



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

: A Case Example of the Heatwave Assessment Tool.

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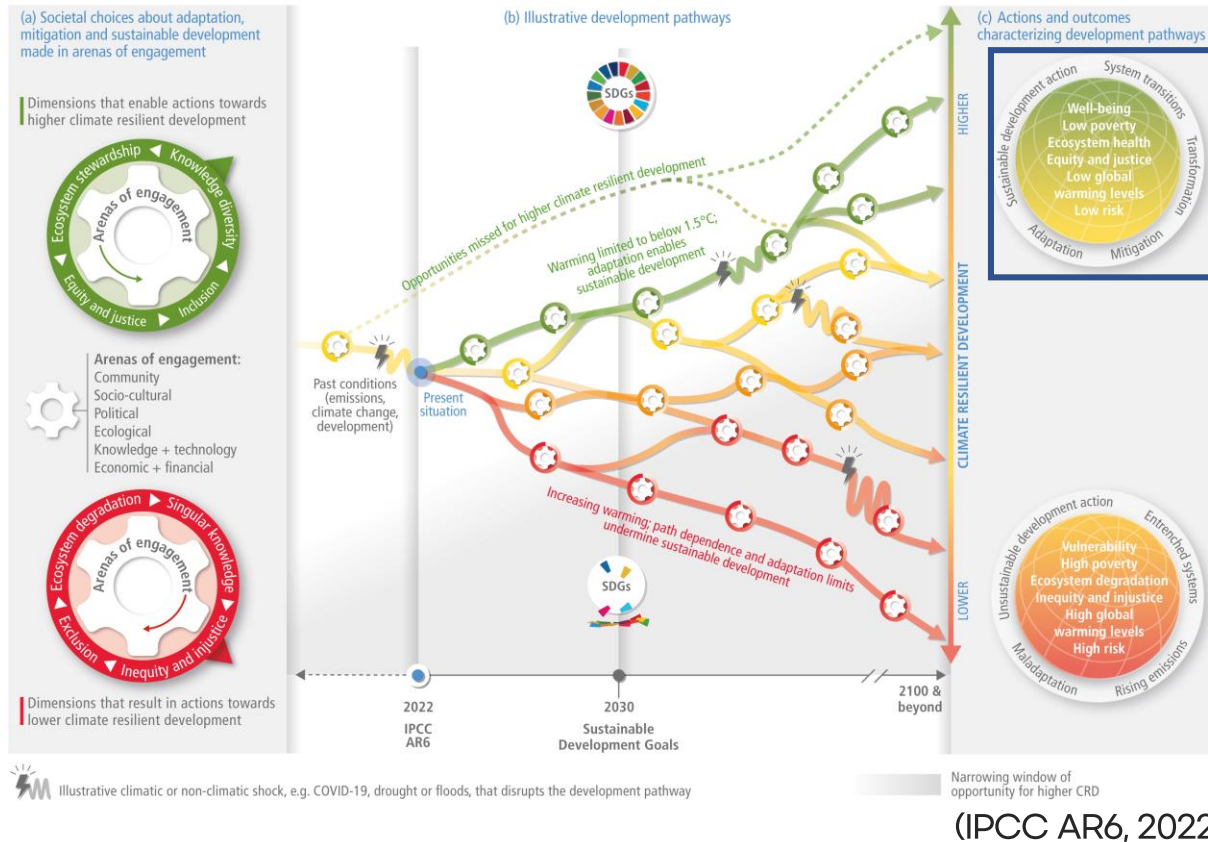
01

Background



The Importance of Climate Resilience

There is a rapidly narrowing window of opportunity to enable climate resilient development



- 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

② 기후적응 도시계획 및 자연기반해법(NbS) 적용 사회기반시설 관리 강화

- o (재해대응 도시계획) 도시 기후계획 수립 시 계획 취약지역 분석권역 취약성 1·2등급 지역에 우선하여 건축물 등 방재계획(국토안전개발사업 등)을 수립·추진

Climate-Adaptive Urban Planning

* 도시·군 기본계획 수립지침 및 도시·군 관리계획 수립지침 개정(~'23)

- o (자연기반해법 시설관리) NbS 활용 저탄소 그린산단 조성사업*('23~, 5개소) 및 도시 기후탄력성 확보 평가·

관리기술** 개발('23)

Development of Assessment and Management Technologies for Enhancing Urban Climate Resilience

* 노후산단(부산 등 5개소)에 식생체류지, LID-브

** 적응 사업(벽면녹화 등), 그린인프라 등 효과의 정량적 평가체계 구축, 이를 통한 최적의 도시설계 모델 마련

<식생체류지>	<식생도랑>	Developing a Quantitative Assessment System for the Impacts of Adaptation Measures and Green Infrastructure
		

