Resilience Smart City

for Natural Disaster Risk Reduction and Climate Change

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Department of Civil Engineering, National Taiwan University

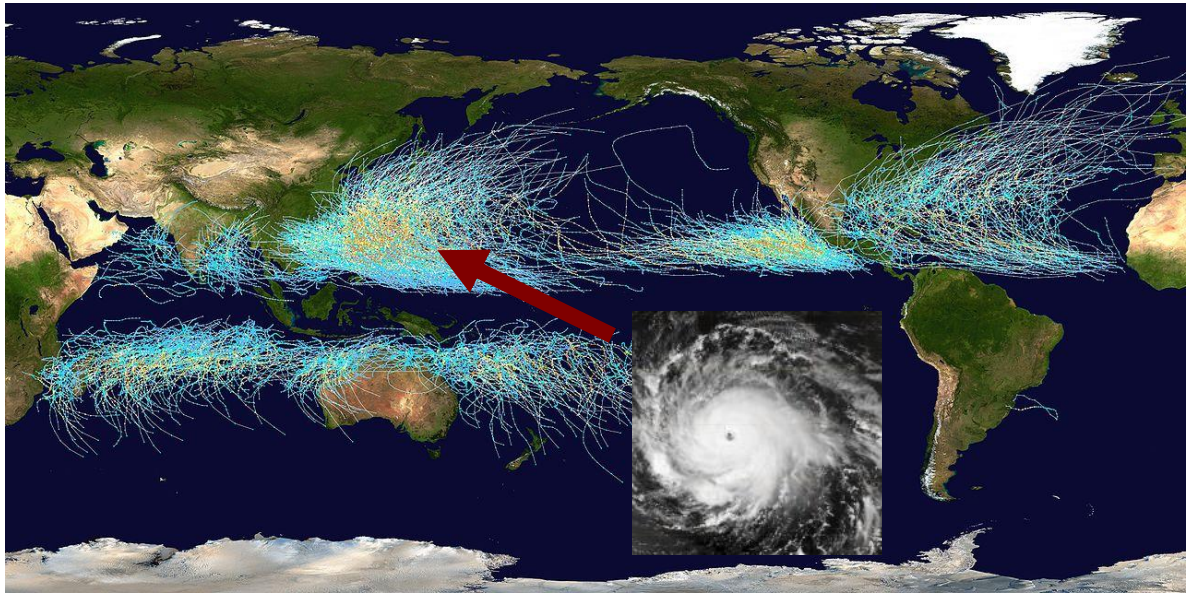
Extreme Flood n Germany

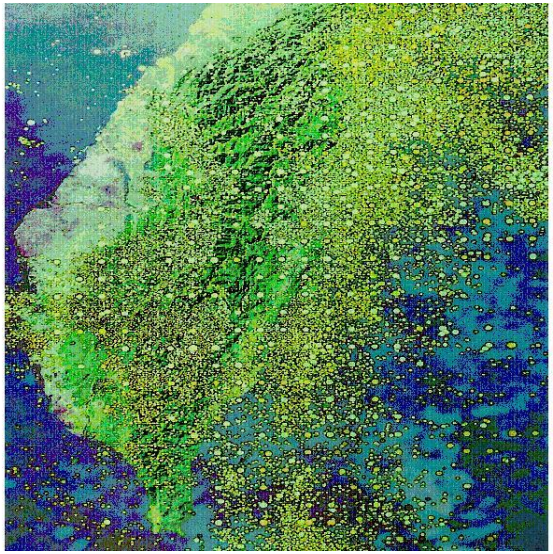
The New York Times reports that a number of meteorologists and German officials have suggested that flooding of this scale is a once-in-500 to once-in-1,000-year event. The extreme rainstorm in Germany is a clear example of global warming caused by greenhouse gas emissions and the resulting climate change, with studies showing that a warmer atmosphere carries more water and increases the incidence of heavy rainfall.

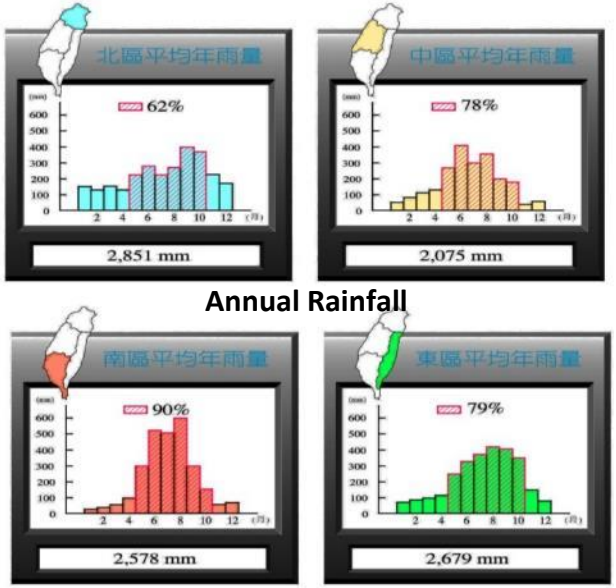
SOURCE: Maxar Technologies/Reuters Sky News

