World Conference on climate Change
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Adaptation Technology of Infrastructure under Climate Change

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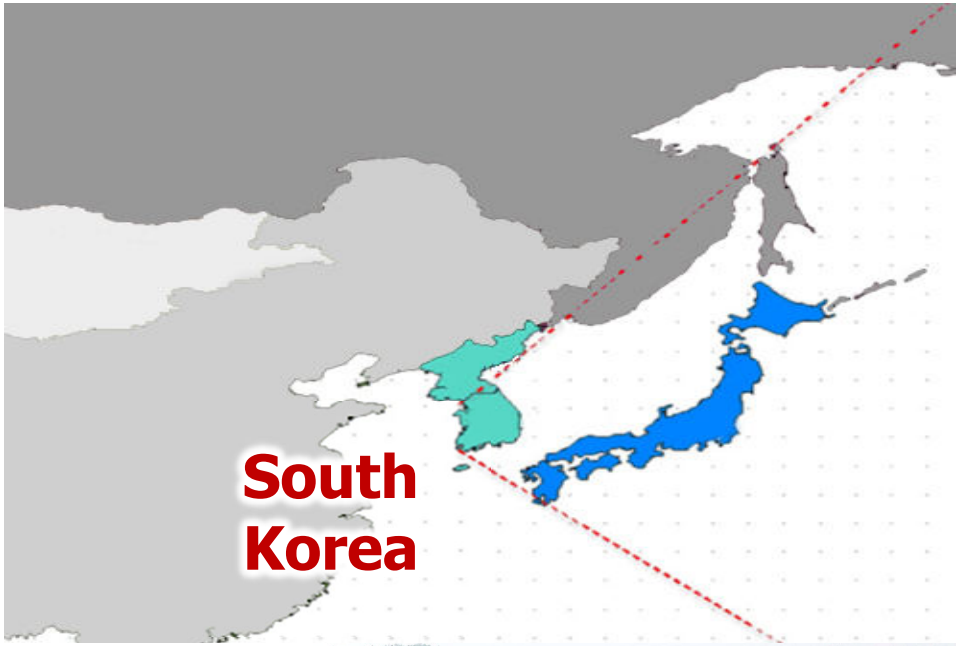
III Conclusions

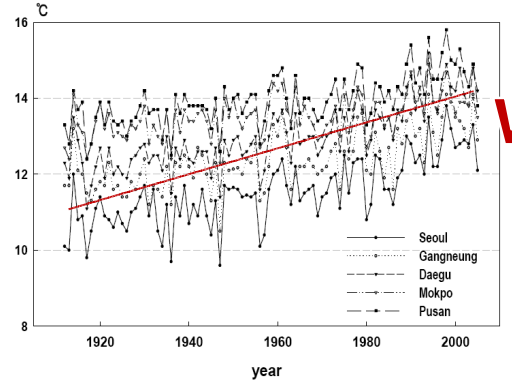


I Introduction of GIT4CC

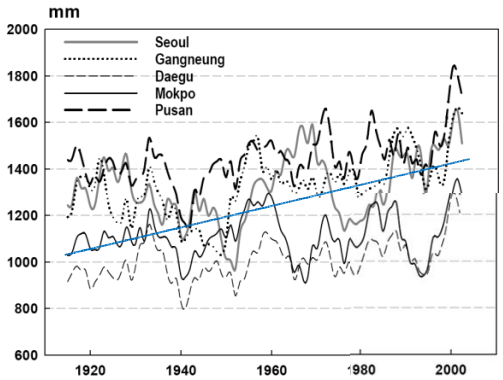
1. Introduction
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1 Introduction





Warming



Rainfall increase



Infrastructure failure

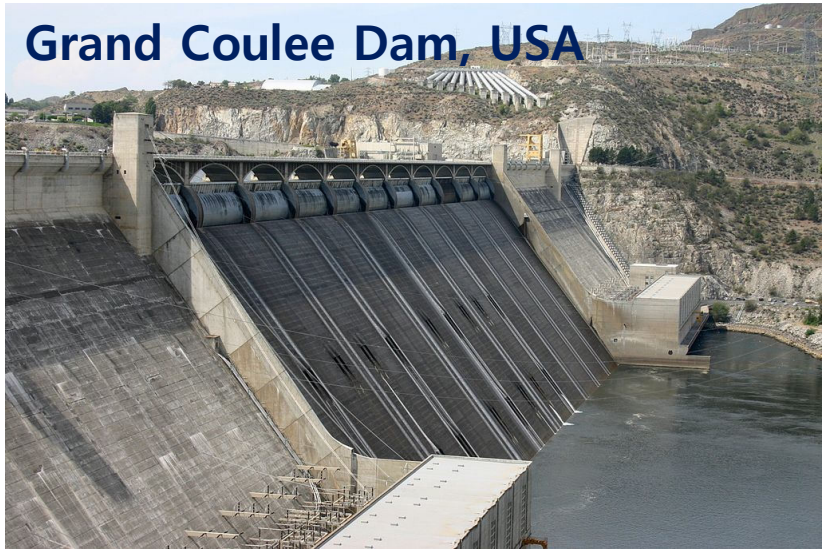




What is the Infrastructure?

- Infrastructure refers to structures, systems, and facilities serving the economy of a business, industry, country, city, town, or area.

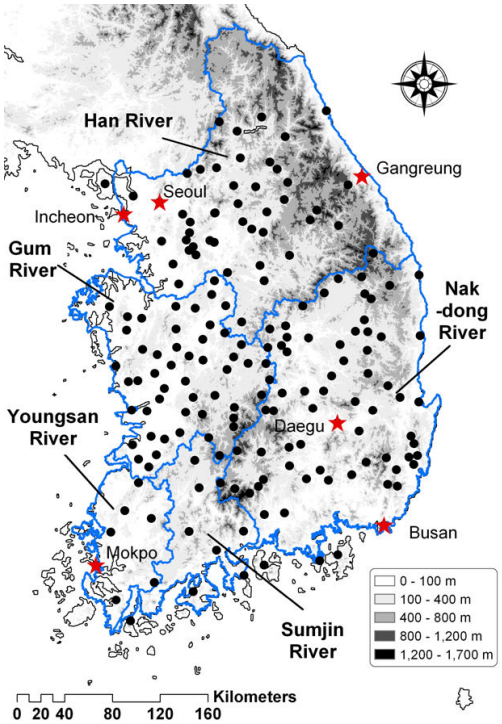
- Infrastructure needs to be adapted to the climate change through new design, construction, or rehabilitation methods.





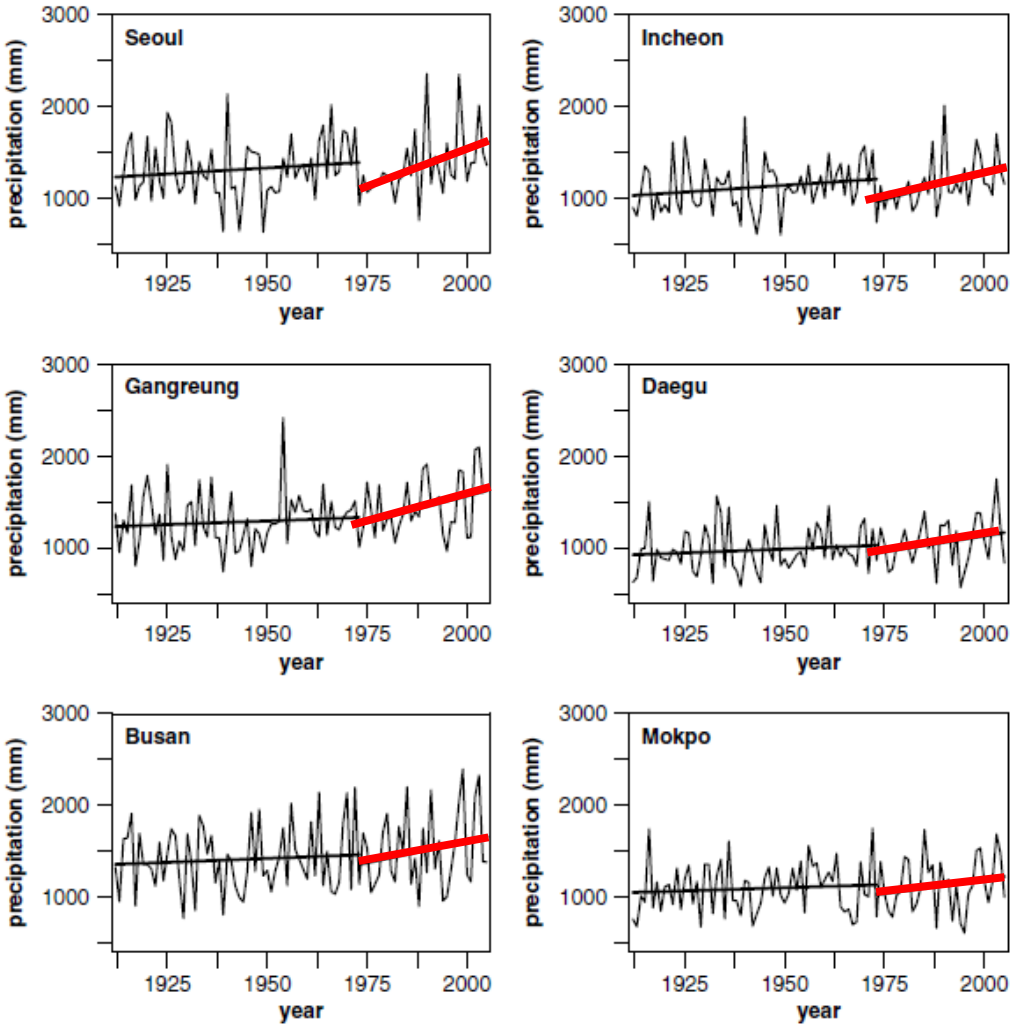
❖ Increasing annual precipitation

- **Change of annual precipitation : 1,274mm/year to 1,441mm/year (13% increase) during last 10 years**