※ 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

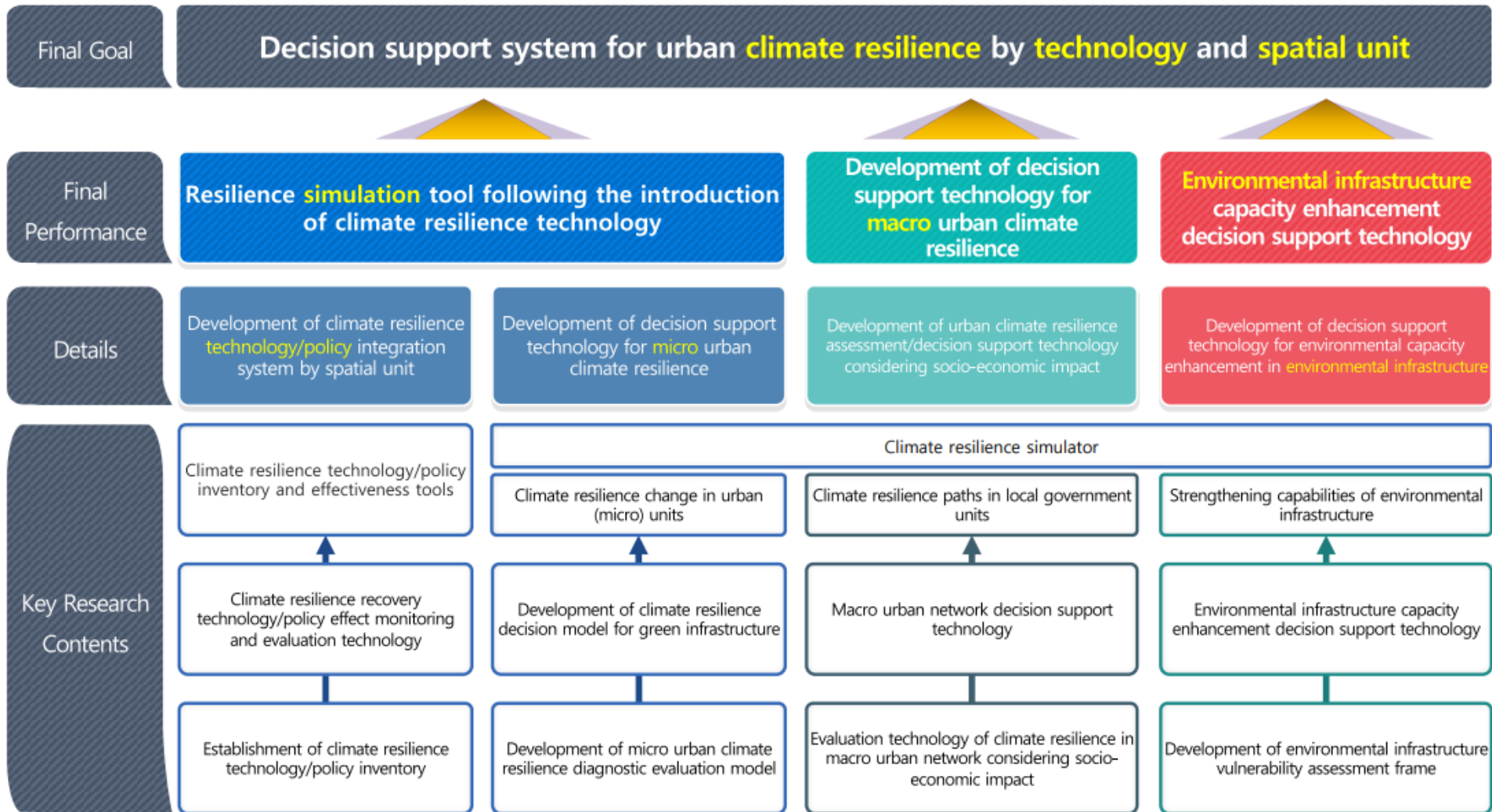
- What technologies and policies are effective for addressing urban climate risks?
- How do their quantitative impacts compare?
- What are the installation and maintenance costs?

2. Lack of Decision-Support Tools for Spatial Planning

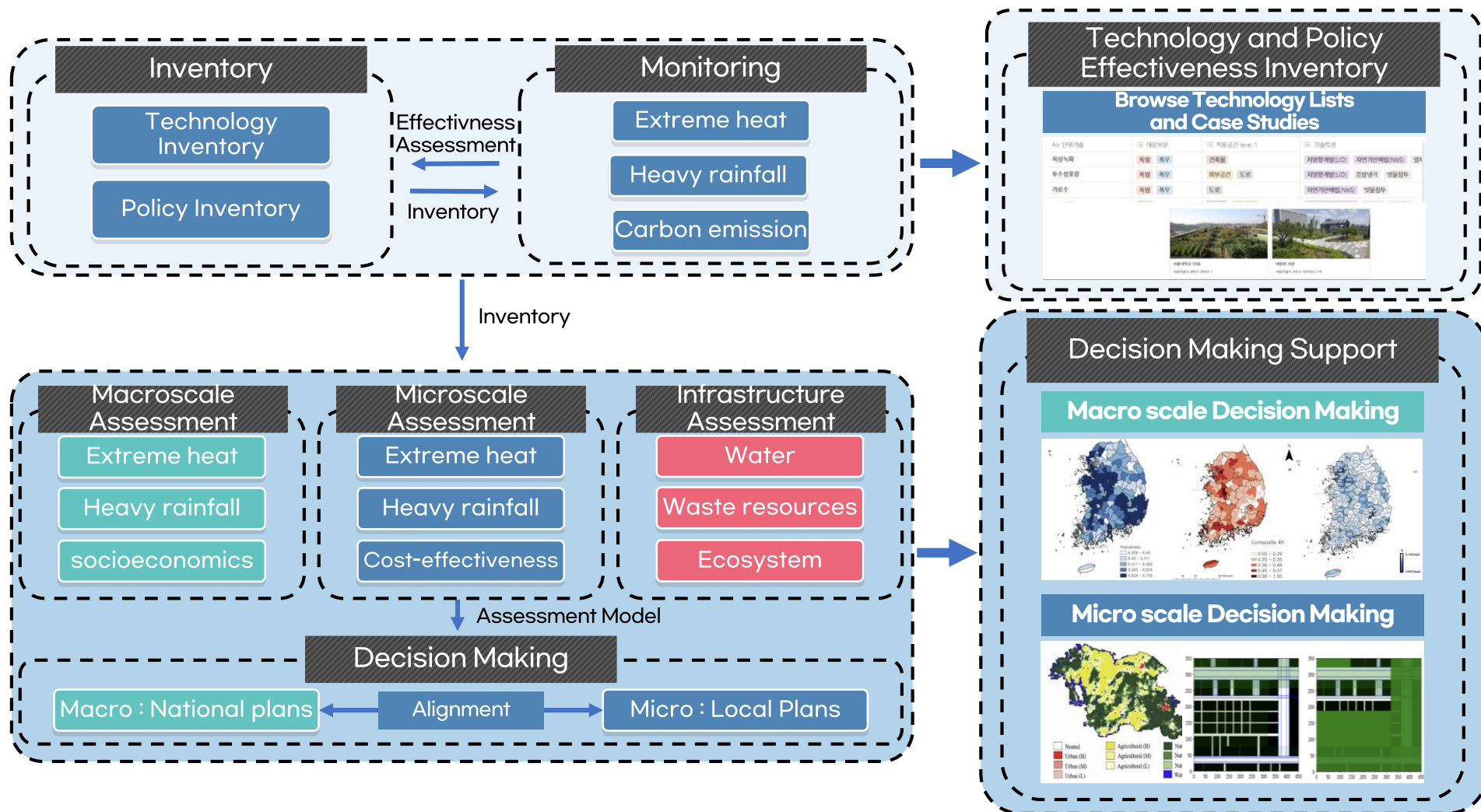
- No scientific and quantitative models for assessing climate resilience at the national or local level
- No micro-scale tools that can be integrated into real-world spatial planning