Extreme Flood in China

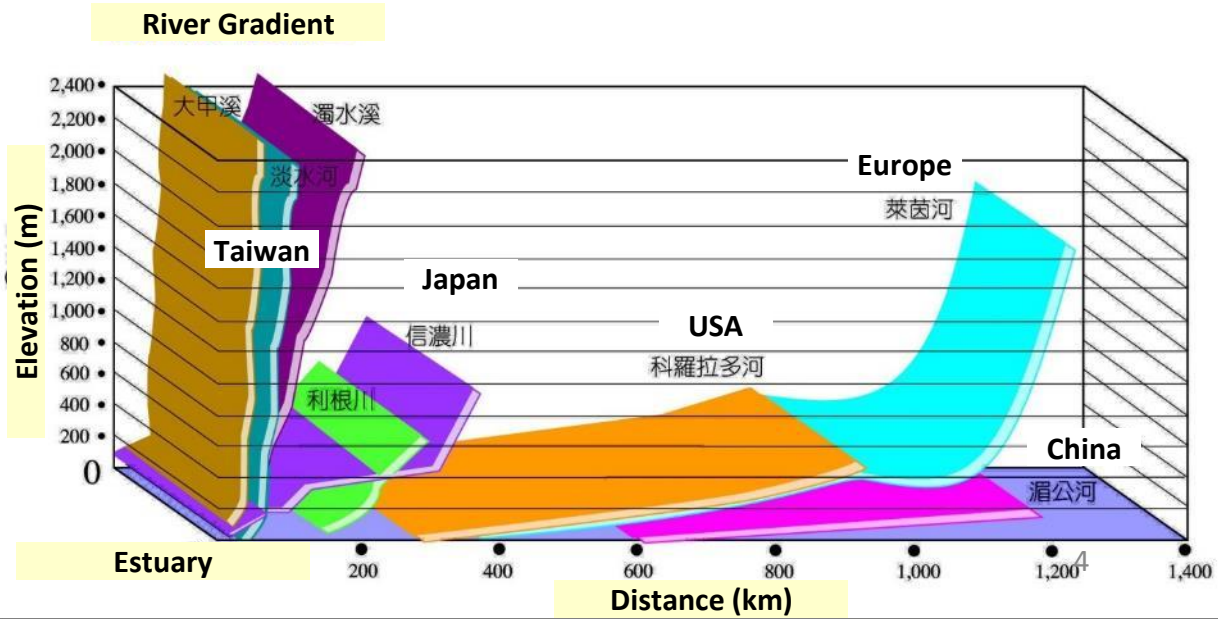
Highly exposed to multiple risks





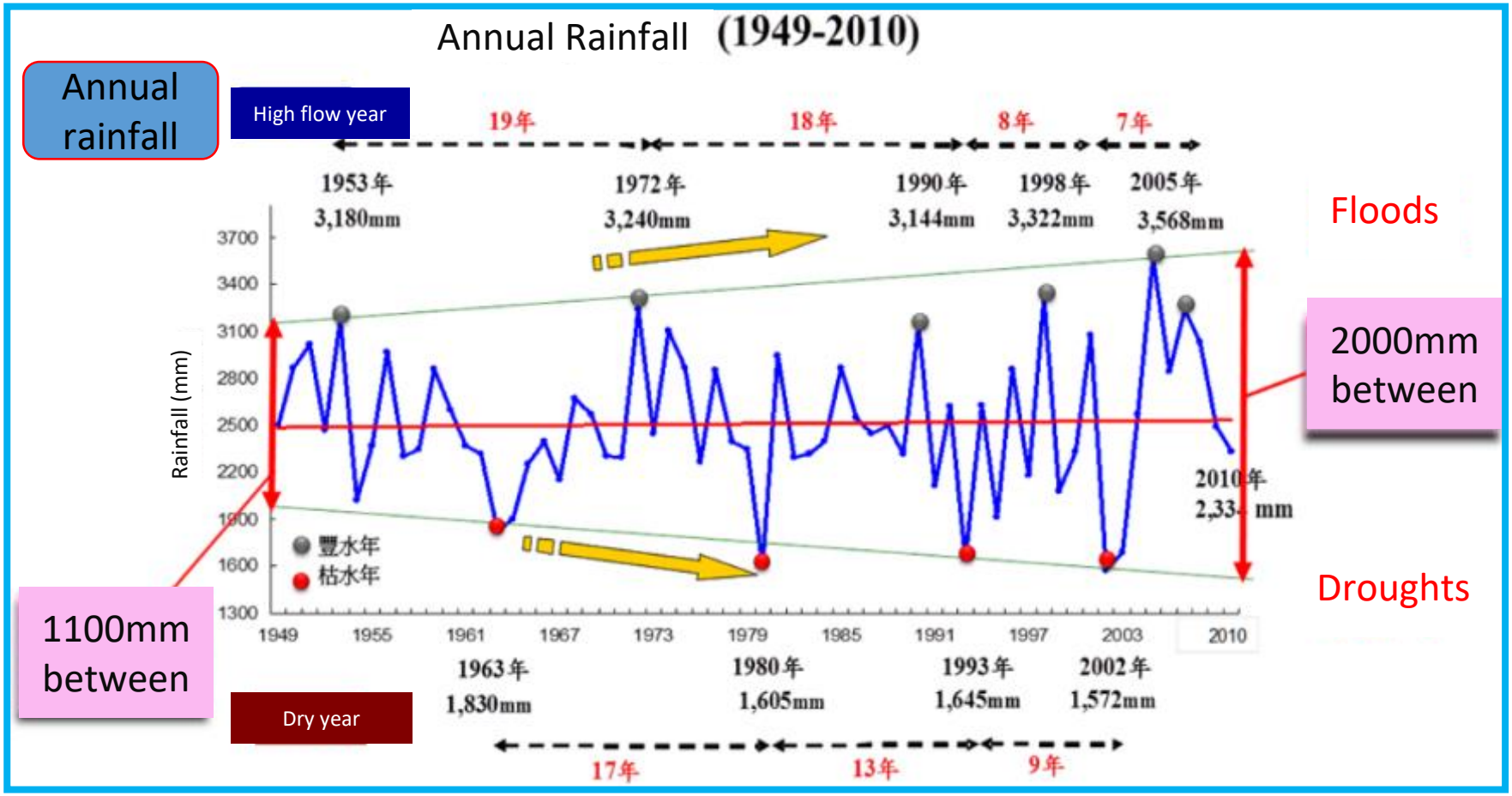


Annual Rainfall



Extreme events—Annual precipitation

Extreme events (heavy rain and drought) happen much more rapidly.



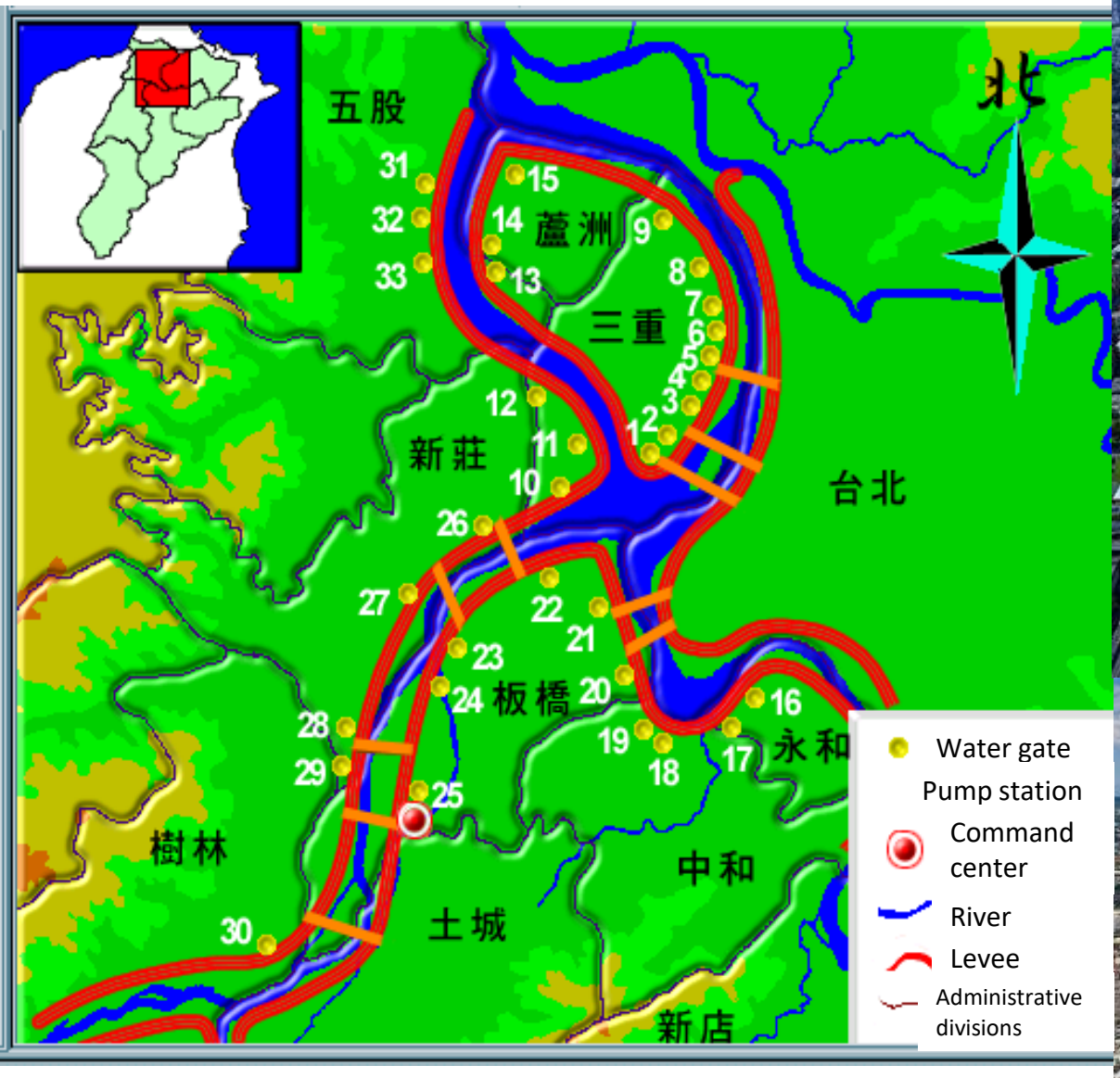
The risks associated with Taipei Flood Control System

The overall management involves 8 million people!!

