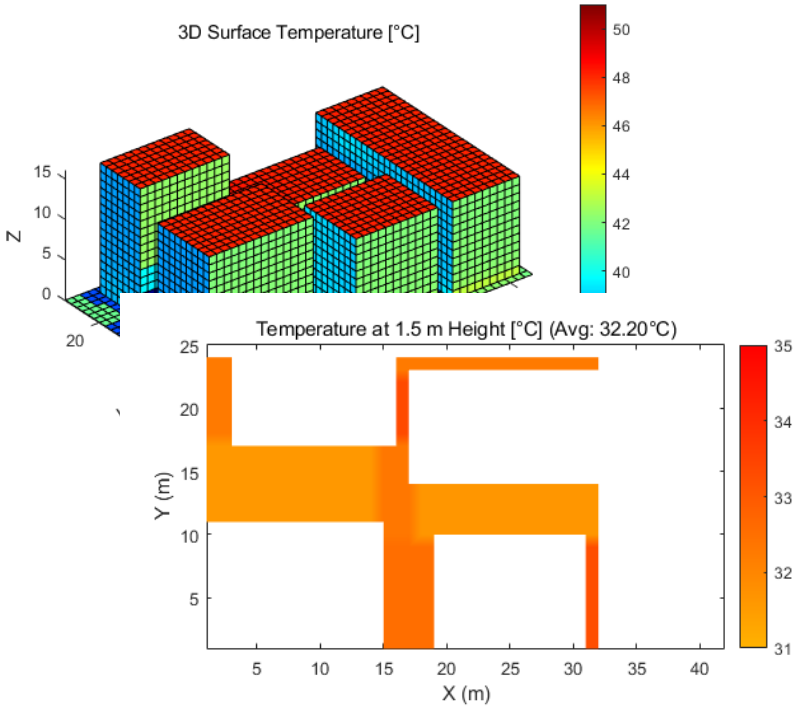
(Feedback & Adjustment)
Based on monitoring results, develop new A-2 level strategies to supplement or adjust policy measures
(→ Feedback loop linked with planning tools)

Ministry of Environment:
National & local climate adaptation planning

Ministry of Land, Infrastructure and Transport:
Urban master plans, district plans, urban management plans