- 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



02

Technology and Policy Effectiveness Inventory



Technology and Policy Effectiveness Inventory

기후탄력성 인벤토리

기술 인벤토리 조회

목록

목우

한파

기술 적용사례

모니터링 정보 조회

기술 인벤토리 조회

검색결과 : 총 55개

검색어를 입력하세요

적용공간 및 기술특성 선택

적용공간

기술특성

전체

도시

하천

환경기초시설

건축물

학교

공공청사

사회복지시설

노후건축물

대형건축물

지하층

전통시장

외부공간

공원

녹지

광장

공공공지

노후주차장

가로

자동차도로

보행자도로

철도

교차로

버스정류장

배후조직

전체

공기순환

냉난방

방열배수

방열저장

방열차단

방열창문

방열단

방열창문

자연기반해빙(NBS)

저영향개량(LID)

충돌방지

옥상녹화

벽면녹화

그린커튼

물루프

물길

반사성포장/차열블록

투수성포장/투수블록

쿨링로드

살수차

Categorization	
Function	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/Project	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

The first screenshot shows the main menu of the '기후탄소정책 실행도구' (Climate and Carbon Policy Implementation Tool). It includes a sidebar with navigation options like '기술 선택' (Technology Selection), '기술 적용사례' (Technology Application Cases), and '기술 정보' (Technology Information). The main area displays a grid of technology icons, including '태양광' (Solar), '풍력' (Wind), '수소' (Hydrogen), and '바이오' (Bio).

The second screenshot shows the '기술 적용사례' (Technology Application Cases) screen. It displays a grid of application cases, including '태양광' (Solar), '풍력' (Wind), and '수소' (Hydrogen). A blue arrow points from the '태양광' icon in the first screenshot to this screen.

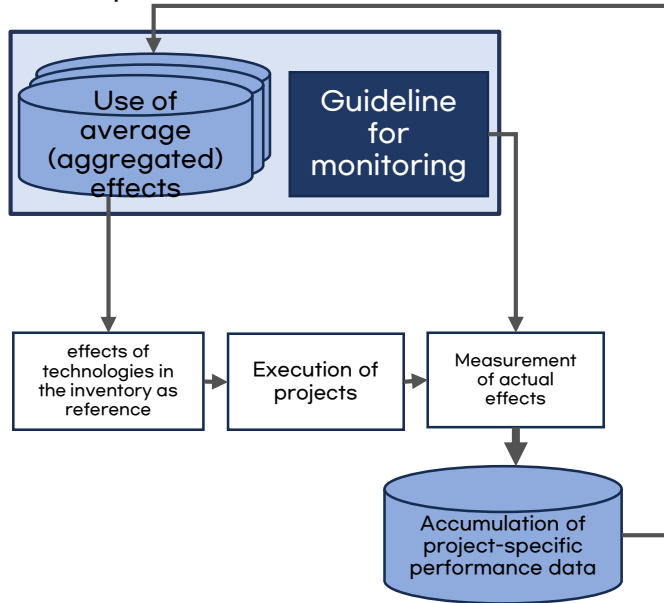
The third screenshot shows the '기술 정보' (Technology Information) screen for '태양광' (Solar). It provides detailed information about the technology, including its definition, operating principles, and effectiveness. The screen is divided into sections: '기술정의' (Technology Definition), '기술원리' (Technology Principle), and '기술효과' (Technology Effectiveness). It also includes a table of '기술특성' (Technology Characteristics) and a diagram of the technology's components.