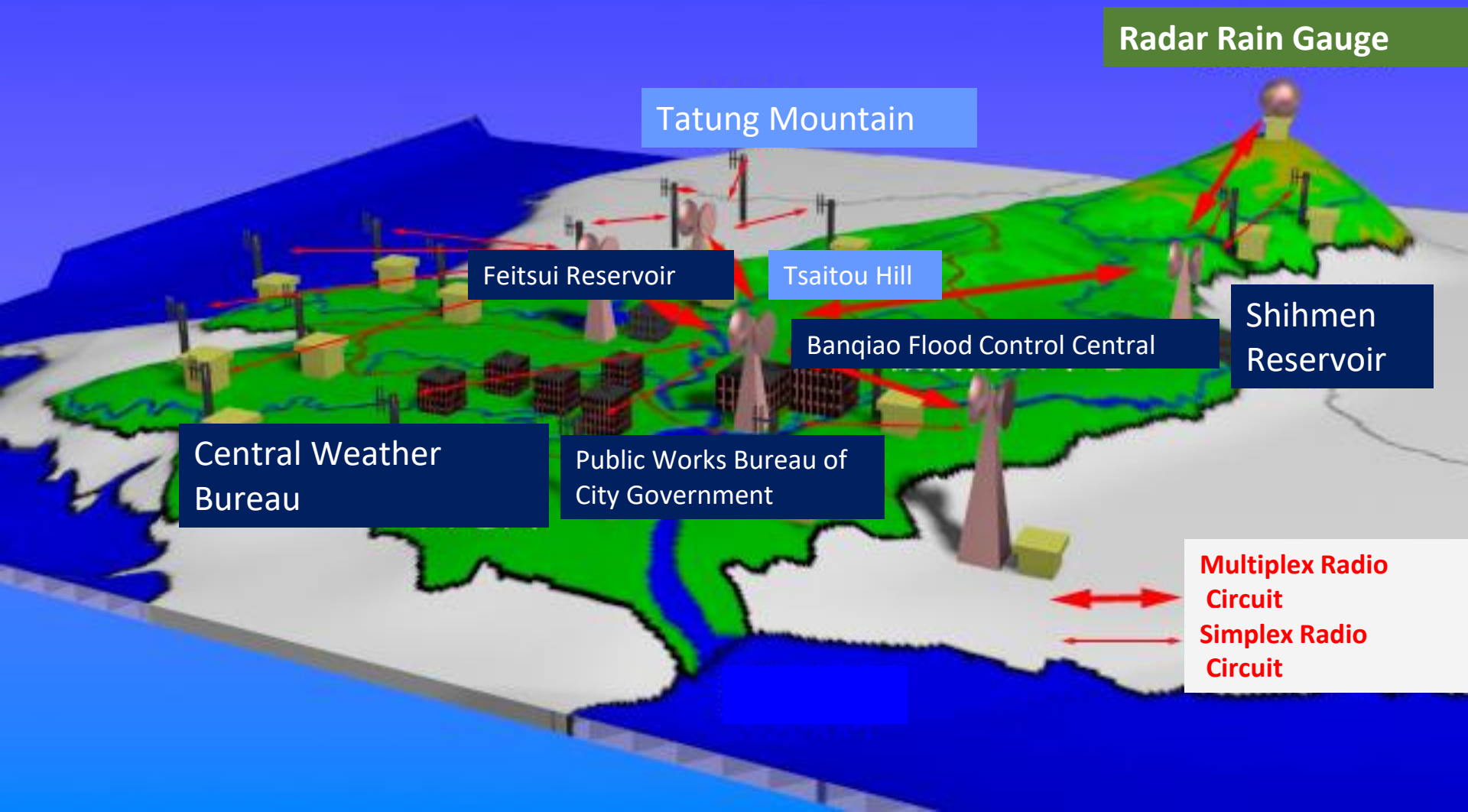
Population Density

- >20 thousands (people/km^2)
- >10 thousands (people/km^2)
- >5 thousands (people/km^2)
- >1 thousands (people/km^2)
- <1 thousands (people/km^2)

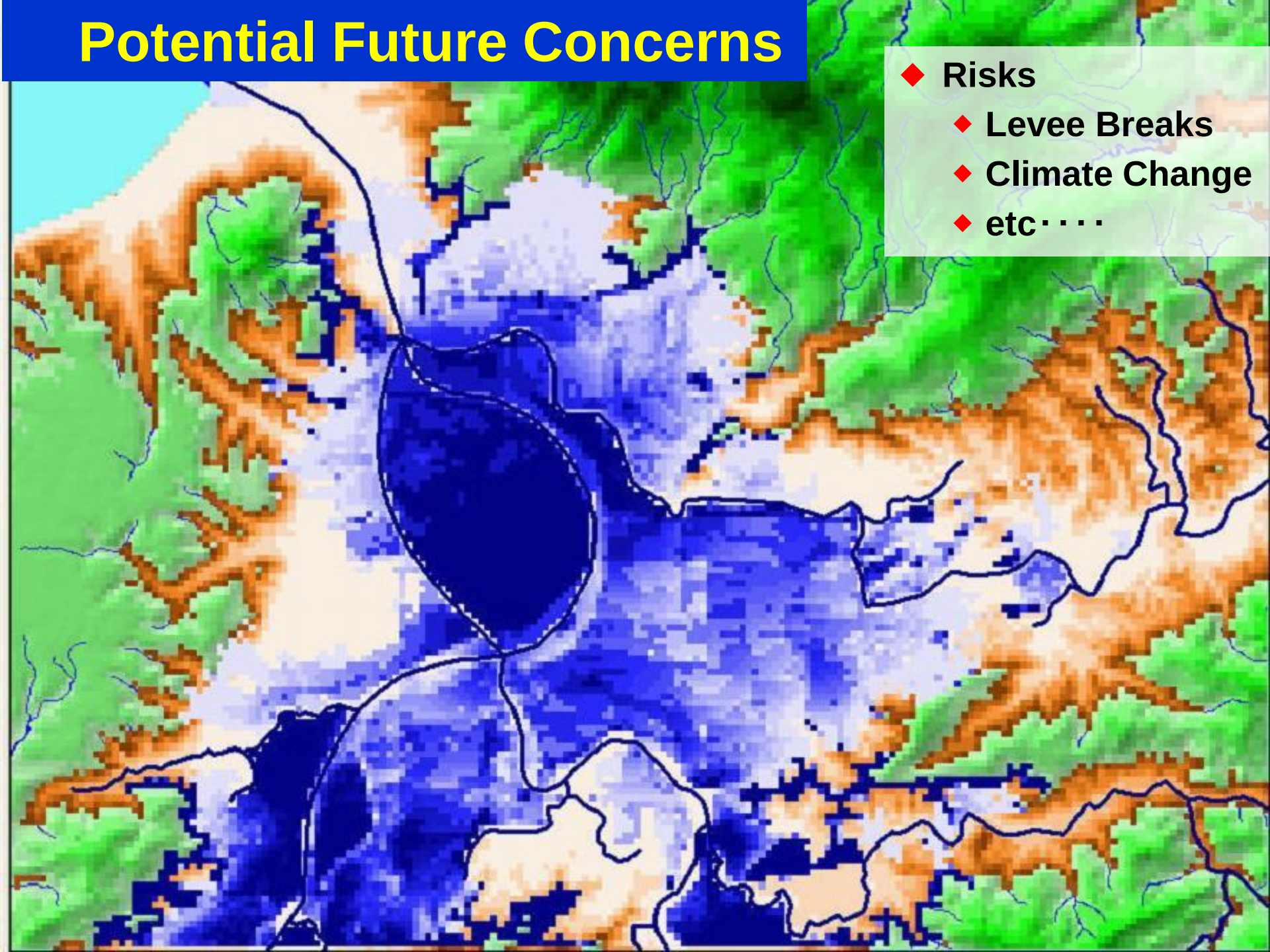
The Big Taipei Flood Control Planning from the "Engineering perspective"



The Outlook of Tamsui River Flood Forecasting System



Potential Future Concerns



- Risks
  - Levee Breaks
  - Climate Change
  - etc····

Typhhon Nari (2001) – Catastrophes in Northern Taiwan

Yongji Rd.