183 weather stations

1910-2005

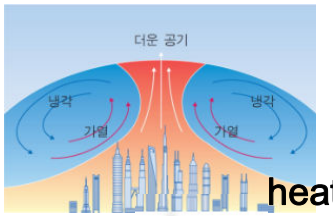


Source: Bae et al., (2015)

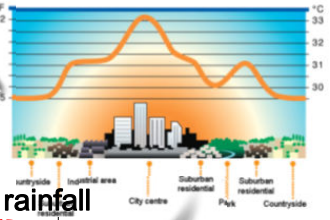
❖ Urban disaster risk due to urbanization

- Heavy rainfall (increases of frequency and intensity)
- Increased runoff and reducing arrival time
- Disaster risk increases with high densities of population and property

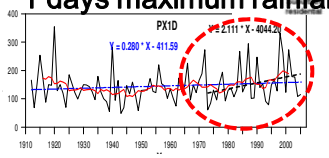
Increase in frequency and intensity



Urban heat island effect

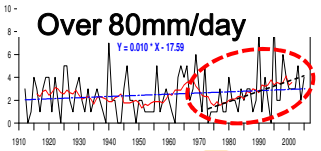


1 days maximum rainfall

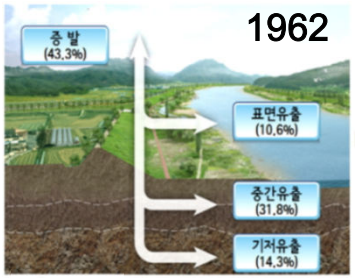


Urban Heavy rainfall

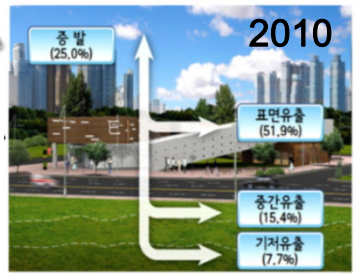
Over 80mm/day



Increased runoff

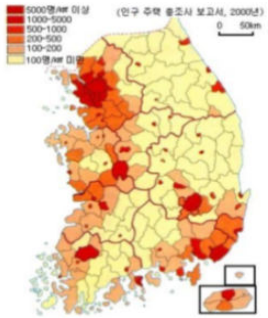


Increased runoff



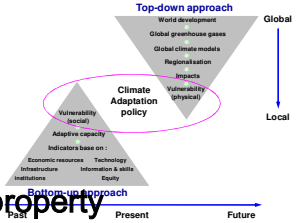
(Seoul city hall, 2013)

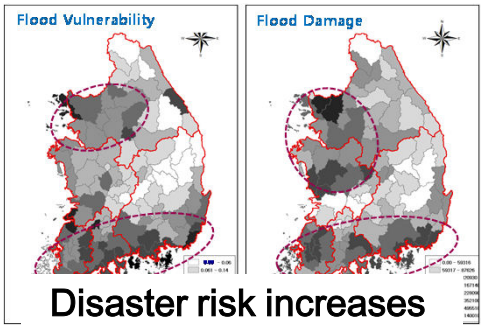
Disaster risk increases



High densities of population and property

Risk assessment





Disaster risk increases

❖ Chronicle of climate change induced urban disaster in Korea

- The frequent occurrence of extreme events such as flood and drought



Seoul
Heavy rainfall



Busan
Typhoon “Maemi”



Seoul
Typhoon “Ewiniah”

2001~2002 | 2003~2004 | 2005~2006 | 2007~2008

Busan
Typhoon “Rusa”



Busan
Typhoon “Navy”



Jeju island
Typhoon “Nari”





Busan
Heavy rainfall



Ulsan
Typhoon “Sanbi”



Busan
Heavy rainfall

2009~2010

2011 ~ 2014

Seoul
Heavy rainfall



Seoul
Heavy rainfall, landslide





❖ Adaptation under climate change in urban areas

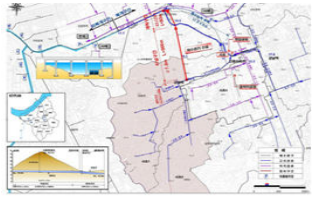
- Risk assessment and climate change impacts analysis for flood defense structures, slope structures, underground structures are needed
- It requires appropriate measures to reduce the damage of urban disaster

Flood defense structures

River bank



Sewer line



Rainfall storage



Water storage



Prevent water plate



Underground storage



Watershed storage

Slope management



Check dam



Mooring conservation

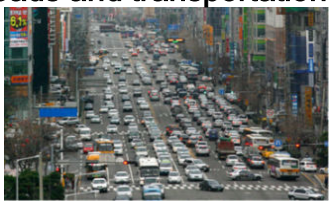


Urban structures

Water transport



Roads and transportation



Skyscraper

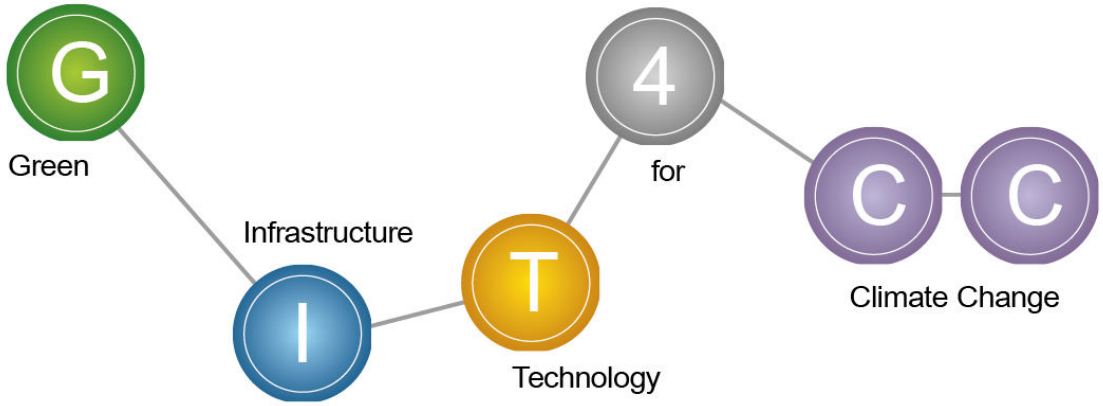


GIT4CC

Green Infrastructure Technology for Climate Change

Objective Adaptation technology development for civil infrastructure

Vision Multidisciplinary research in complex engineered materials, equipments, processes and systems to achieve national and international recognition for infrastructure adaptation technology.



Green : Green growth and sustainable development

Infrastructure : Civil infrastructure

Technology : Practical application of advanced technology

4(for)

Climate Change : Climate change adaptation

2 Objectives

YONSEI UNIVERSITY GIT4CC

Green Infrastructure Technology for Climate Change



Vulnerability assessment of infrastructures and development of core technology

Integrated information management system module, Design Standards, Legislation

Medium to long term adaptation technologies for climate change

3 Study Areas



3 Study Areas

Area I

- **Climate and hydrological models** for infrastructure design
- **Adaptation strategies** from planning and management perspectives

Area II

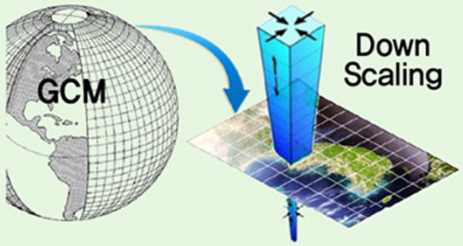
- **Disaster** prediction and prevention methods
- **Adaptive engineering design** for climate changes
- **New construction materials** for extreme weather conditions

Area III

- **Urban hydro-ecology** for climate adaption
- **Coastal management** for sea level rise
- **Water** reuse and rainwater management

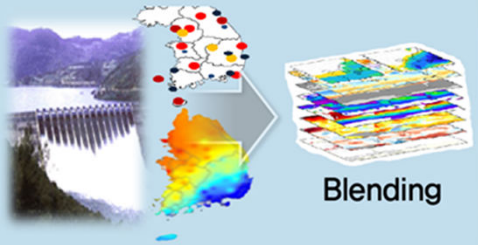
Area I

Area I-1



- Climate scenario for Korea
- Hydrological model for infra design

Area I-2



- Integration of climate model and measured data
- Standardized design parameters

Area I-3



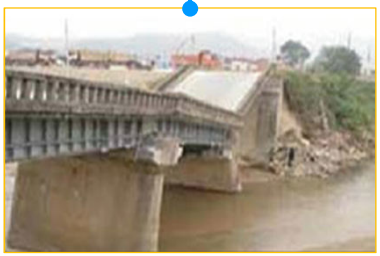
- Probabilistic LCC evaluation
- Adaptation strategies

Infrastructure Adaptation Framework

Area II

Adaptation technologies

for the weakest fields of infrastructure in climate change

Slope failure prediction for natural disaster	Sustainable geotechnical design	Concrete in extreme weather	Slimming technology	Porous pavement technology & Sidewalk block system
				

Core Adaptation Technologies

Area III

Urban hydro-ecology improvement	Costal management for sea level rise	Water reuse and rainwater management
• Bio-swale • Bio-barrier	• Costal erosion prediction • Submerged structure for prevention of the erosion	• New organic based water quality indicators

Regenerative water resource and environmental technologies







4 Flow chart of research collaboration

Engineering parameters based on climate change scenarios

1 Core technology	▪ Development of core technologies in each area ▪ Development of water/environmental technologies
2 Assessment of the economic value	▪ Technology assessment and economic analysis ▪ Economic assessment for climate change strategies
3 Integrated management system	▪ Urban landslide and drainage management ▪ Joint research in various fields
4 Design manual	▪ Amendment of design criteria ▪ Design manual (adaptation to climate change)