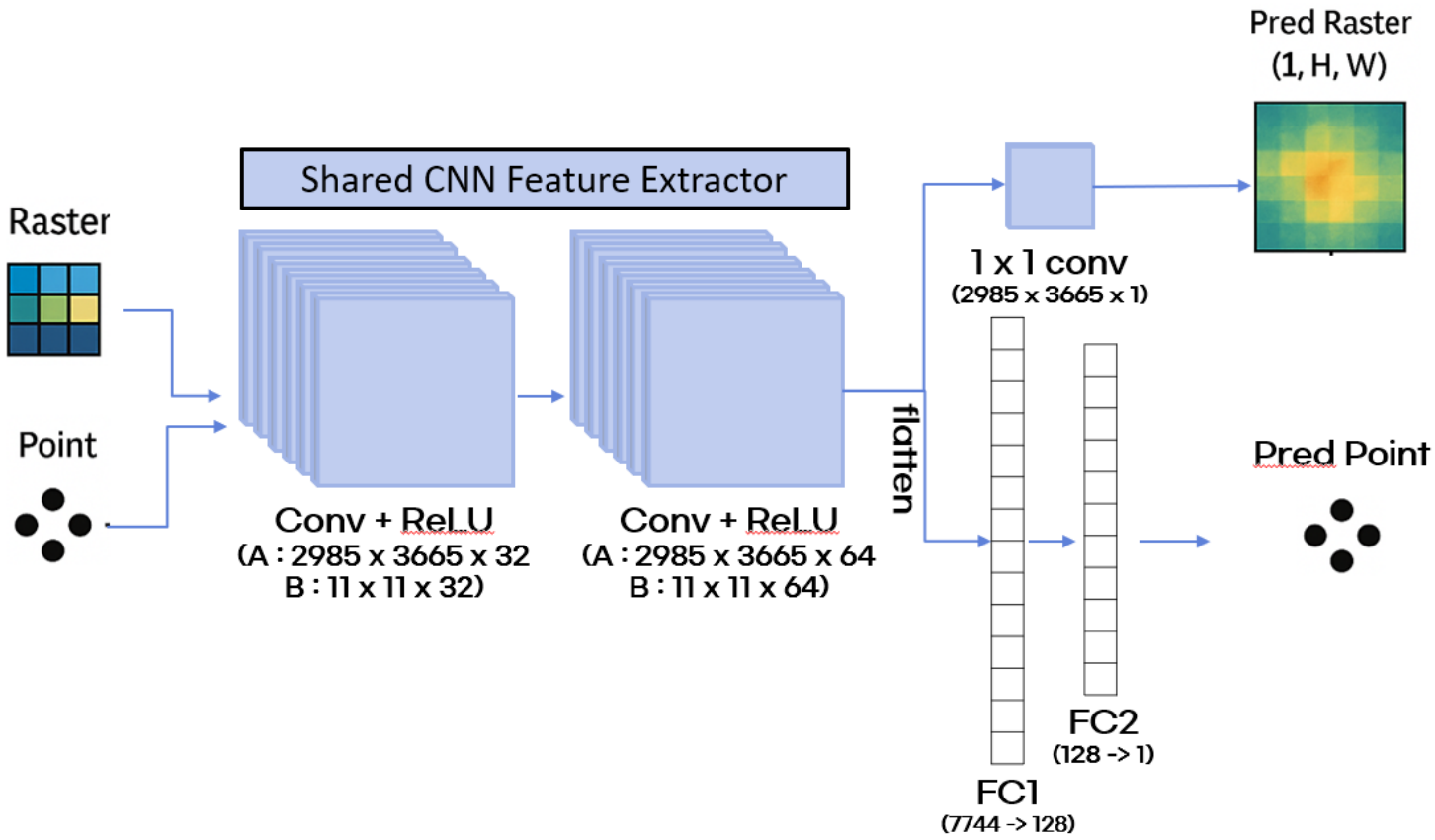
Microscale Assessment - Extreme heat





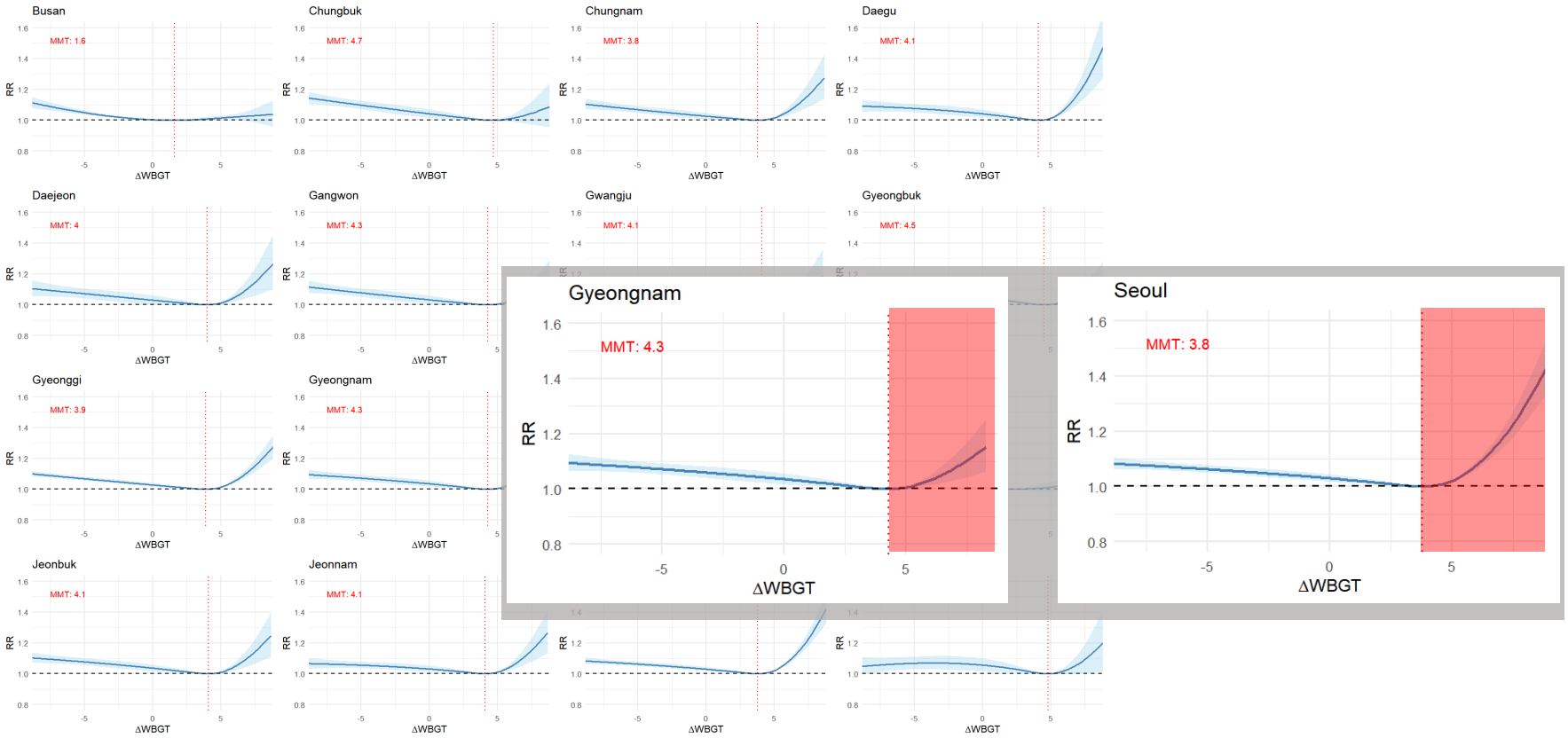
- A 3D evaluation model was developed to assess technologies for heatwave response
- Outdoor spaces were spatially divided based on existing buildings in the target area, and average temperatures were assessed
- Technologies were applied to three-dimensional locations to simulate changes in temperature.

Microscale Assessment - Extreme heat



- While the 3D model provides high accuracy, it requires a significant amount of time for evaluation
- For use in a decision-support system, it is essential to rapidly evaluate a wide range of technologies and policies
- Therefore, a CNN model was trained to predict near-surface air temperature (at 2 meters) by constructing 100m × 100m training data from the 3D model and integrating it with observed data