Keelung River Levee Failure

Taipei City MRT Station

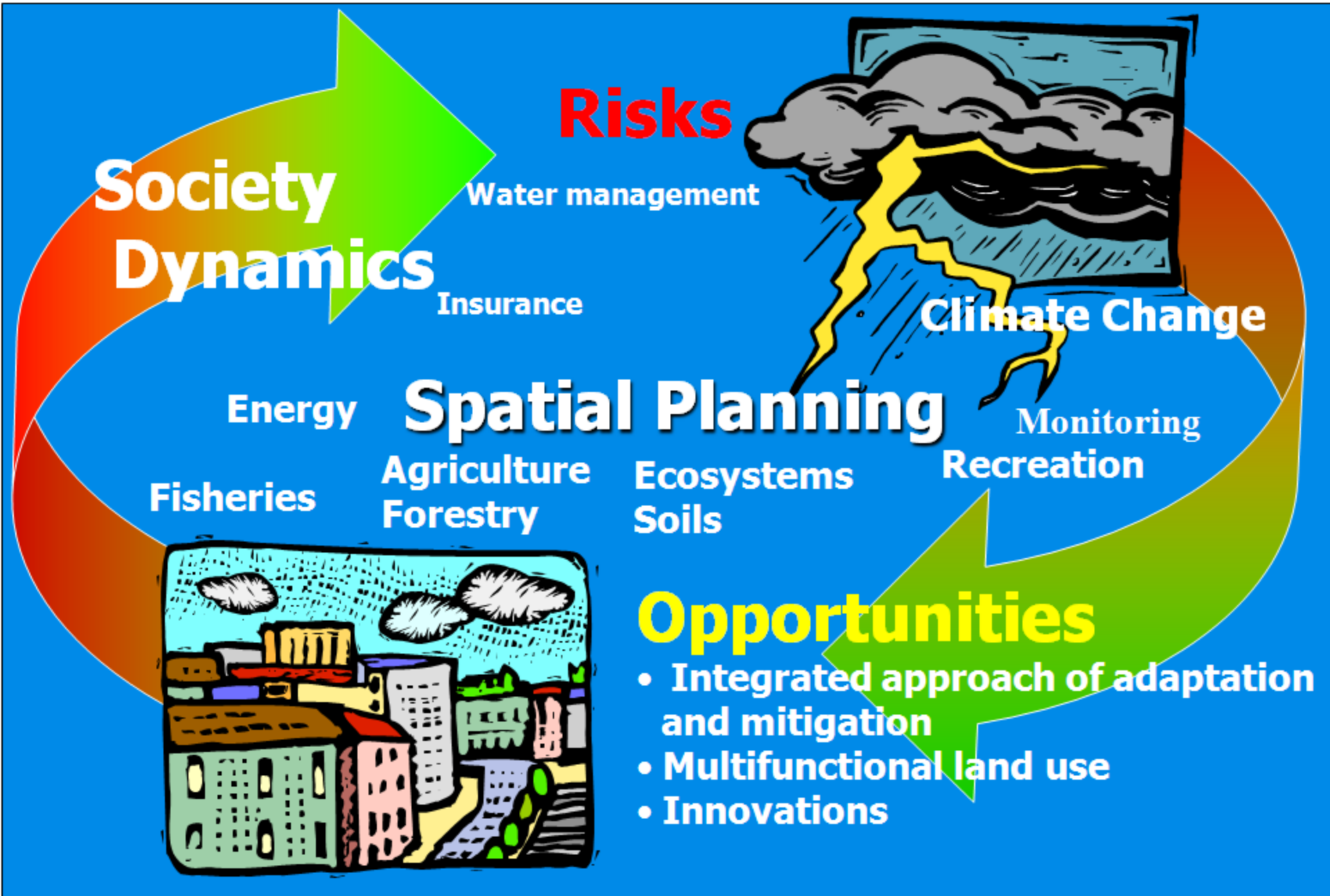
Land Use Planning

Is the solution of **Floods**

SPATIAL PLANNING– PARADIAM SHIFT

- National Spatial Planning is the critical strategy to prevent/prepare for the challenges brought by unpredictable weather conditions in the future.
- National Spatial Planning is not just about the exploitation, distribution and allocation of lands.
- National Spatial Planning should comprise ethical principles, regulations, enforcement, and management.
- National land reform is essentially built upon the CHANGING of traditional living patterns and values.

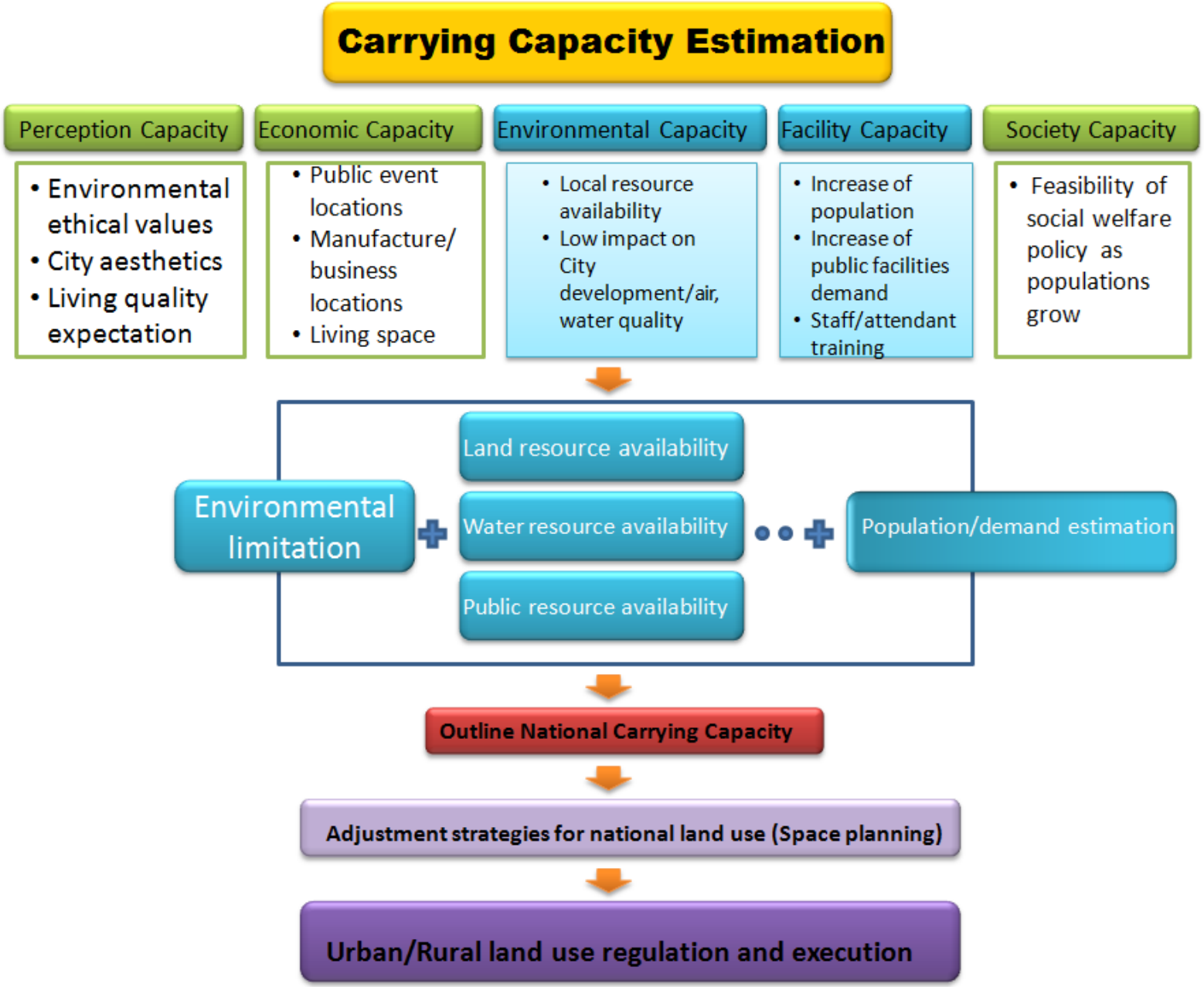
Impacts of Climate Change



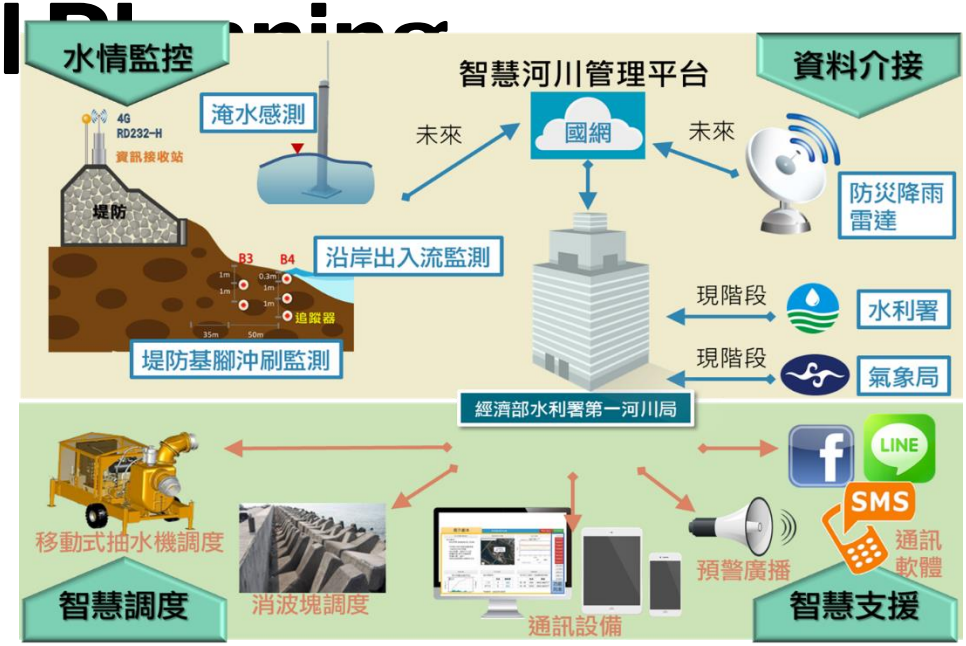
1945 Taipei City
(1 million population)