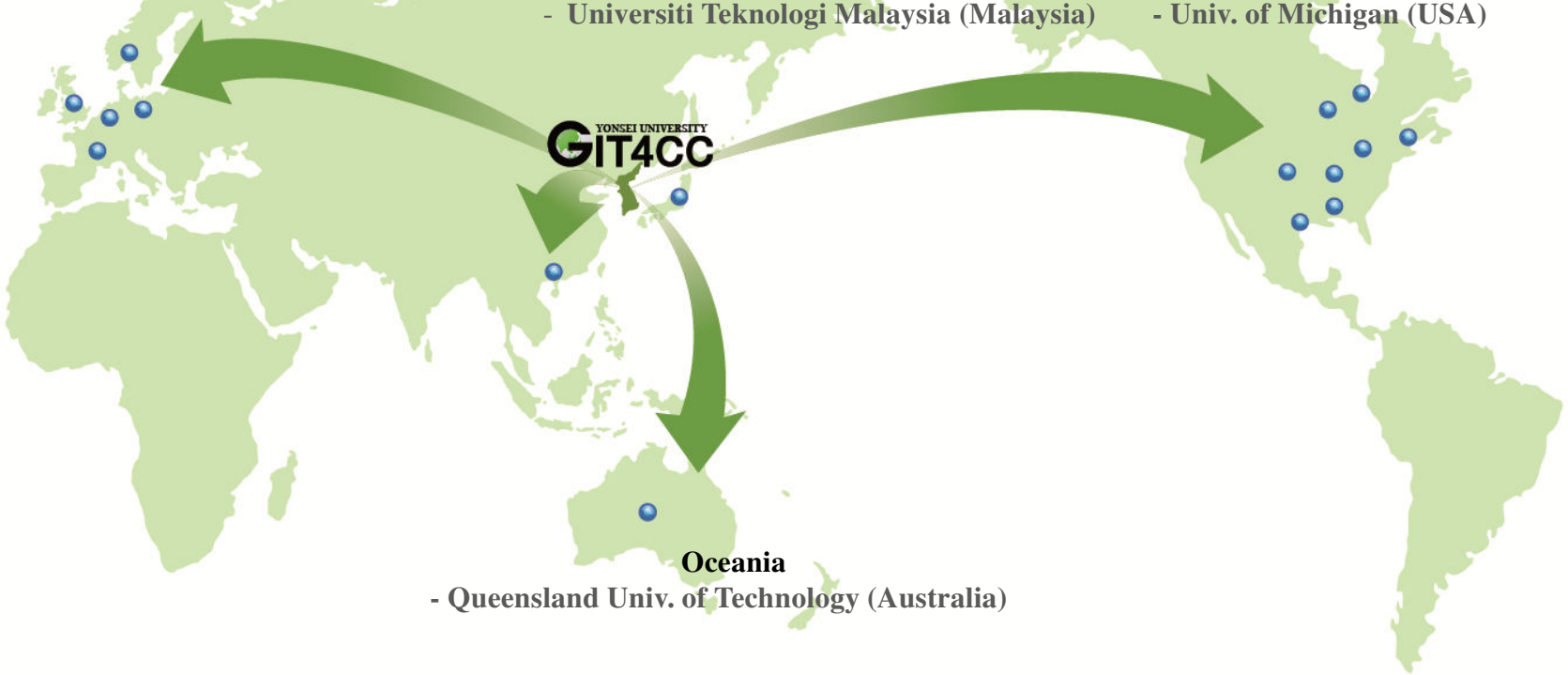
Proactive climate change adaptation of infrastructure

International Research

European
- Norwegian Geotechnical Institute (Norway)
- Delft Univ. of Technology (Netherlands)

Asia
- Univ. of Tokyo (Japan)
- Hong Kong Polytechnic Univ. (China)
- Universiti Teknologi Malaysia (Malaysia)

North America
- Texas A&M Univ. (USA)
- George Washington Univ. (USA)
- Univ. of Michigan (USA)



Oceania
- Queensland Univ. of Technology (Australia)