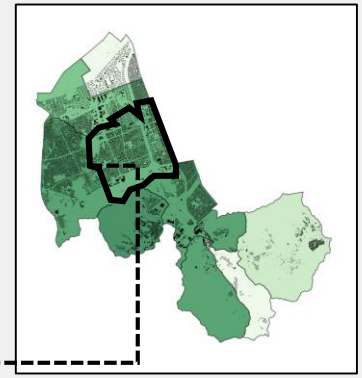
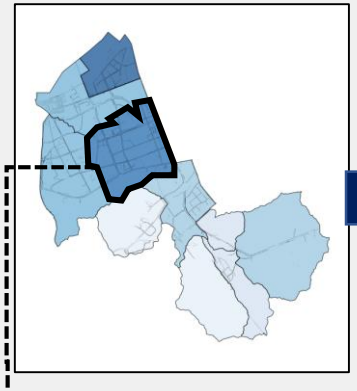
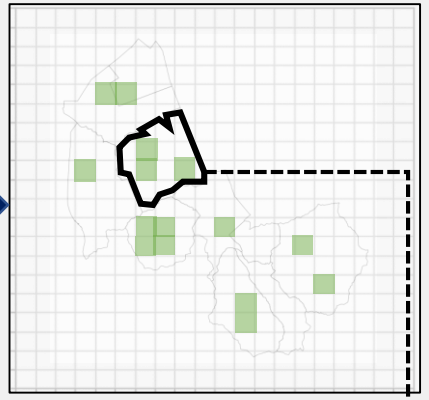
Setting threshold - Extreme heat



- Due to rising temperatures caused by climate change, using a fixed threshold poses potential risks.
- Therefore, **delta WBGT**—defined as the deviation from the average of the past two years—was selected as an indicator to reflect temperature trends.
- The **Minimum Mortality Temperature (MMT)** was analyzed based on this trend-sensitive indicator and applied as a dynamic threshold
- Changes in climate resilience for each region were assessed by calculating **the cumulative risk on days exceeding this threshold during the summer period**.