2008 Taipei City
(8 million population)

Land Carrying Capacity Estimation



Decision Supporting System for Spatial Planning

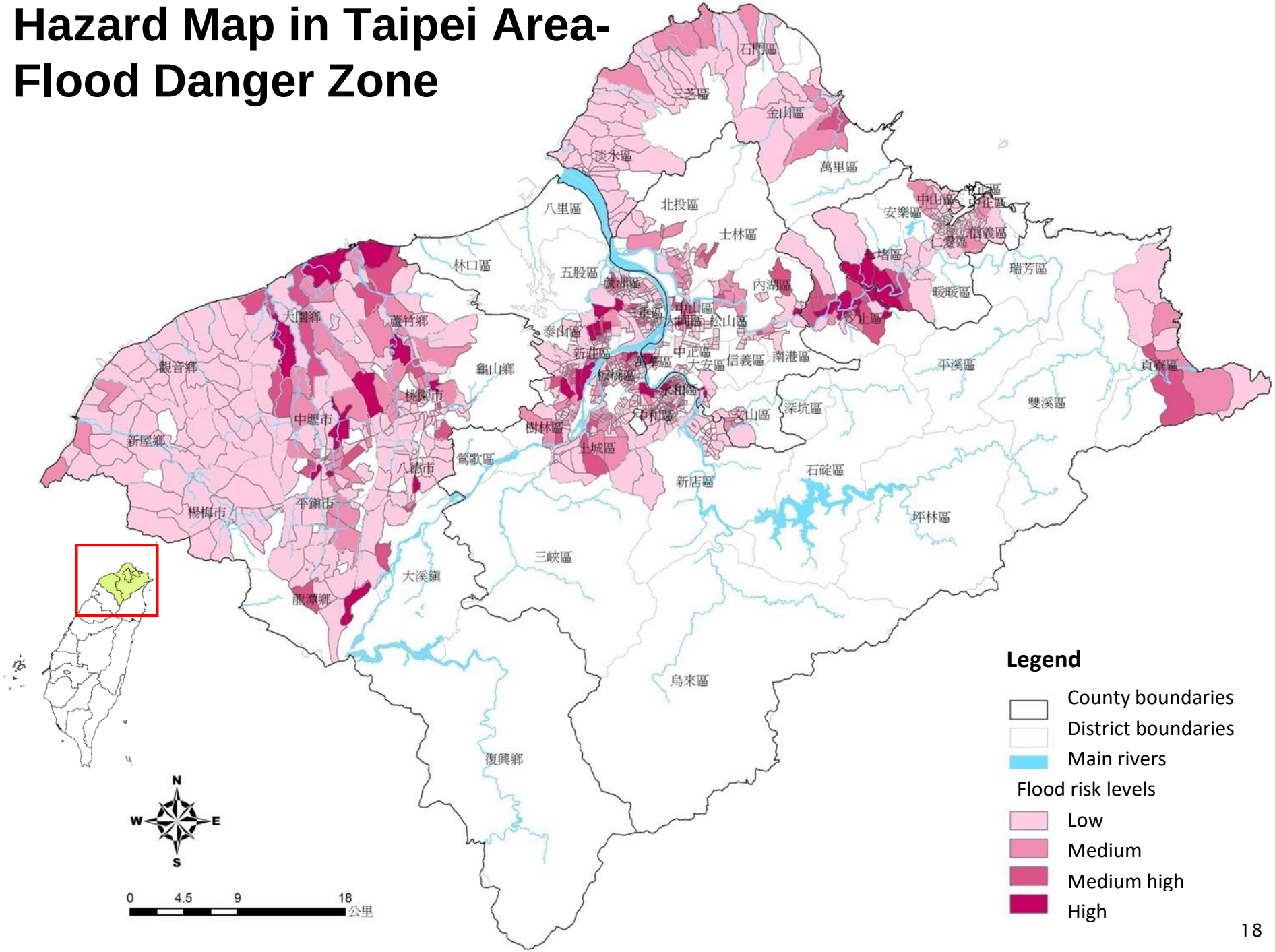


Data Bank

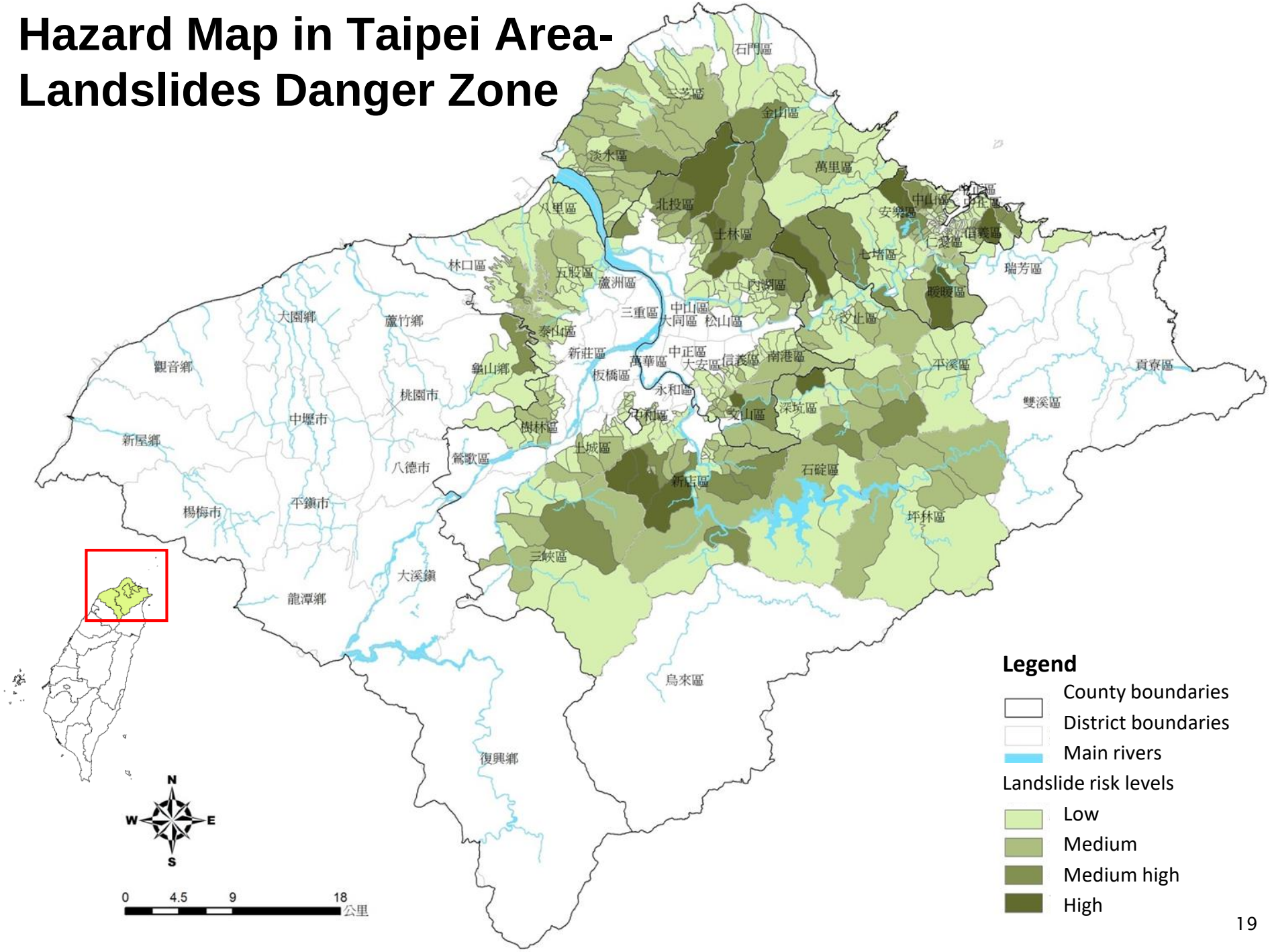
- Quantity
  - Quality

- ☐ **Cloud**
- ☐ **Data Mining**
- ☐ **Decision Supporting System (DSS)**
- ☐ **Scenario Analysis**
- ☐ **Policy**
- ☐ **Action Plan & Budget Allocation**

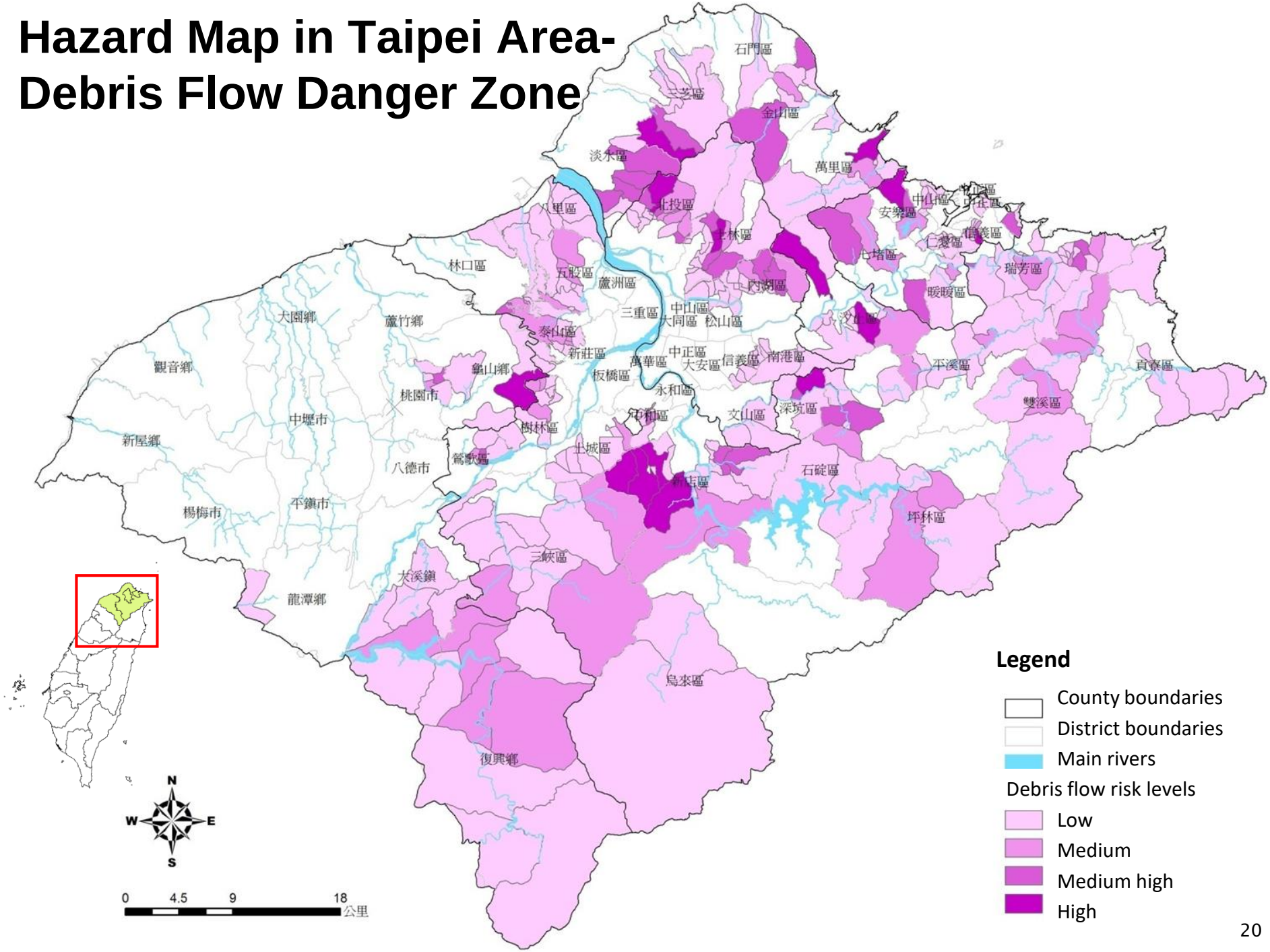
Hazard Map in Taipei Area-Flood Danger Zone