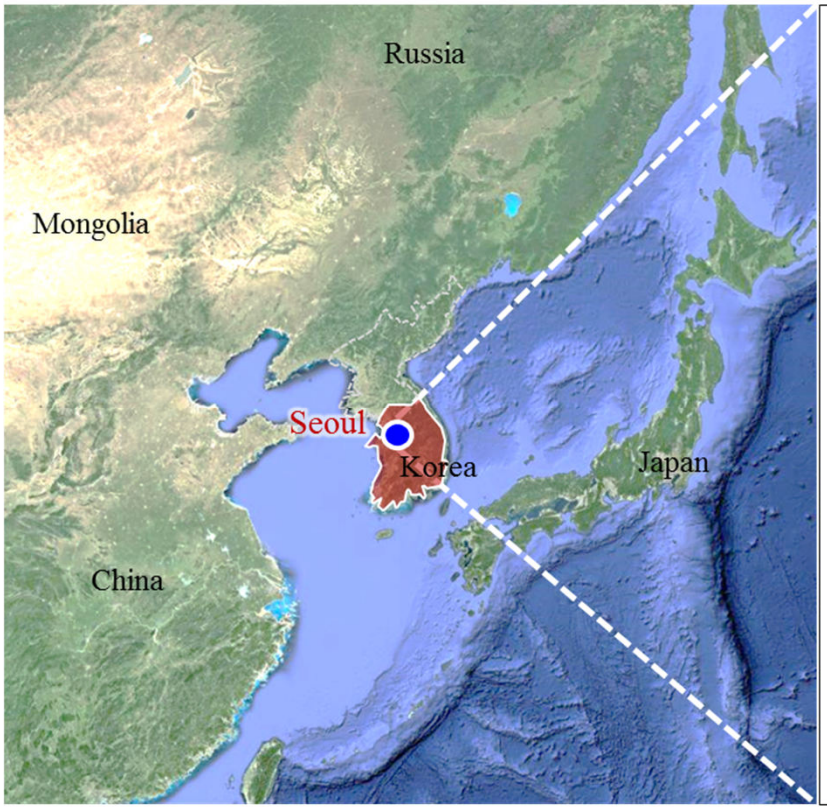


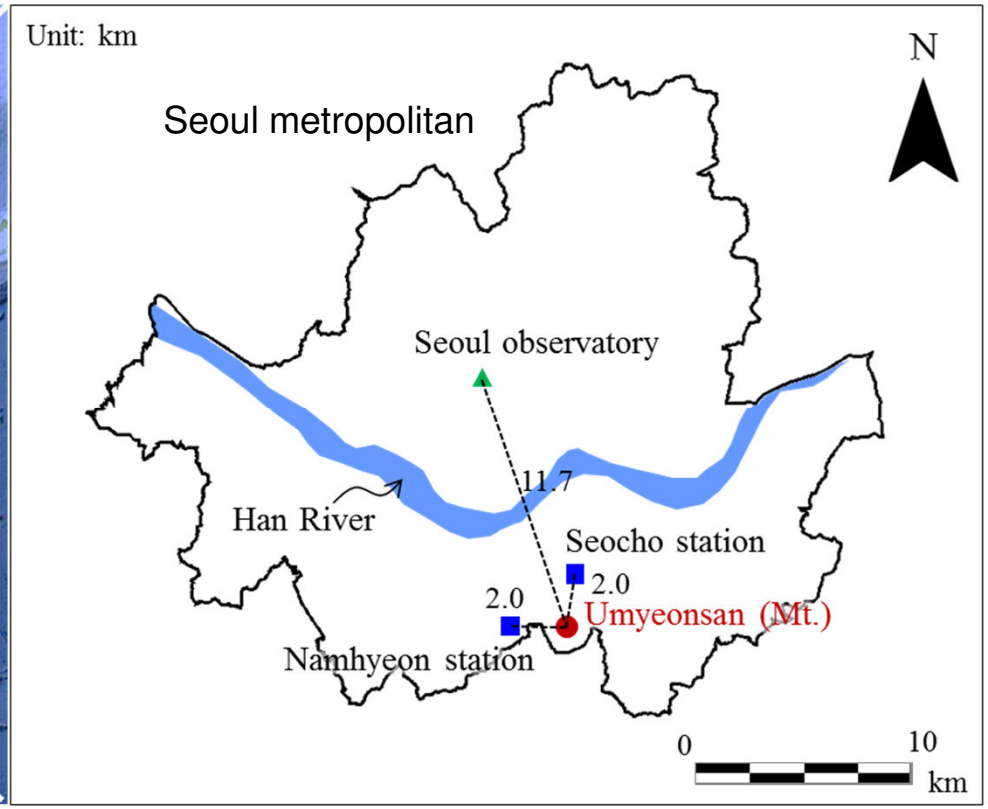
Climate Change-induced Geo-disaster

1. A case study on Umyeonsan (Mt.) landslides analysis in Korea
2. Result and discussion

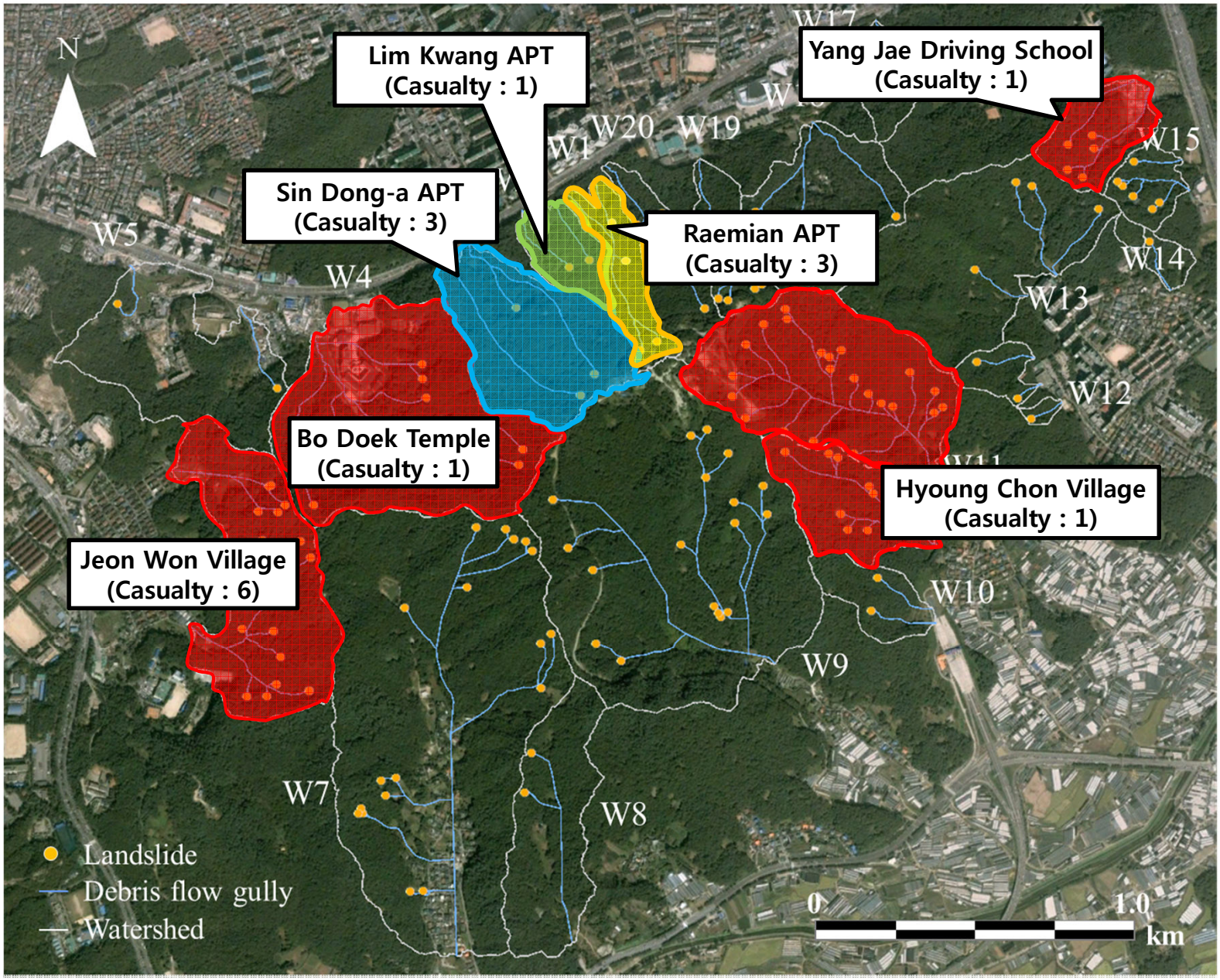
1 A case study on Umyeonsan (Mt.) landslides analysis in Korea

❖ Umyeonsan (Mt.) landslide in July 2011



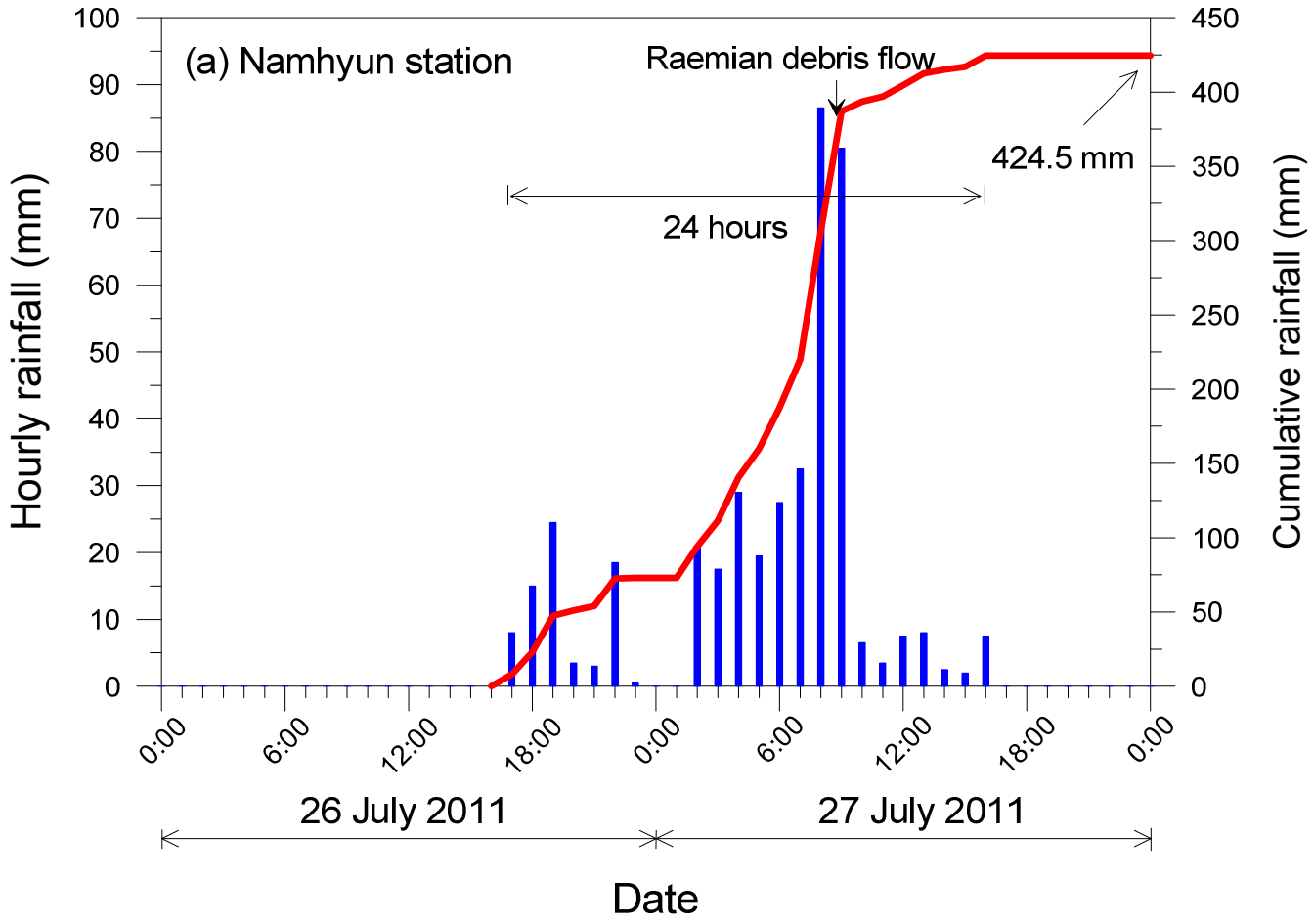


- ✓ Umyeonsan(Mt.) is located in **south-east of Seoul**
- ✓ **151 landslides** and **33 debris flows** occurred in 20 watersheds
- ✓ The accumulated rainfall of **24-h was 424.5 mm**.



- **151 landslides, 33 debris flows, 16 casualties**

❖ Rainfall characteristics



1) The **accumulated rainfall of 24-h** was **424.5 mm**, which is very heavy rainfall.

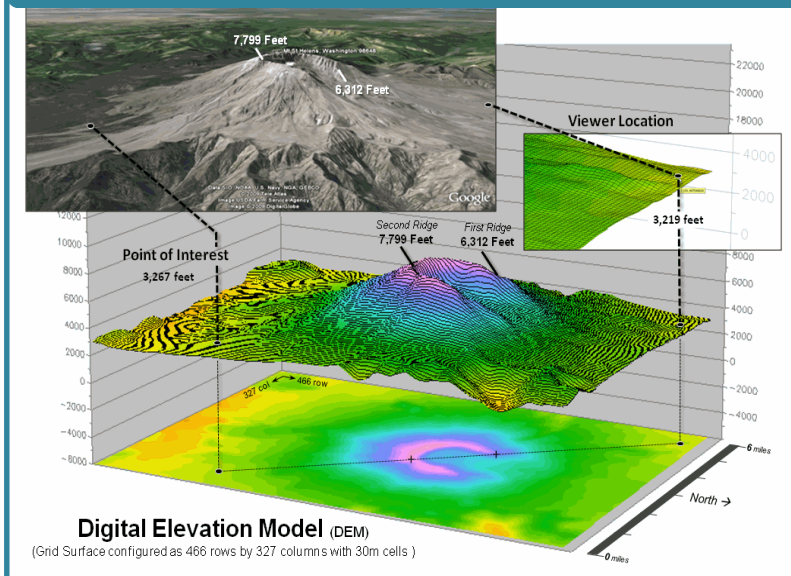
2) The **1-h rainfall** between 7:40 and 8:40 am was the most severe, corresponding to **return period of > 120 years**.

(Jeong et al., 2015, Landslide)

2 Result and discussion

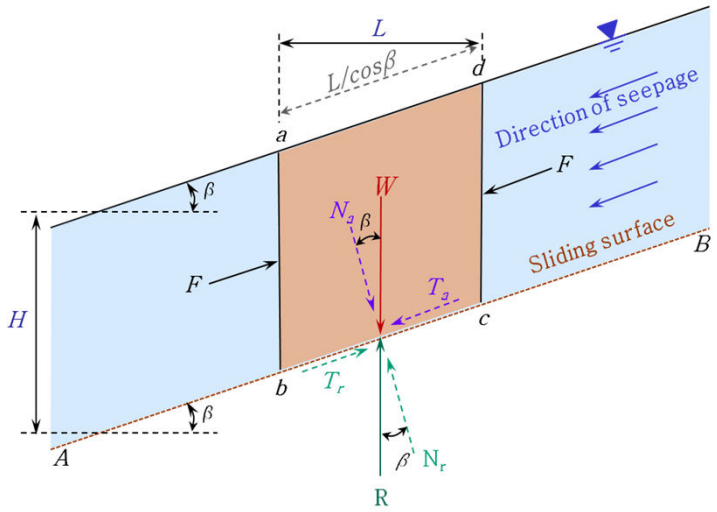
❖Regional scale analysis

3D Spatial Data



- Topography: Slope, slope direction
- Hydrology : Precipitation data
- Spatial data : Soil and forestry