- 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

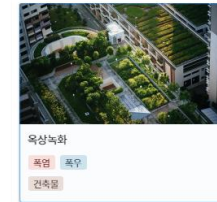
- Policies have also been reviewed and categorized through a similar process
- Particular emphasis has been placed on aligning policies with the Sustainable Development Goals (SDGs)
- Each policy is linked to relevant technologies and associated SDGs, allowing for integrated display and retrieval

Technology Inventory Access



Technology Inventory

주요기공	대용부분	적용분야	기술특성
죽산녹화	죽, 목우	건축물	비물질탄출, 열차
백면녹화	죽엽	건축물	열차단, NBS,
그린커튼	죽엽	건축물, 외부공간	열차단, NBS,
클라우드, 풀월	죽엽	건축물	열반사
반사성포장	죽엽	도로	열반사
탄소성포장	죽엽, 목우	도로, 외부공간	비물질탄출, LID
불량포도, 실수자	죽엽	도로	증발냉각
비밀포그	죽엽	건축물, 도로, 외부공간	증발냉각
그늘막(차양막)	죽엽	도로, 외부공간	열차단
기온수	죽엽, 목우	도로	비물질탄출, 공기
지표면녹화	죽엽, 목우	외부공간	비물질탄출, NBS
방열막	죽엽	도시	공기온화
바우워쉬터, 이음돌칠기	죽엽, 산타	도로, 외부공간	냉난방, 열차단
냉온열합치	죽엽, 산타	도로, 외부공간	냉난방
외부차양	죽엽	건축물	열차단
내부차양	죽엽	건축물	열차단
단열개선	죽엽, 산타	건축물	열효율
이음돌칠기	죽엽, 산타	건축물	열효율
냉온에너지자려서시스템	죽엽, 산타	건축물	열효율
공기순환시스템	죽엽	건축물	공기순화
나무여과장치	죽우	외부공간	비물질탄출, LID
비물질탄출	죽우	건축물	비물질탄출, LID
식물재배본	죽우	도로, 외부공간	비물질탄출, LID
식생수로	죽우	도로, 외부공간	비물질탄출, LID
식생여과대	죽우	외부공간	비물질탄출, LID
식생재배지, 비물질장점	죽우	외부공간	비물질탄출, LID
점토죽공	죽우	도로, 외부공간	비물질탄출, LID
점토벽	죽우	건축물, 외부공간	비물질탄출, LID
점토벽돌지	죽우	건축물, 외부공간	비물질탄출, LID
비물질보아, 질수장	죽우	도로	비물질저류
비물질저장조	죽우	건축물, 외부공간	비물질저류



건축물 및 시설물의 옥상과 같은 인공지반에 토심 1m 미만의 토양층을 새롭게 조성하고 식물을 식재하거나 조경시설 등을 설치하여 녹화하는 기술이다.

대응부문	폭염, 폭우
적용공간	건축물
기술특성	저영향개발(LID), 자연기반해법(NbS), 열차단, 증발냉각, 빗물침투

육상녹화 시스템은 일반적으로 하중과 관리방식에 따라 크게 경량형(생태형, extensive), 중량형(이용형, intensive), 혼합형(semi-intensive)으로 구분한다(그림 1).

조심하고자 하는 옥상녹화 유형에 따라 도입되는 식물의 종류와 식재패턴 등이 달라진다. 경량형 옥상녹화의 경우 관리요구를 최소화할 수 있도록 설계되며 주로 지피식물이 식재된다. 중량형 옥상녹화의 경우 지피식물을 비롯해 관목과 교목이 식재될 수 있으며 관수, 예초, 시비 등 지속적인 관리가 요구된다.

국유식물 온도저감 관련 국내논문 분석결과 연구방법은 크게 실험, 모의실험, 모델영역으로 분류
실험 논문이 경우 실내온도와 국유식물 기온은 저감효과를 뚜렷하게 확인할 수 없었음
모의실험은 국유식물 기온이 가장 심한 8월이 평균 3.3도에서 0.6도까지 저감되는 것을 확인
모의실험 논문들 통해서 실내온도가 1.7도에서 2.2도까지 저감되는 것을 확인
모의실험 논문은 5.9%~9.7% 저감되는 것을 확인
모델영역 논문의 경우 국유식물온도에는 지역대기온도가 0.68도에서 1.85도까지 저감되는 것을 확인

출발지/도	목적지/로	운행차량종류	출발시간대	입국인원(명)			출국인원(명)			회차인원(명)		
				회차	회차	회차	회차	회차	회차	회차	회차	회차
2001	부산/부산시내버스(대동로) 발/도청 앞 수송인원 회차에 관한 연구	기차/도청 대동로/대동로	8.15-8.31	103	100	102	101	100	100	-	-	-
2011	부산/부산시내버스(대동로) 발/도청 앞 수송인원 회차에 관한 연구	기차/도청 대동로/대동로	8.15-8.31	103	100	102	-	-	-	-	-	-
2003	부산/부산시내버스(대동로) 발/도청 앞 수송인원 회차에 관한 연구	기차/도청 대동로/대동로	8.15-8.31	-	-	-	101	102	100	-	-	-