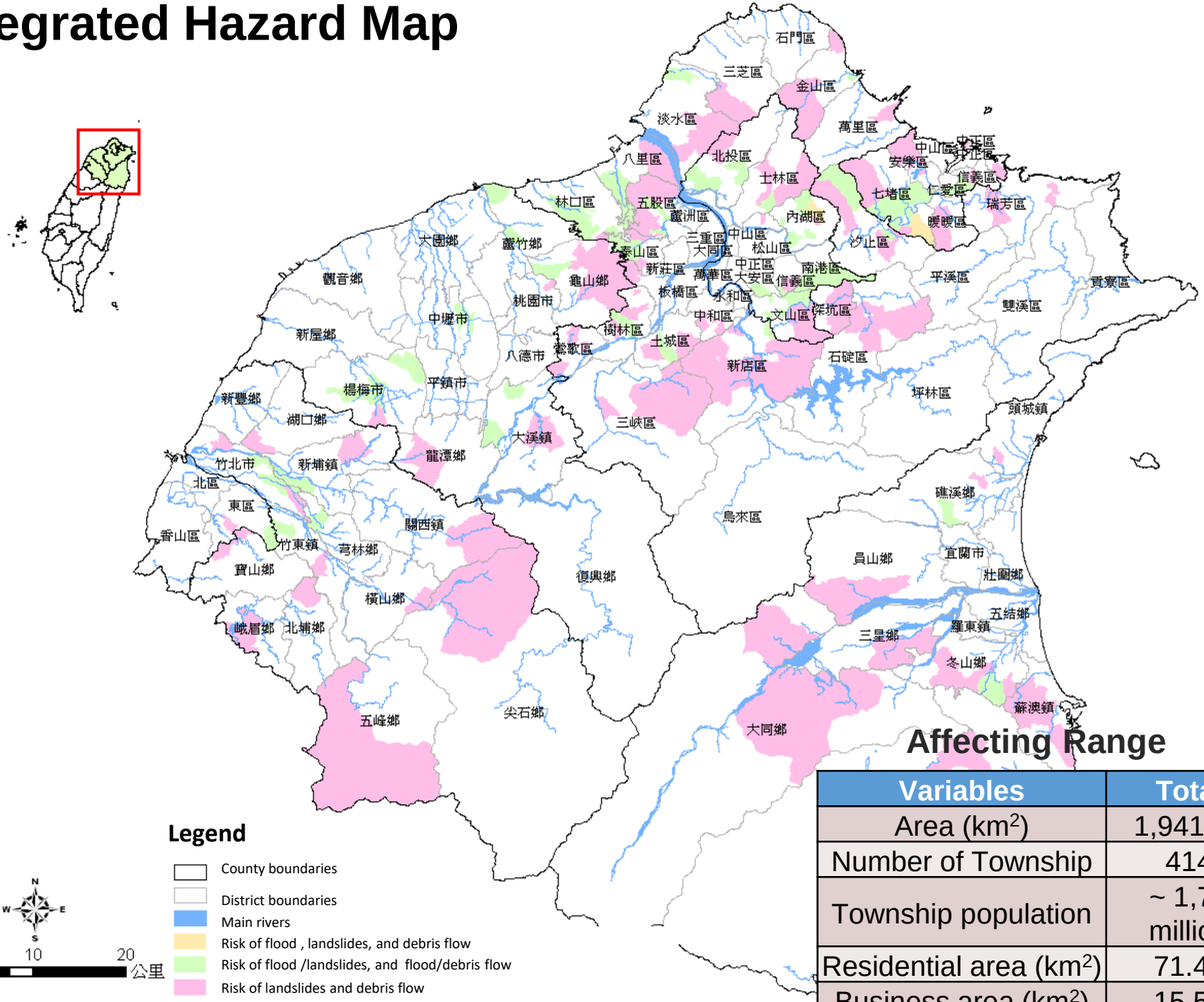
Hazard Map in Taipei Area-Landslides Danger Zone



Hazard Map in Taipei Area-Debris Flow Danger Zone



Integrated Hazard Map



Affecting Range

Variables	Total
Area (km^2)	1,941.13
Number of Township	414
Township population	~ 1,74 million
Residential area (km^2)	71.42
Business area (km^2)	15.56

Land Use Adaptation

Prevention/ Monitoring

- Preventing new disaster
- Preventing the impact

Low Risk Area

Emergency Response

- Disaster level control
- Information of potential disaster
- Training of disaster prevention
- Develop insurance system

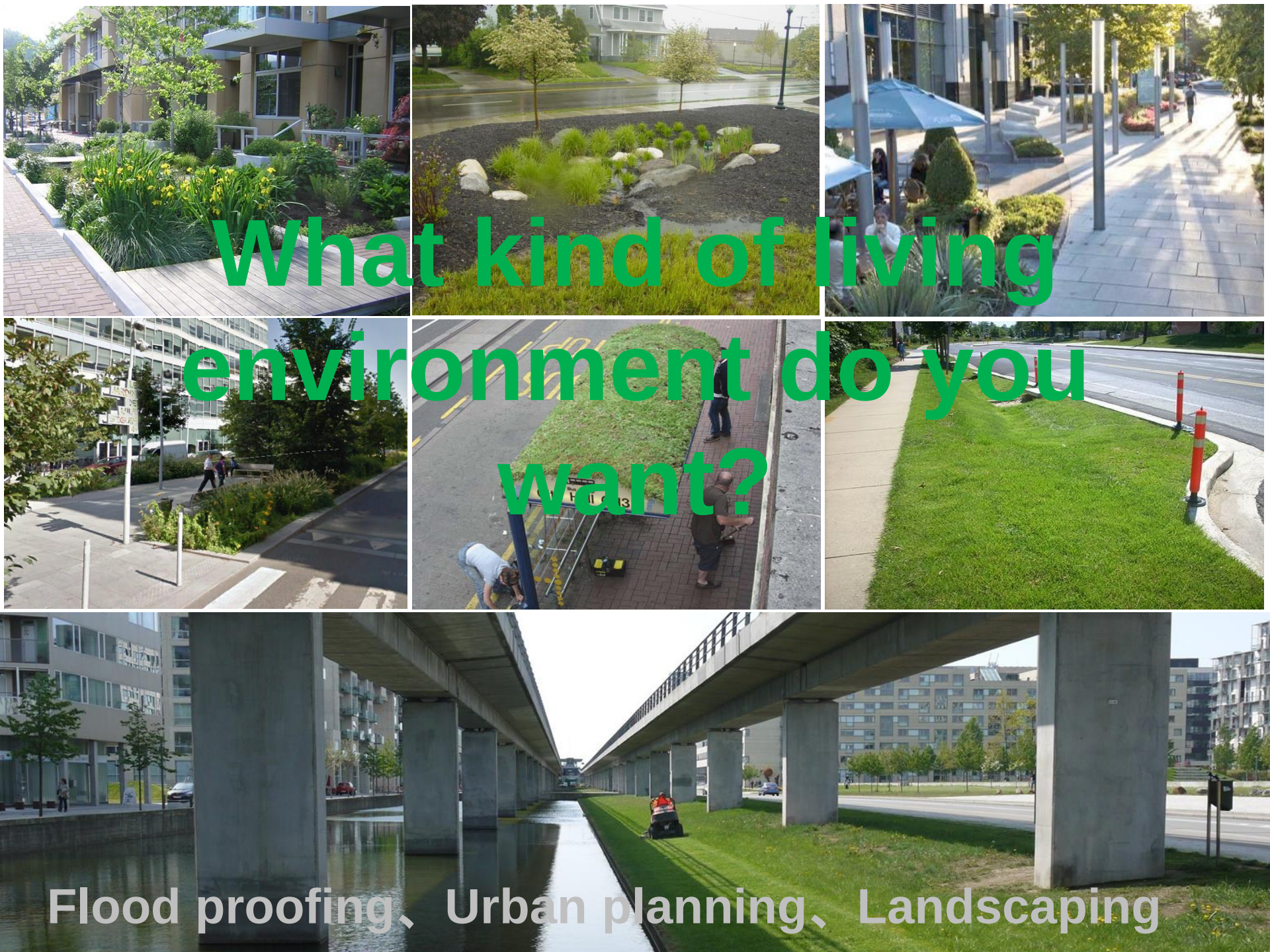
Medium-Low Risk Area

Land Use Adaptation

- Controlling the use of land
- Revaluate the intensity of development
- Regulate the height of buildings
- Strengthen the water and soil conservation