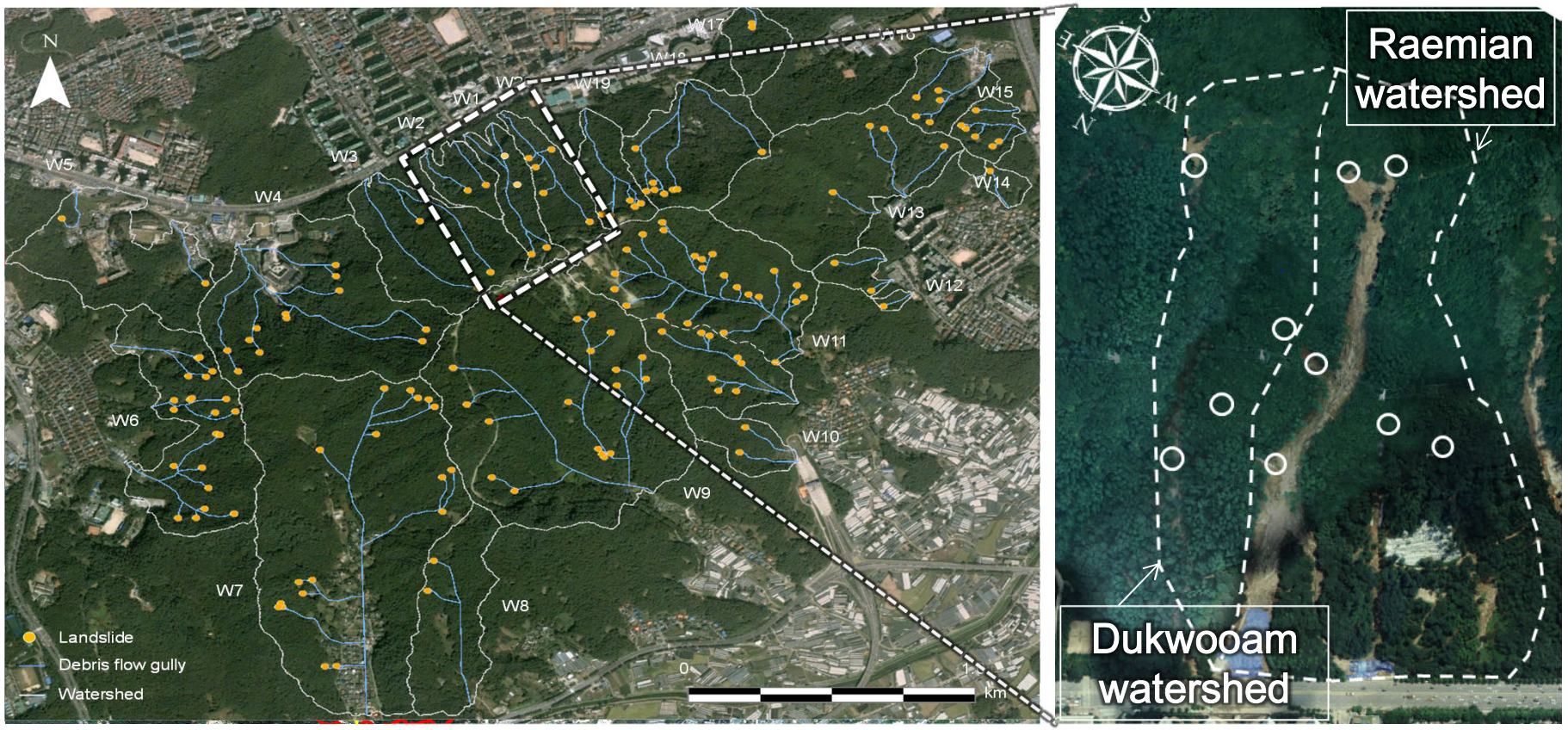
Physical Model



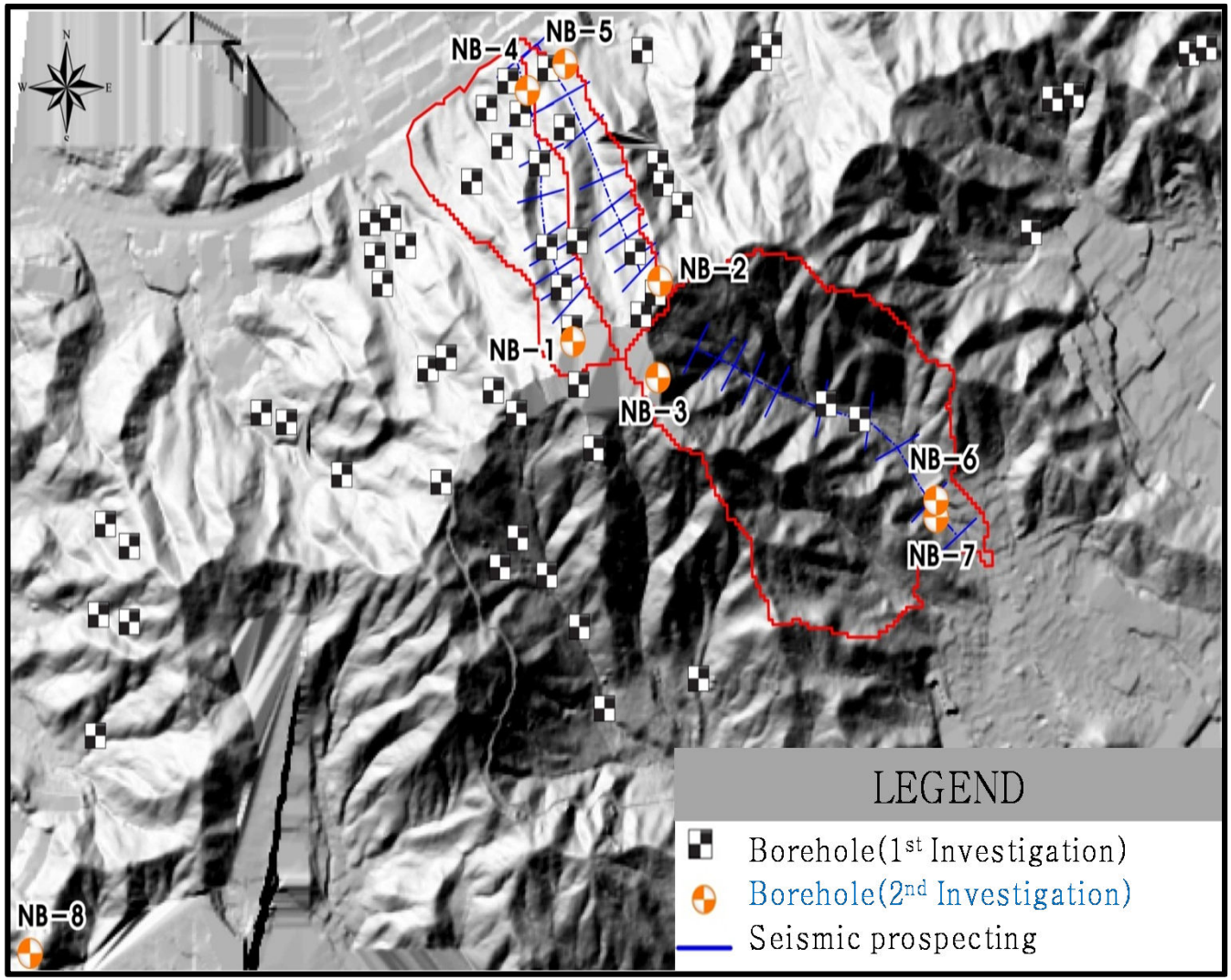
- Geotechnology: Unsaturated soil
- Infiltration : Modified G-A Model
- Failure model : Infinite slope model

Experimental tests and suction monitoring

- ✓ Test site located in **Umyeonsan (Mt.)**
- ✓ Landslides in **Ramian watershed** : **6** locations
- ✓ Landslides in **Dukwooam watershed** : **4** locations