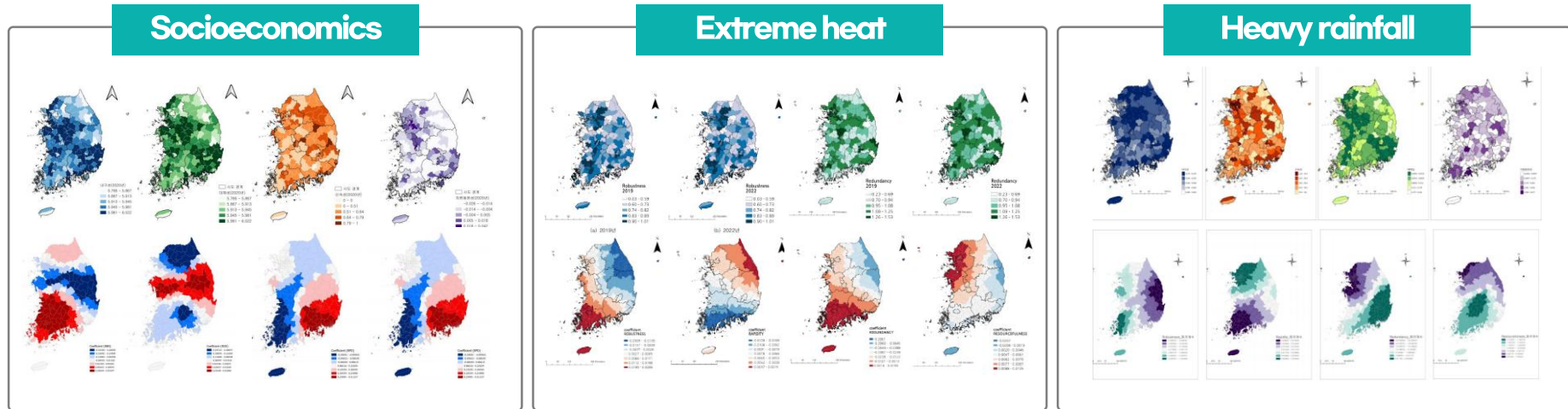
- By linking **climate resilience policies, technologies, effects, and the technology inventory**, the platform effectively supports **decision-making by central and local governments** during project implementation
- Building an **Effect Estimation Guideline** and linking it to the inventory database 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

03

Decision Making Support



Macroscale Assessment



- 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

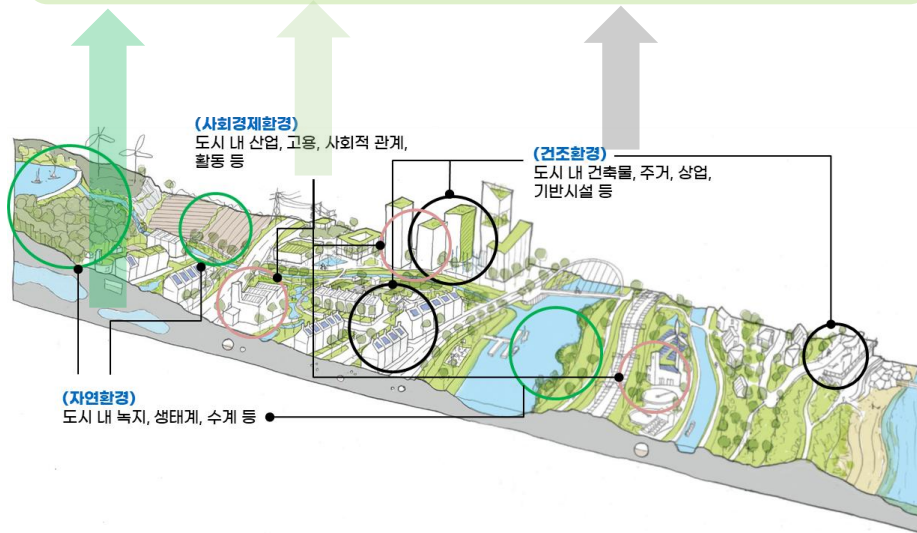
Resourcefulness : The capacity to mobilize resources and respond effectively during disruptions

- 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



Ministry of Environment:
National & local climate
adaptation planning

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

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)

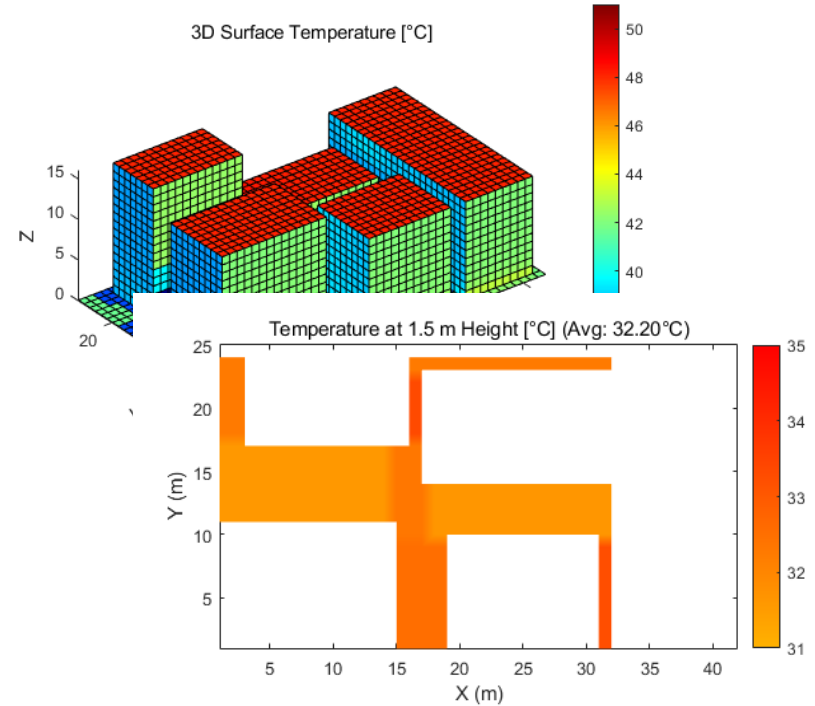
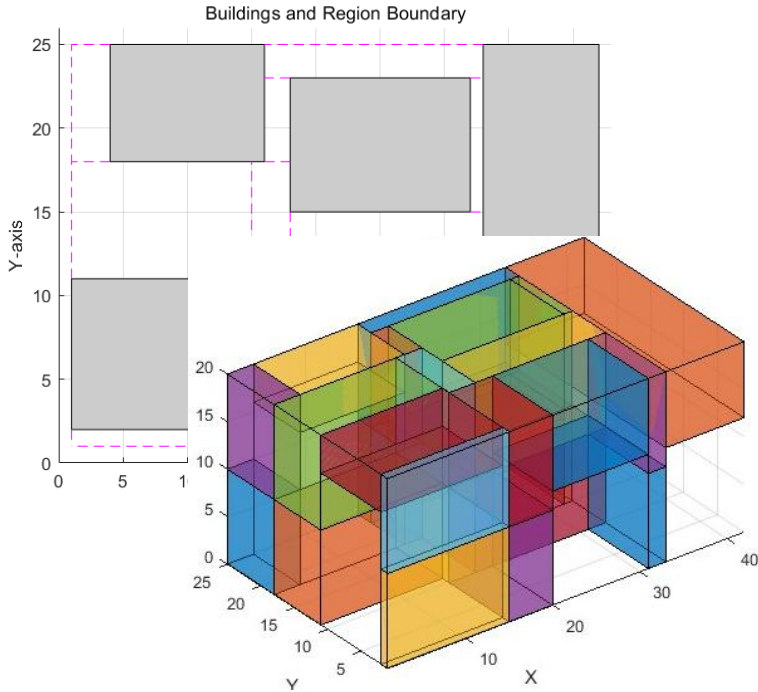
(Monitoring & Implementation)