Medium/High Risk Area Restricted Area

Engineering the Future City with Non-engineering Way


What kind of living environment do you want?
Flood proofing、Urban planning、Landscaping

Resilient-based approach

(to infrastructure design)

Embraces unforeseen extreme weather events

- designed for failure ("**safe-to-fail**" infrastructure, exceedance of design criteria)

Safe-to-Fail:

- Maintaining system-wide critical services (instead of preventing component failure)
- Minimizing consequences (instead of probability)
- Designing decentralized, autonomous infrastructure systems (instead of centralized, hierarchical systems)

Resilient-based approach

(to infrastructure design)

Sail-to-Fail infrastructure:

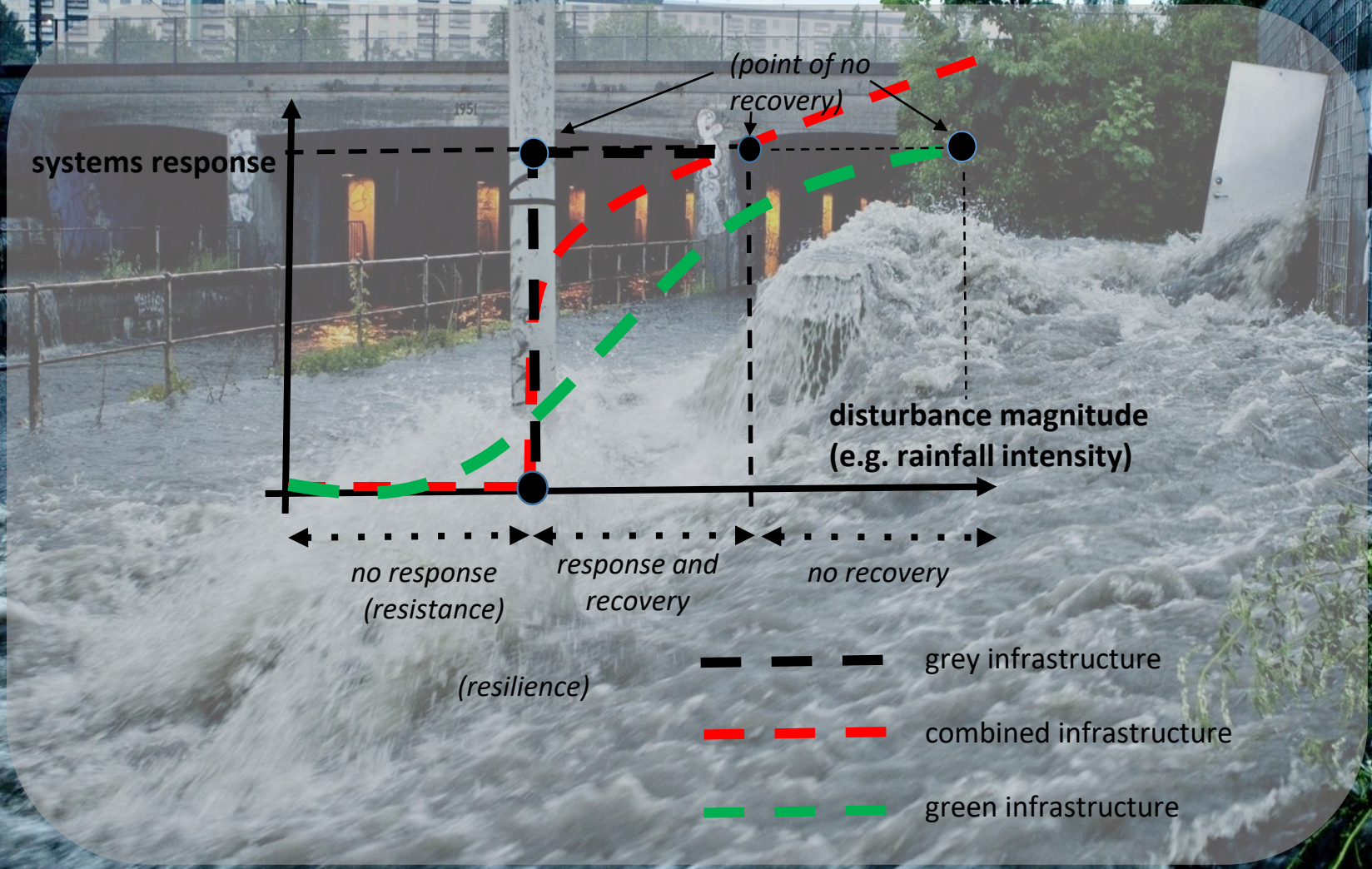
- Ability to respond to unexpected threats by rebuilding/adapt infrastructure (adaptive capacity (sense and adapt))
- Ability to recover (recoverability)

via *social, ecological and technological* interactions (SETs)