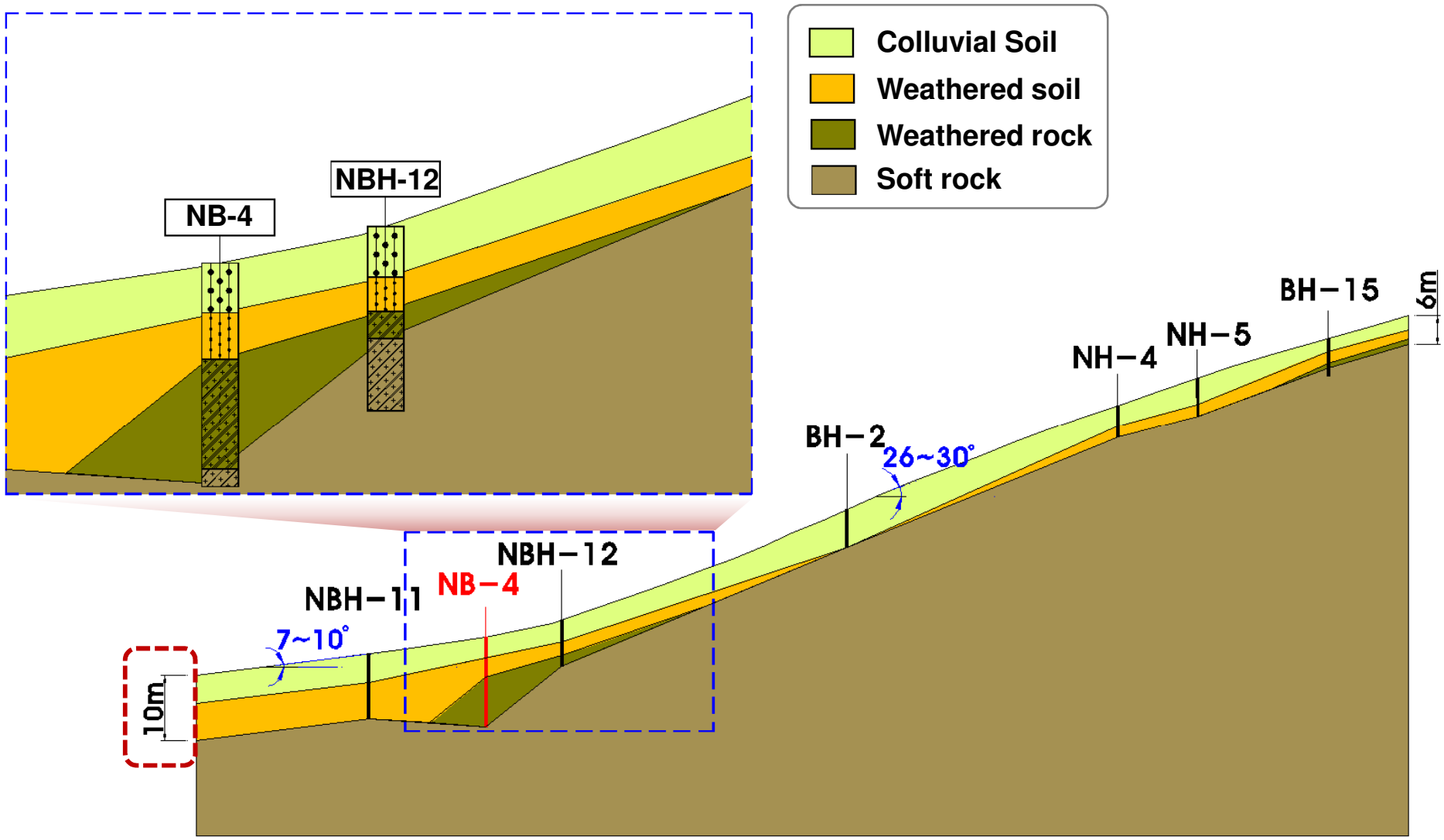


Site investigation

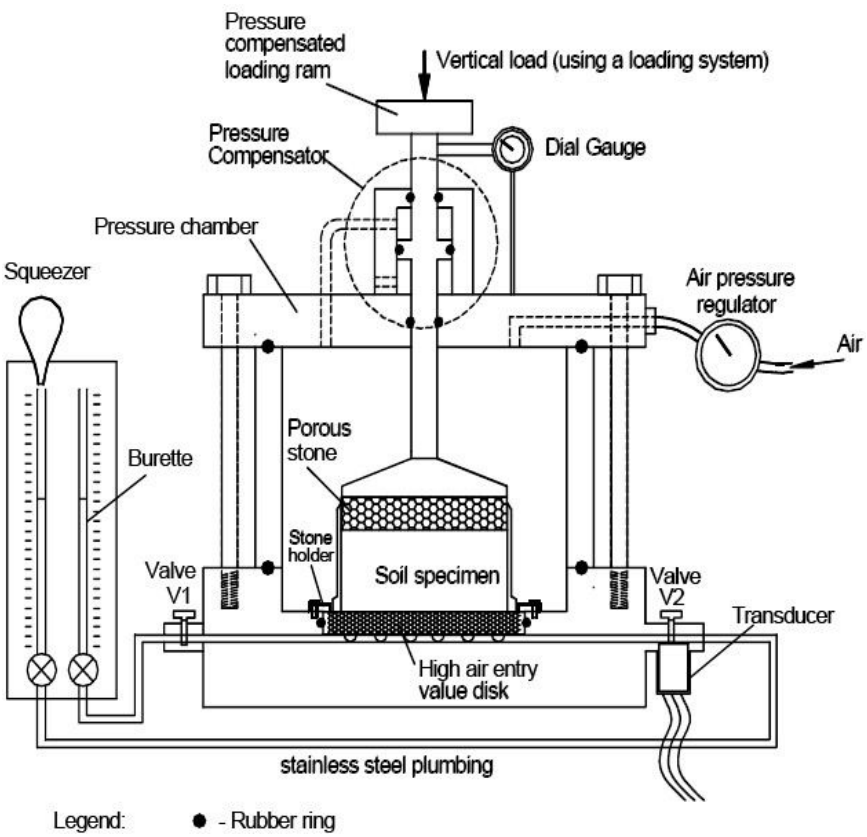


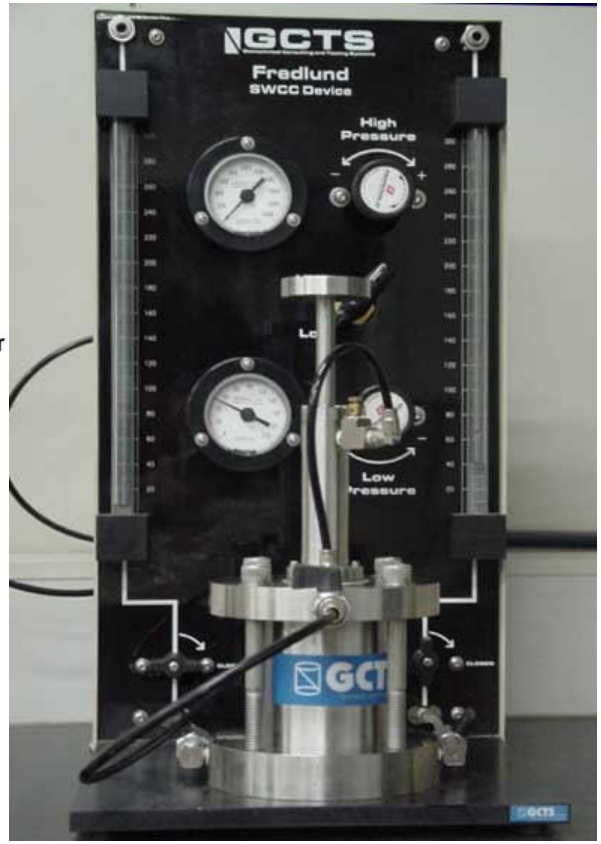
- Seismic Prospecting
- In-Situ Permeability
- SWCC
- Borehole Shear Test
- Direct Shear Test
- SPT

Typical soil profile



Soil-water characteristic curve (SWCC)





The GCTS pressure plate apparatus (Fredlund and Rahardjo, 1993)

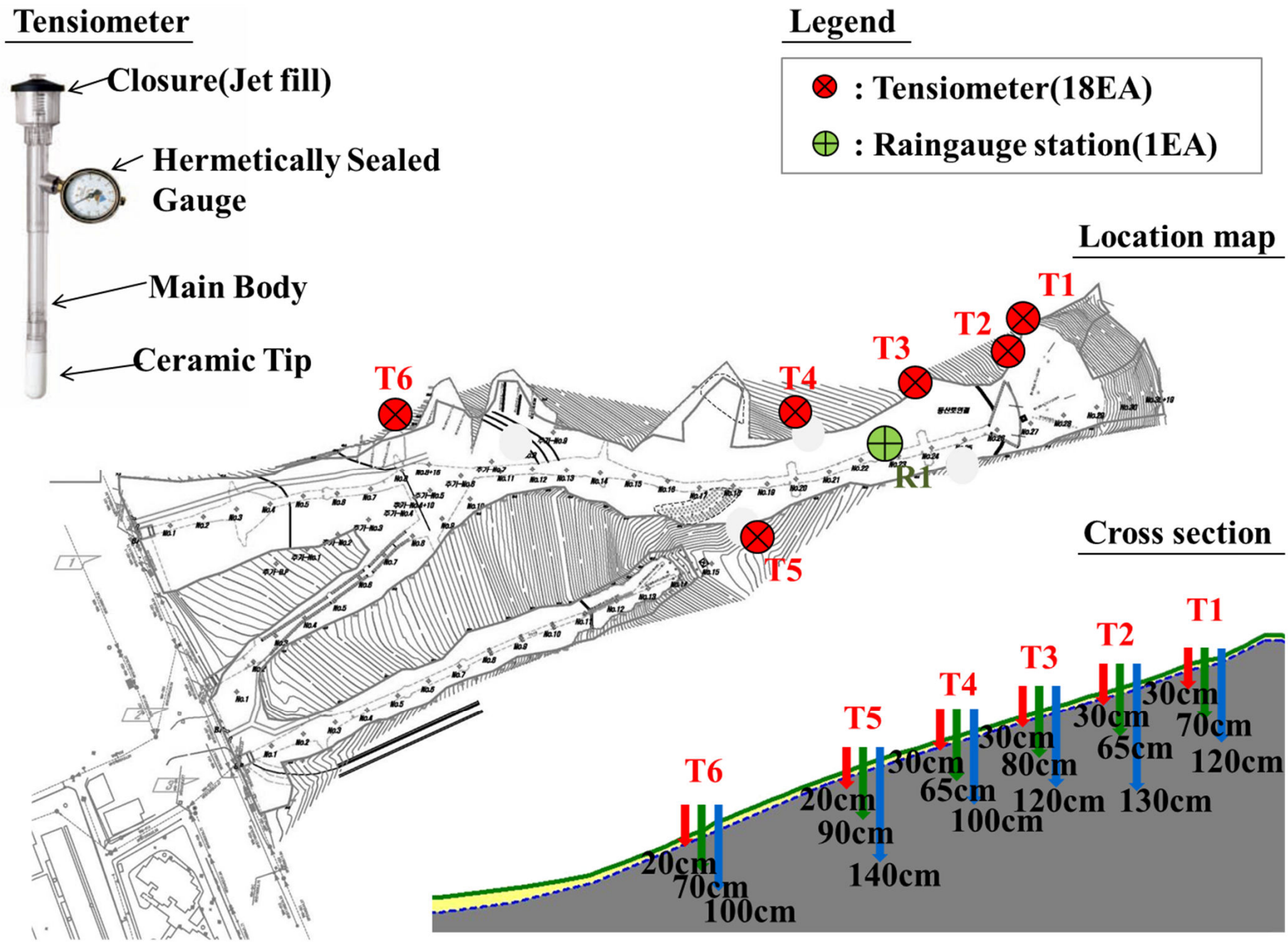
Matric suction monitoring



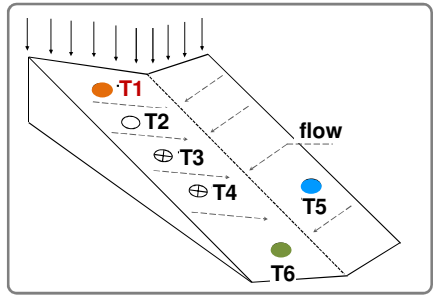







Tensiometer
Closure(Jet fill)
Hermetically Sealed Gauge
Main Body
Ceramic Tip
Legend
: Tensiometer(18EA)
: Raingauge station(1EA)
Location map
T1
T2
T3
T4
T5
T6
R1
Cross section
T1
T2
T3
T4
T5
T6
30cm
70cm
120cm
30cm
65cm
130cm
30cm
80cm
120cm
30cm
65cm
100cm
20cm
90cm
140cm
20cm
70cm
100cm