Decision Making Support

Users Who Need "Quantity" and "Location"

	"Quantity"	"Location"
Unit	Local administrative unit	100m x 100m grid
Results	The required **quantity** of each type of green infrastructure needed to ensure climate resilience within a given budget	The **locations** where expansion of green infrastructure is needed, considering both demand and current supply
Example Images	 Required number of green roofs  Required number of green walls	**Where exactly should additional infrastructure be expanded?**  grid-level priority locations
Example of Use	**In Seocho-dong, Seocho-gu, 70% more green roofs and 80% more green walls are needed**	**Identify priority sites where green roofs and green walls should be installed first**

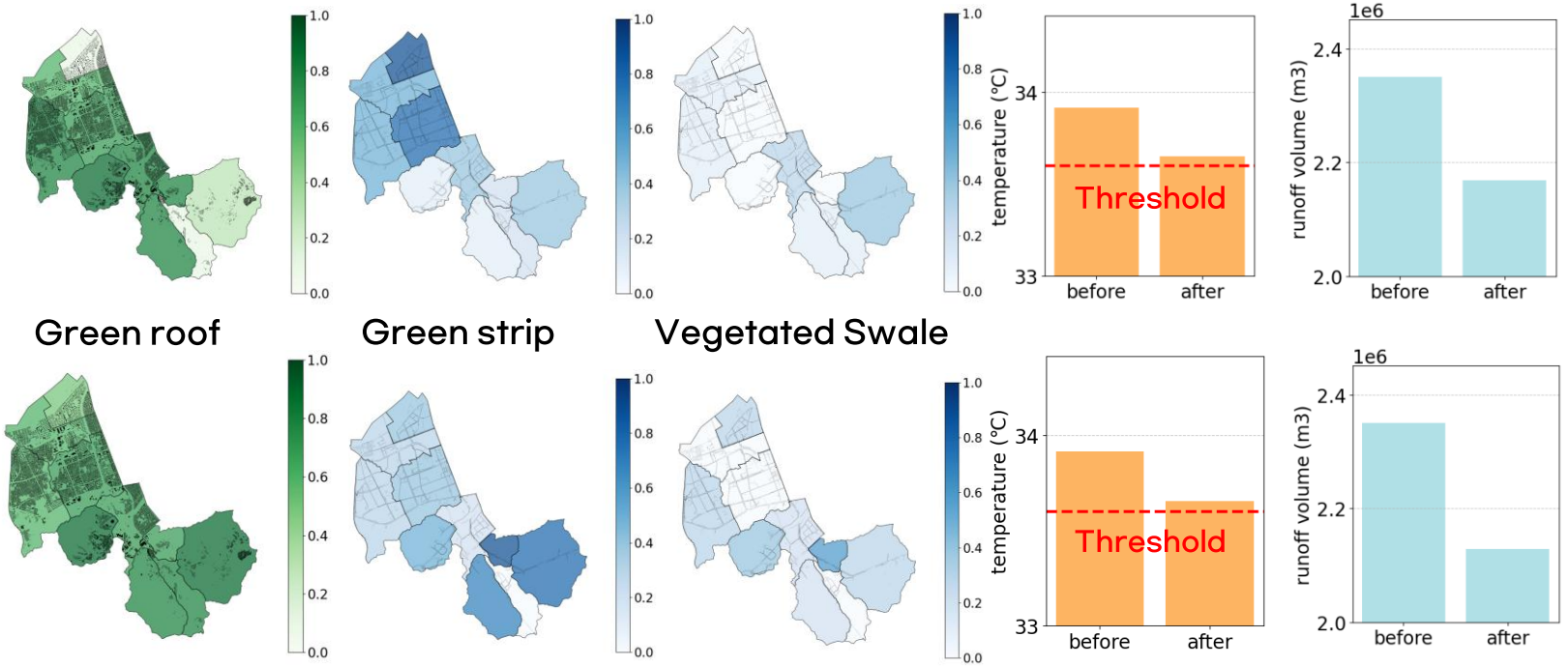
Decision Making Support - Quantity

An optimal plan within the budget

Before-and-After Comparison of the Plan

Heatwave - focused

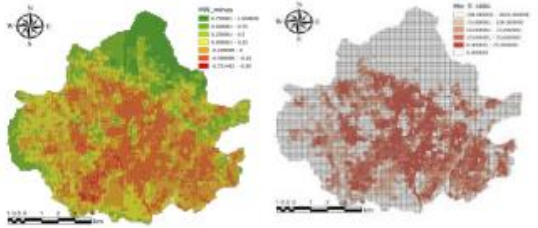
Heavy rain - focused



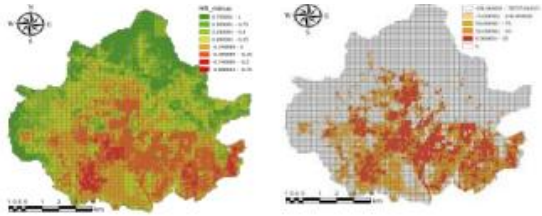
- The previously described heatwave evaluation methods and indicators, along with the SWIM-based model for heavy rainfall and its assessments of runoff and inundation area, were integrated into a comprehensive framework.
- This framework supports decision-making for the adoption of climate resilience technologies and policies addressing heatwaves and heavy rainfall.