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

(Feedback & Adjustment)

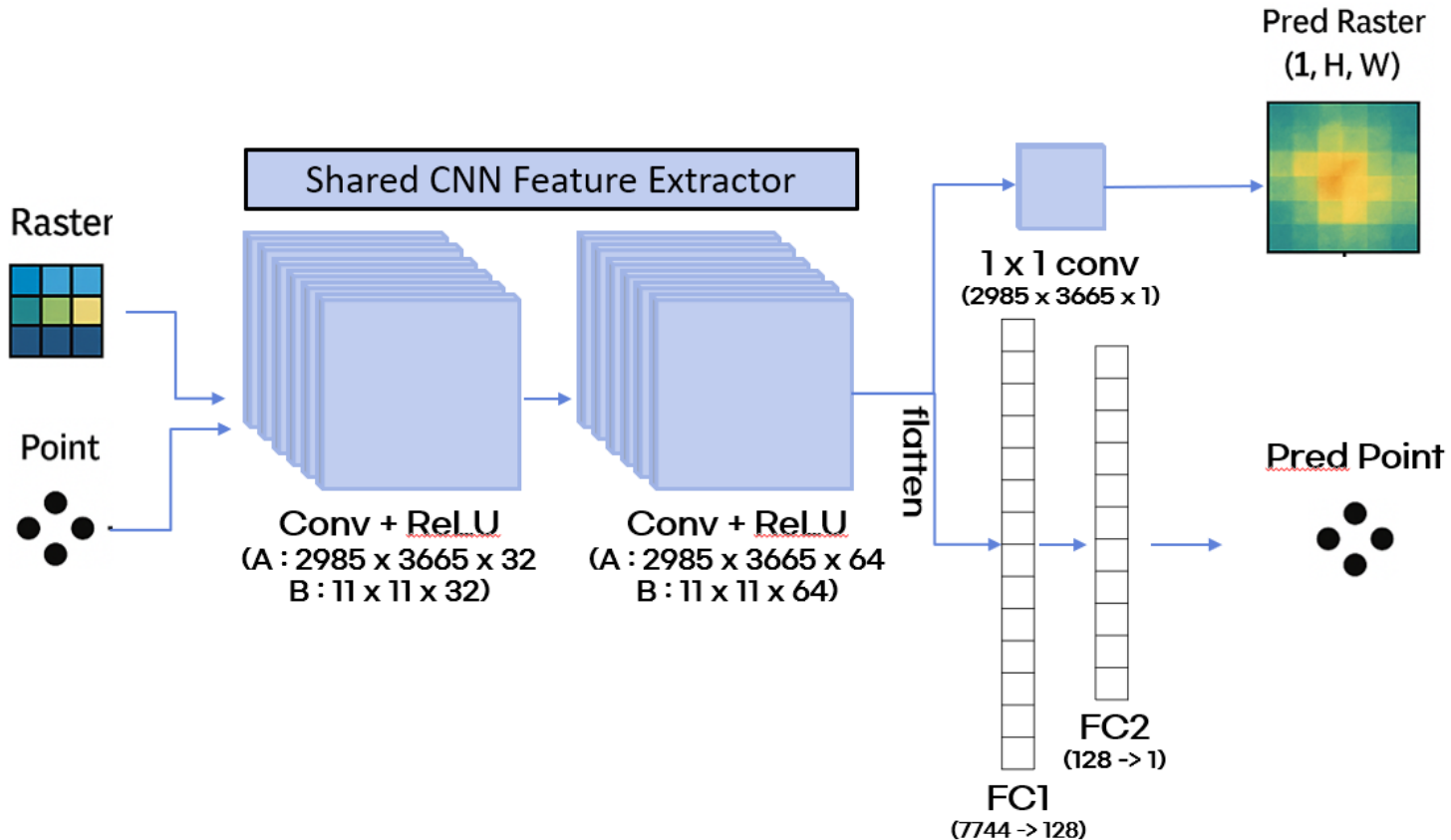
Based on monitoring results, develop new A-2 level strategies to supplement or adjust policy measures
(→ Feedback loop linked with planning tools)