1) Matric suction of dry soil



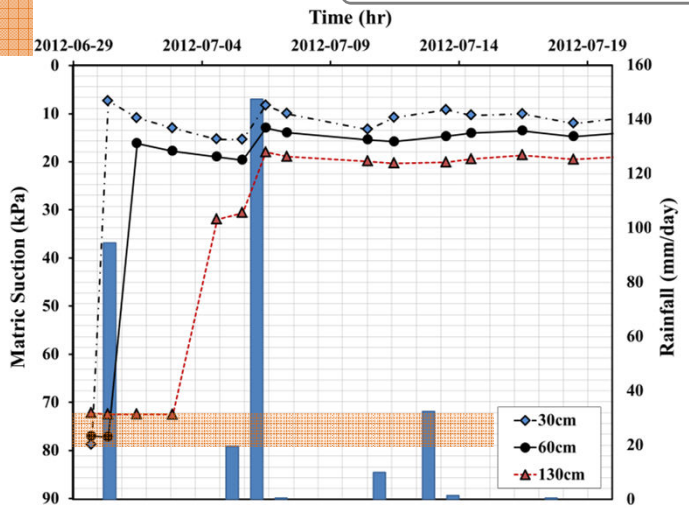
→ **80kPa**

T1 = 72~80 kPa

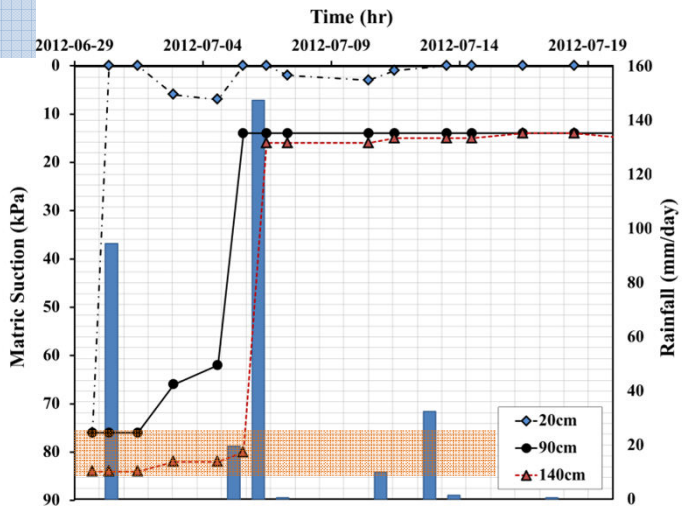
T5 = 75~85 kPa

T6 = 74~88 kPa

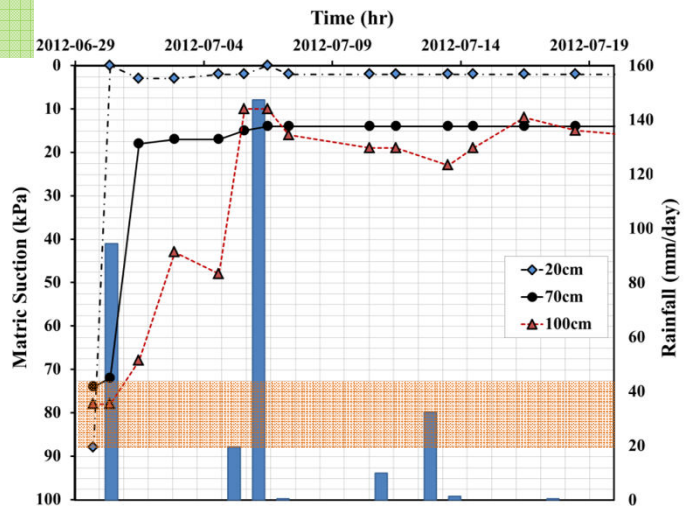
T1



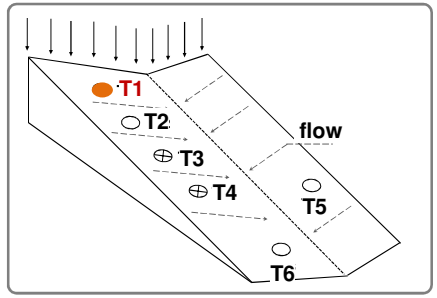
T5



T6

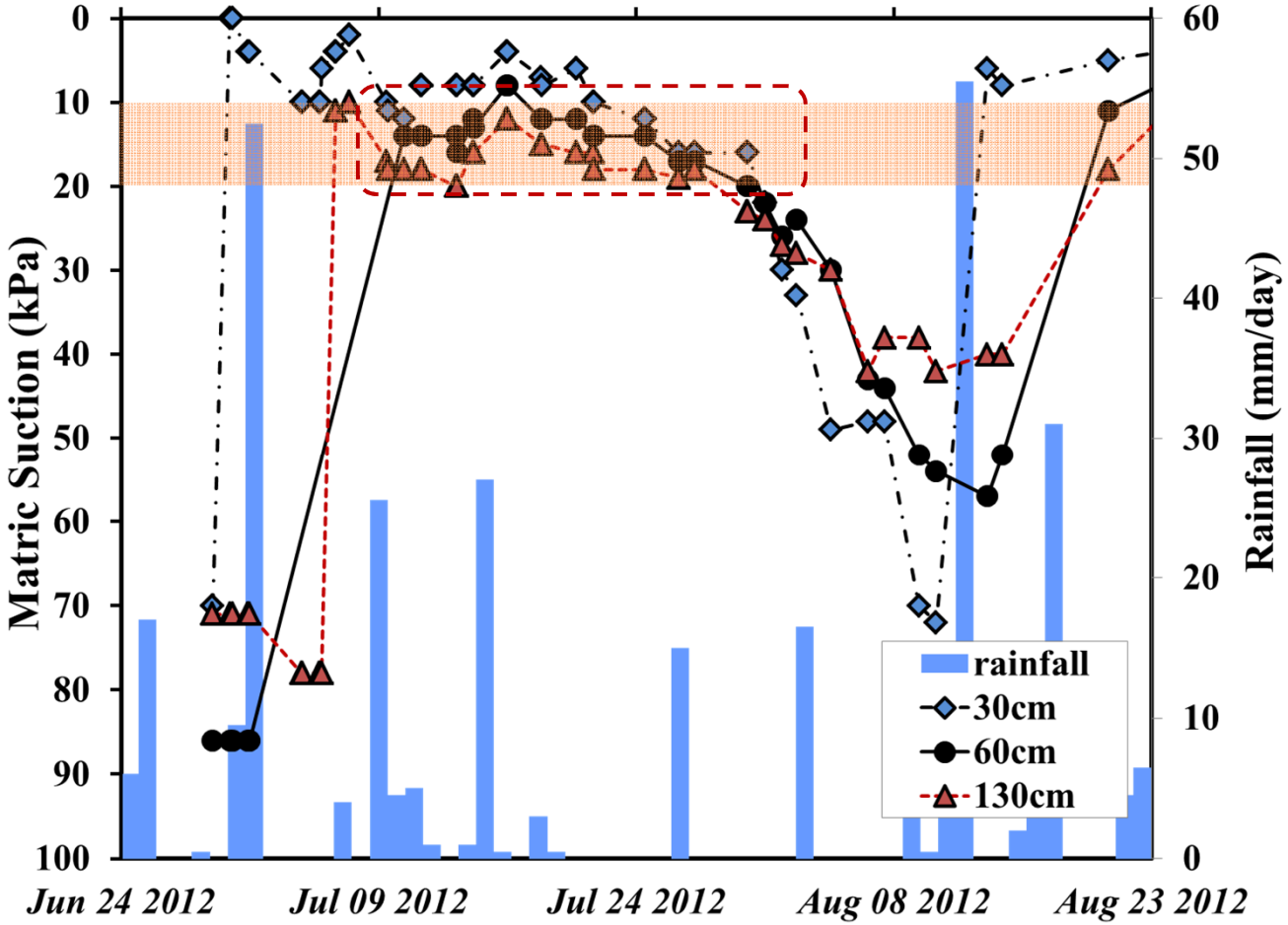


2) Matric suction of unsaturated soil



→ 20 kPa (in rainy season)