- At the **Local administrative unit**, the model evaluates how effectively selected technologies can be implemented within a given budget and presents the optimal deployment strategy based on cost-effectiveness

Decision Making Support - Location

(Extreme heat) Supply / Demand

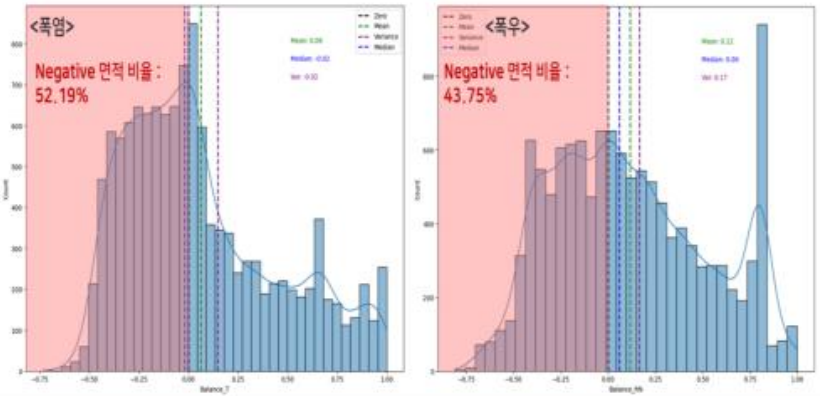


(Heavy rainfall) Supply / Demand



Priority Area

Supply - Demand results



- Developed 100m-grid models to assess demand and supply of green infrastructure for heatwaves and heavy rainfall
  Demand: Based on climate risks, spatial characteristics, and vulnerable populations
  Supply: Evaluated quantity and quality using land cover data
- Based on the identified priority areas, simulations were conducted to determine the optimal installation locations for the designated number of technologies
- The model provides recommendations on where implementation would yield the greatest effect.

Practical Applications for Policy Decision-Makers - Microscale Decision Making

- **Risk-based prioritization enables effective planning**
  → Identifying local risks and simulating the effects of measures in advance enables efficient planning and targeted action

- **Decision-making simulators support evidence-based climate adaptation and urban planning**
  → Support practical, cost-effective adaptation and urban planning by estimating impact and resource needs before implementation

Thank you for your time and attention

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