Microscale Assessment - Extreme heat



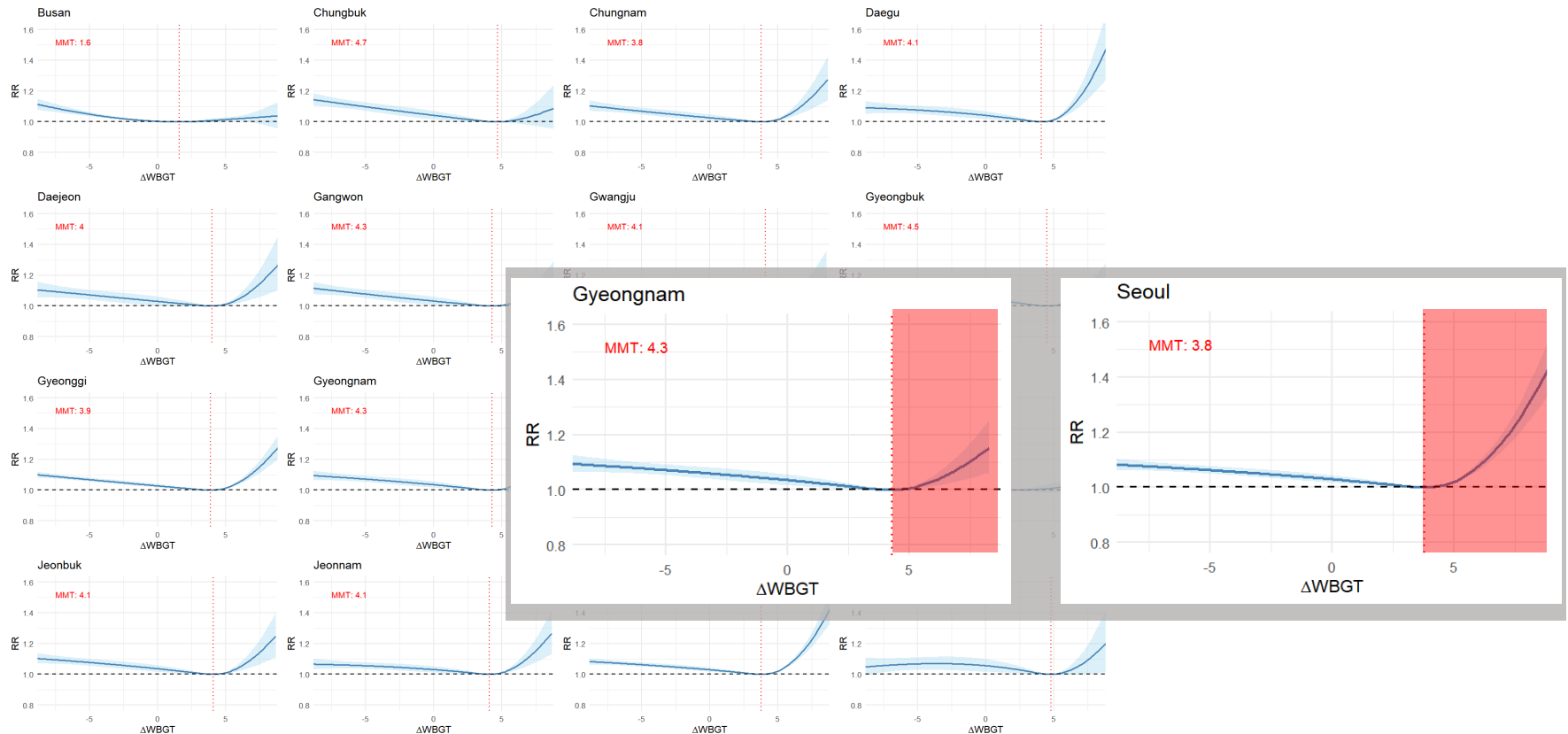
- A 3D evaluation model was developed to assess technologies for heatwave response
- Outdoor spaces were spatially divided based on existing buildings in the target area, and average temperatures were assessed
- Technologies were applied to three-dimensional locations to simulate changes in temperature.

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"

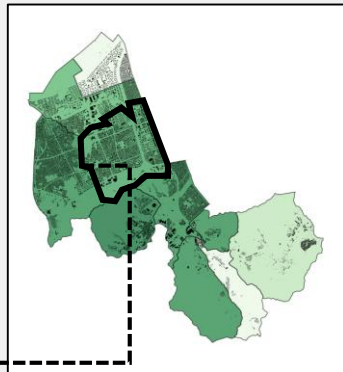
Unit

Local administrative unit

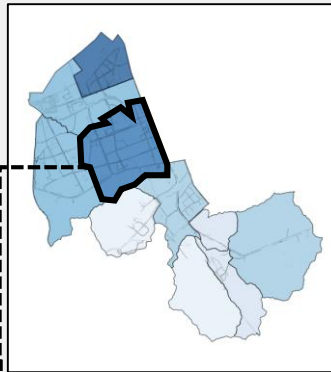
Results

The required **quantity** of each type of green infrastructure needed to ensure climate resilience within a given budget

Example Images



Required number of green roofs



Required number of green walls

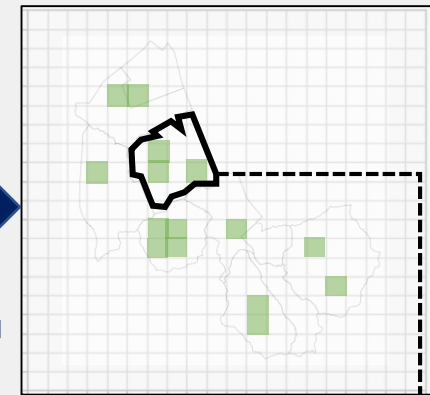
In Seocho-dong, Seocho-gu, 70% more green roofs and 80% more green walls are needed

Example of Use

and "Location"

100m x 100m grid

The **locations** where expansion of green infrastructure is needed, considering both demand and current supply



Where exactly should additional infrastructure be expanded?