T1



Soil property and depth

❖ Soil Property

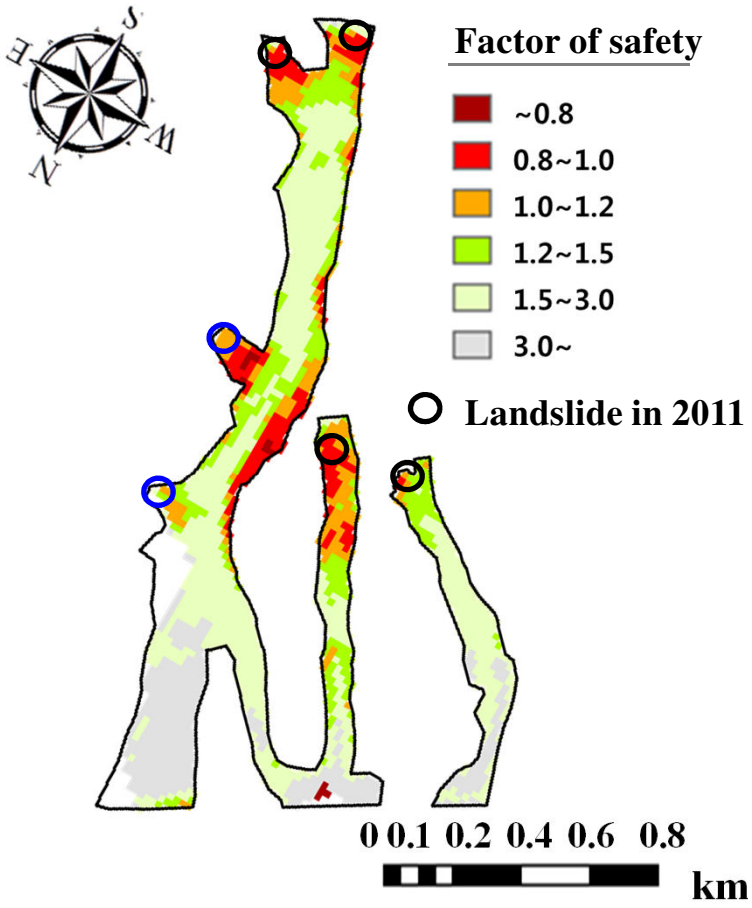
Parameters	Values
Hydraulic conductivity	**8×10^{-4} cm/sec** (28.8 mm/h)
Initial water contents	32.0~28.0 (**30.0**) **%**
Water-content deficit	**0.20**
Wetting front suction head,	**830mm**
Soil cohesion	10.2~12.8 (**11.0**) **kPa**
Soil friction angle	22.4~26.6 (**26.5**) °
Unit weight	17.0~18.5 (**18.0**) **kN/m³**

❖ Soil Depth

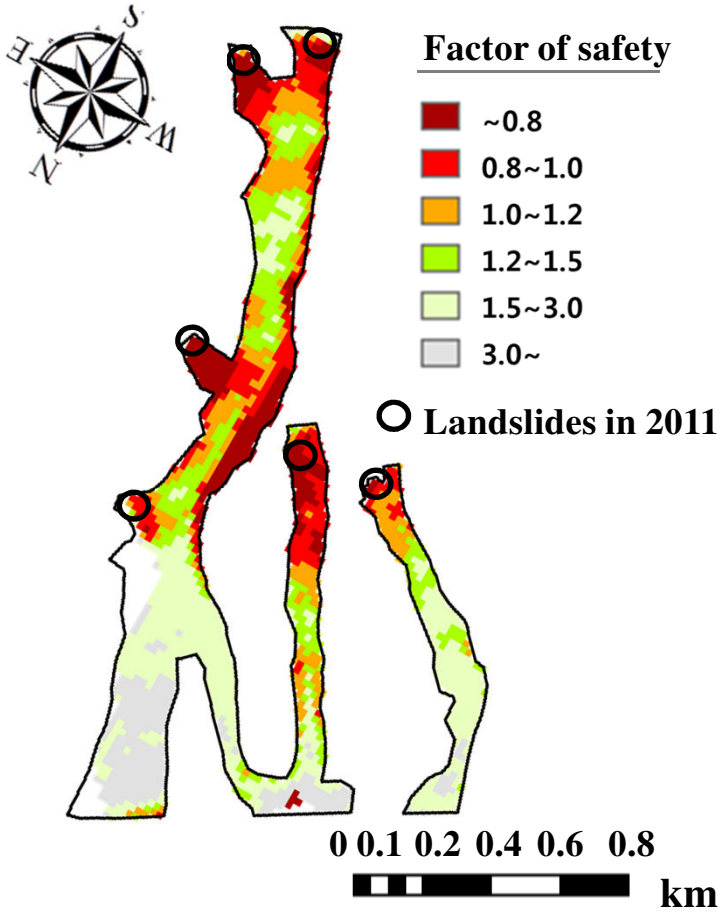
- **Raemian valley :** 4.0~10.0 m
- **Dukwooam valley :** 2.1~7.5 m

❖ Raemian watershed

Type 1- Shallow failure



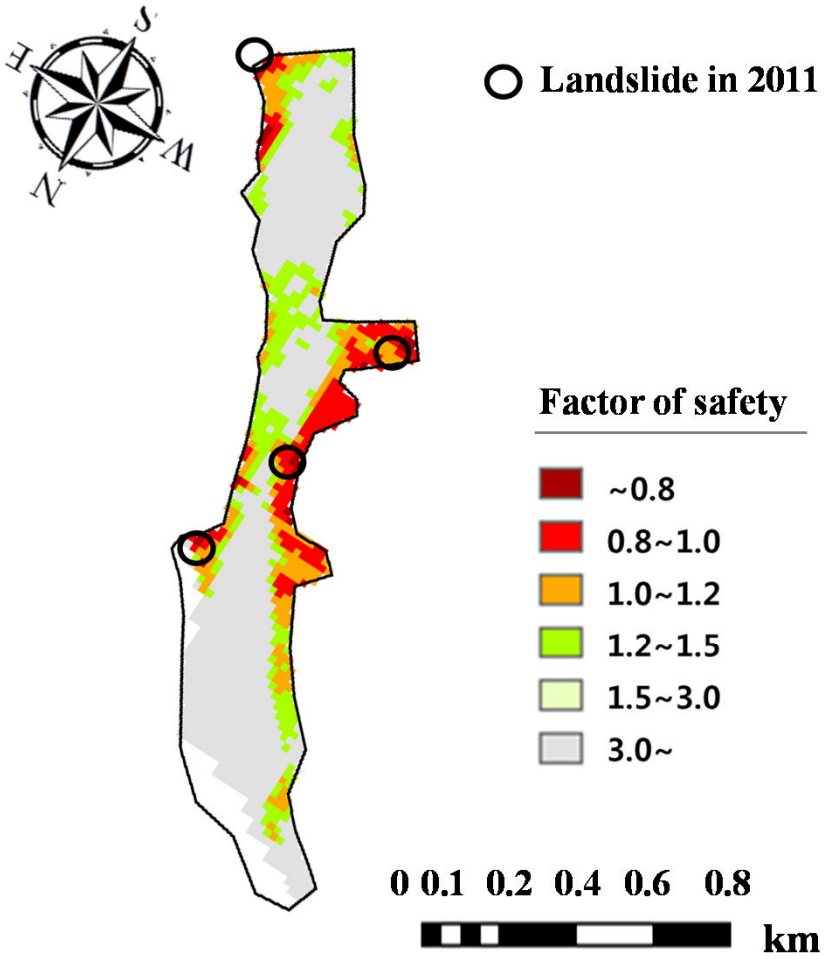
Type 2- Deep failure



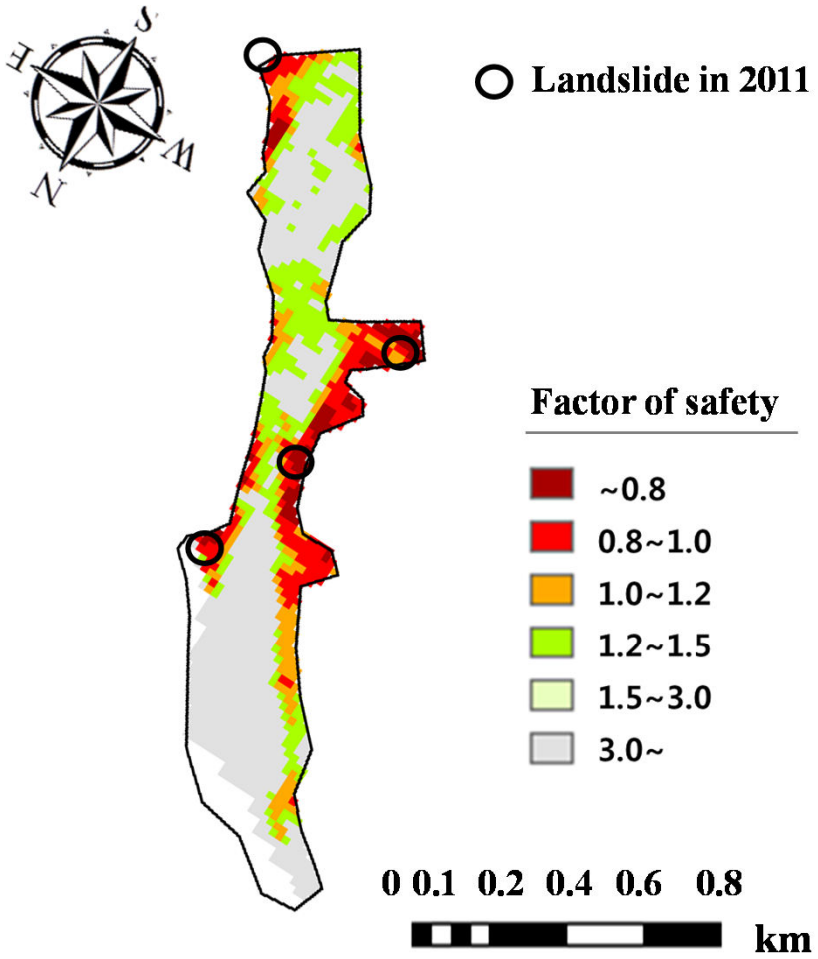
- ✓ **Type-1** agreed **4** landslide observations
- ✓ **Type-2** agreed with **all** of landslide observations

❖ Dukwooam watershed

Type 1- Shallow failure



Type 2- Deep failure



✓ **Type 1 and 2** agreed with **all** of landslide observations

Conclusions

- Extreme events like landslides, flooding, and drought related to civil engineering are caused by climate change.
- Damage to Infrastructures is highly influenced by severe rainfall and hot temperature. It is expected to guide decision making in prioritizing the most cost-effective adaptation strategies for infrastructure.
- Performing joint projects on climate change impact assessment and adaptation strategies in several countries. Sharing the ideas for design rainfall and their hydrologic and geotechnical analysis.



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