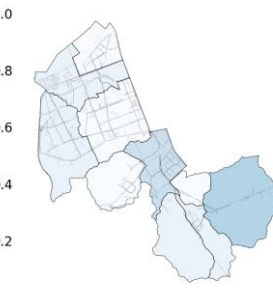
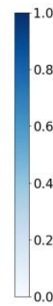
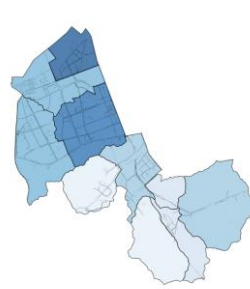
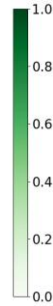
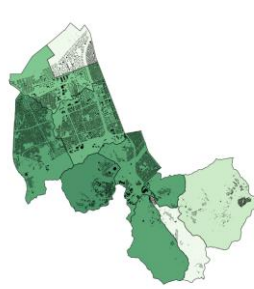
grid-level priority locations

Identify priority sites where green roofs and green walls should be installed first

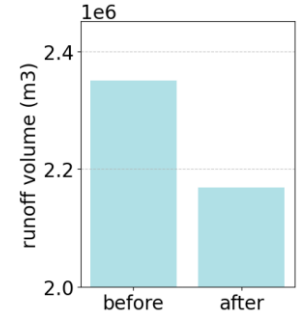
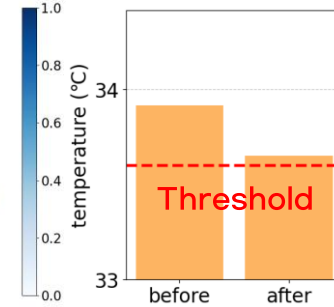
Decision Making Support - Quantity

An optimal plan within the budget

Heatwave
- focused



Before-and-After Comparison of the Plan

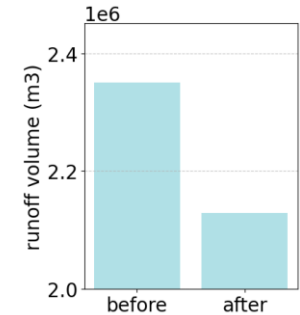
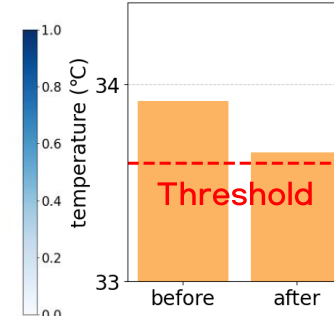
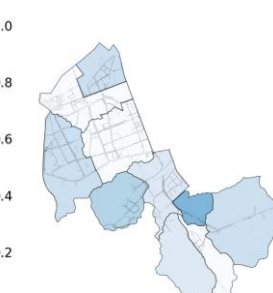
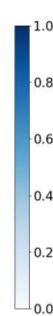
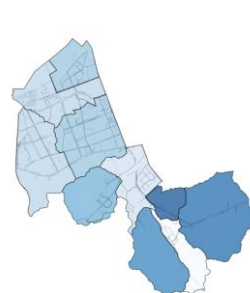
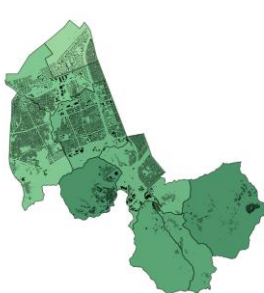


Green roof

Green strip

Vegetated Swale

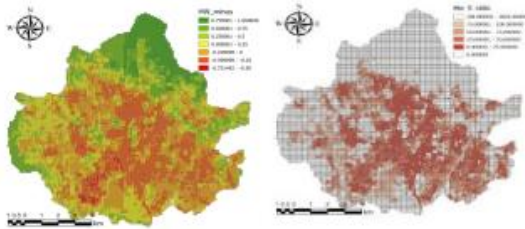
Heavy rain
- focused



- 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

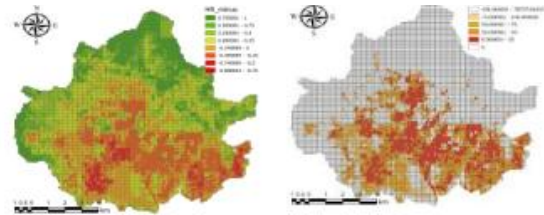
(Extreme heat) Supply / Demand



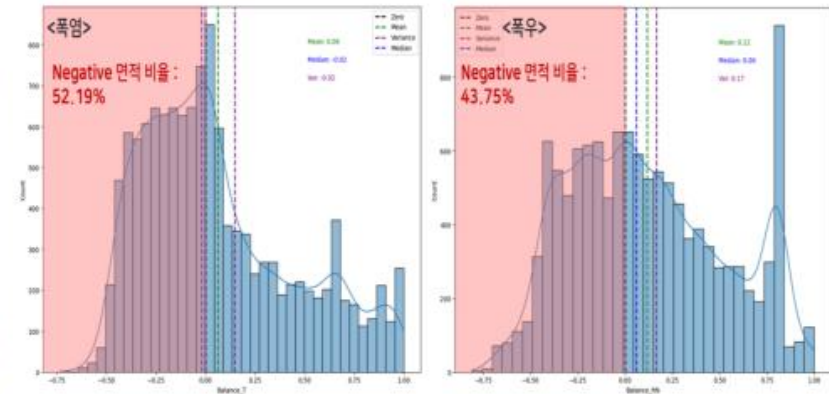
Priority Area



(Heavy rainfall) Supply / Demand



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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