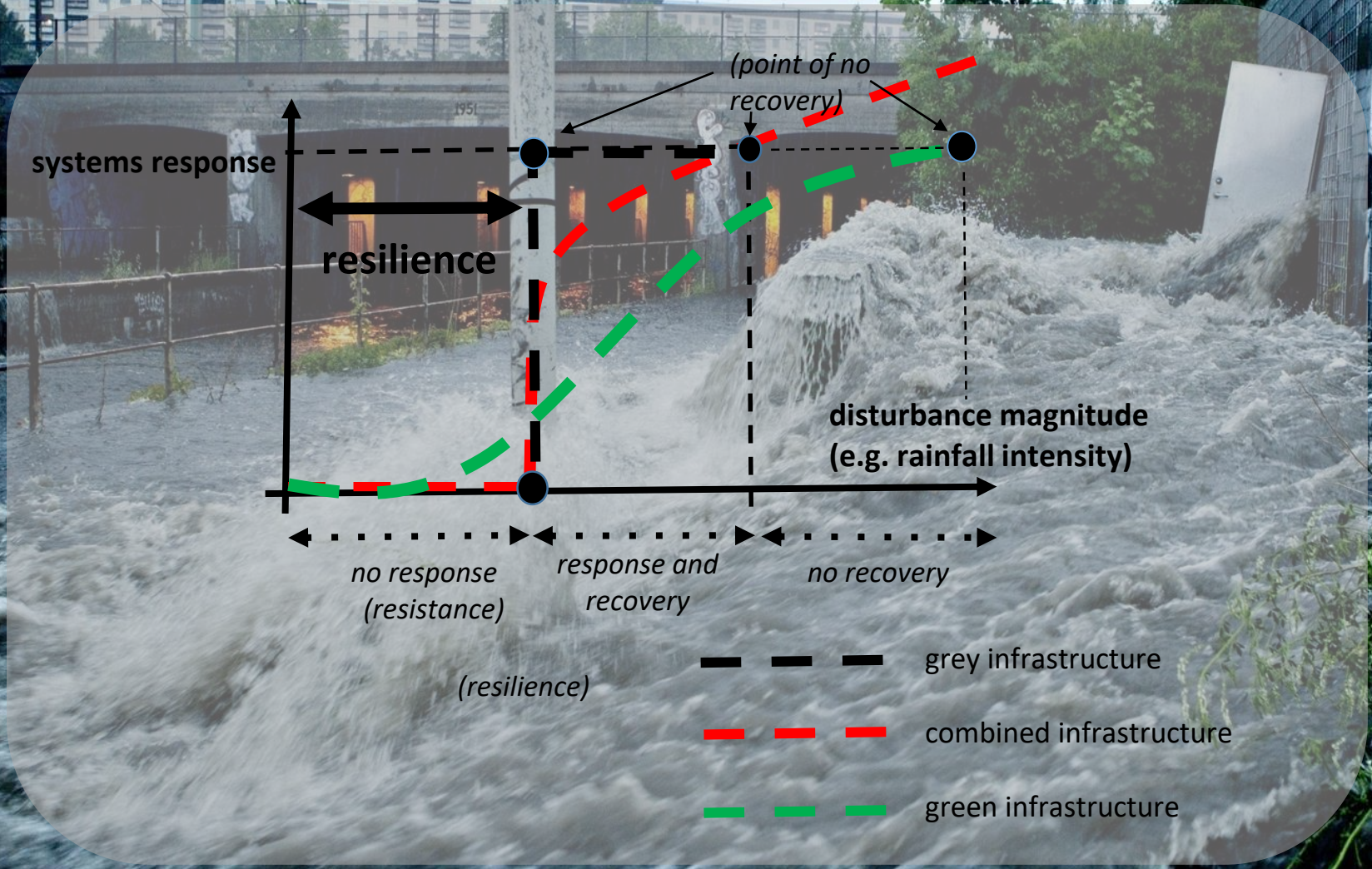

Elbe, 2013


Dordrecht, 2013

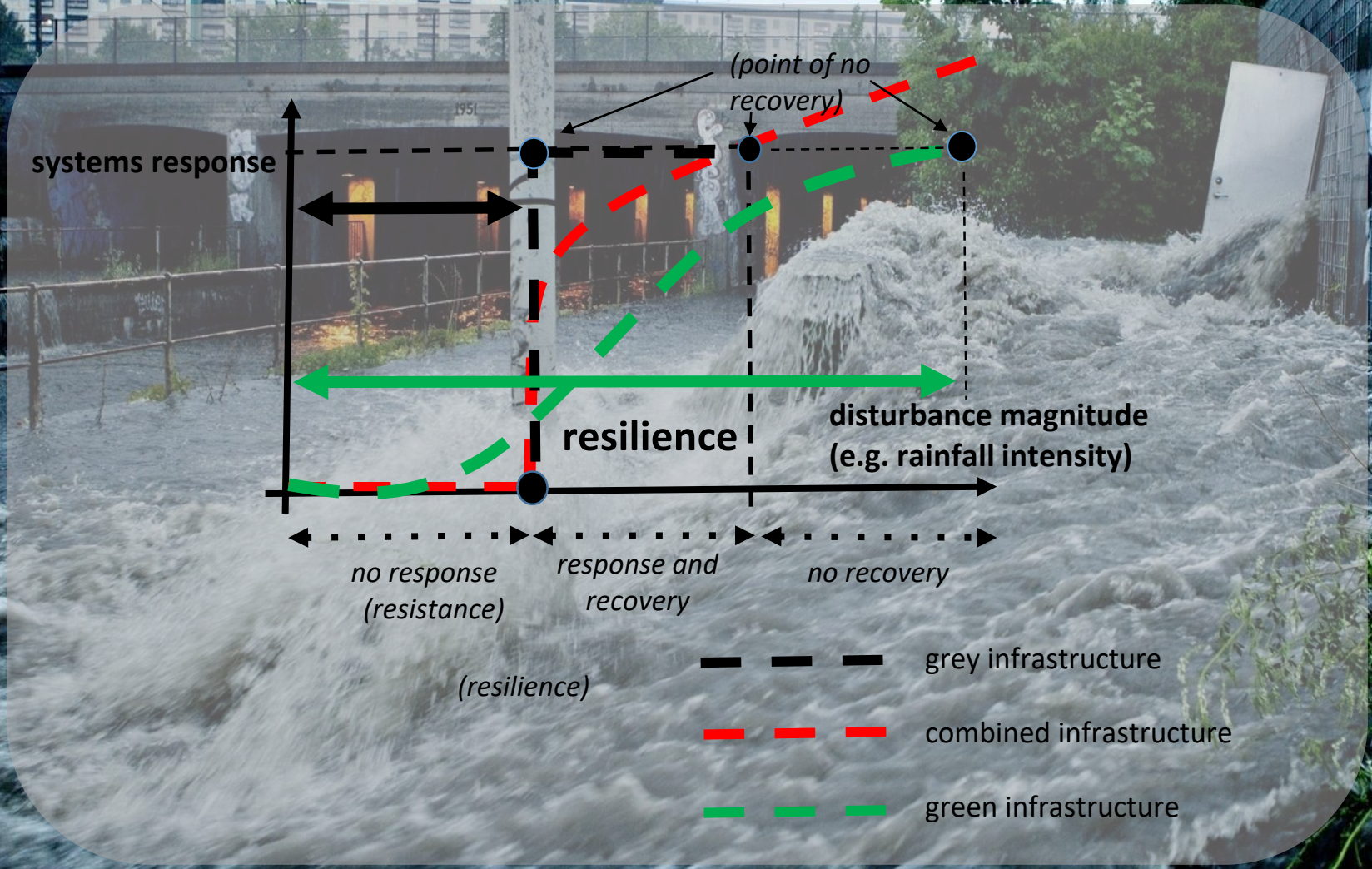
Systems behaviour



Systems behaviour

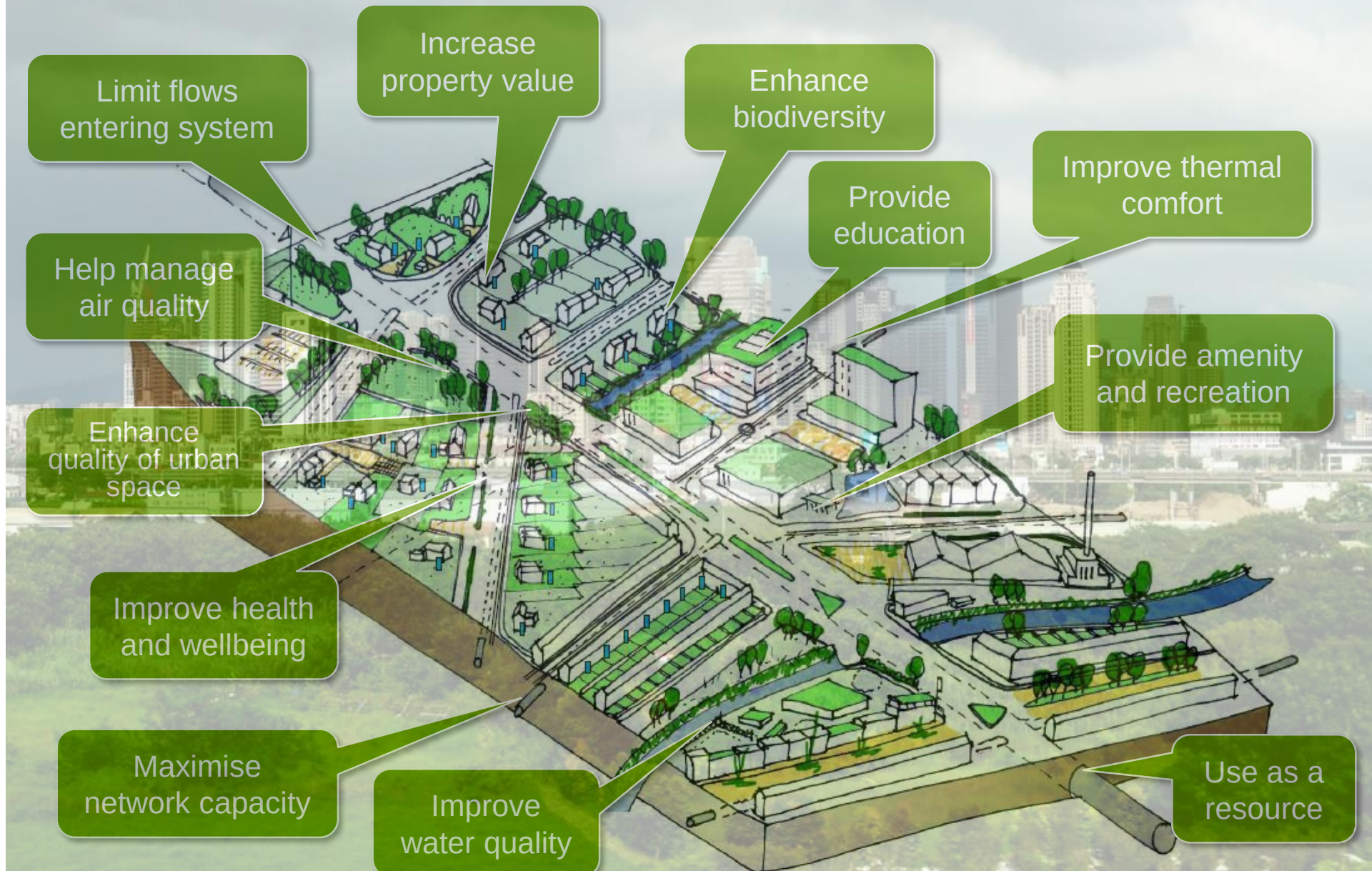


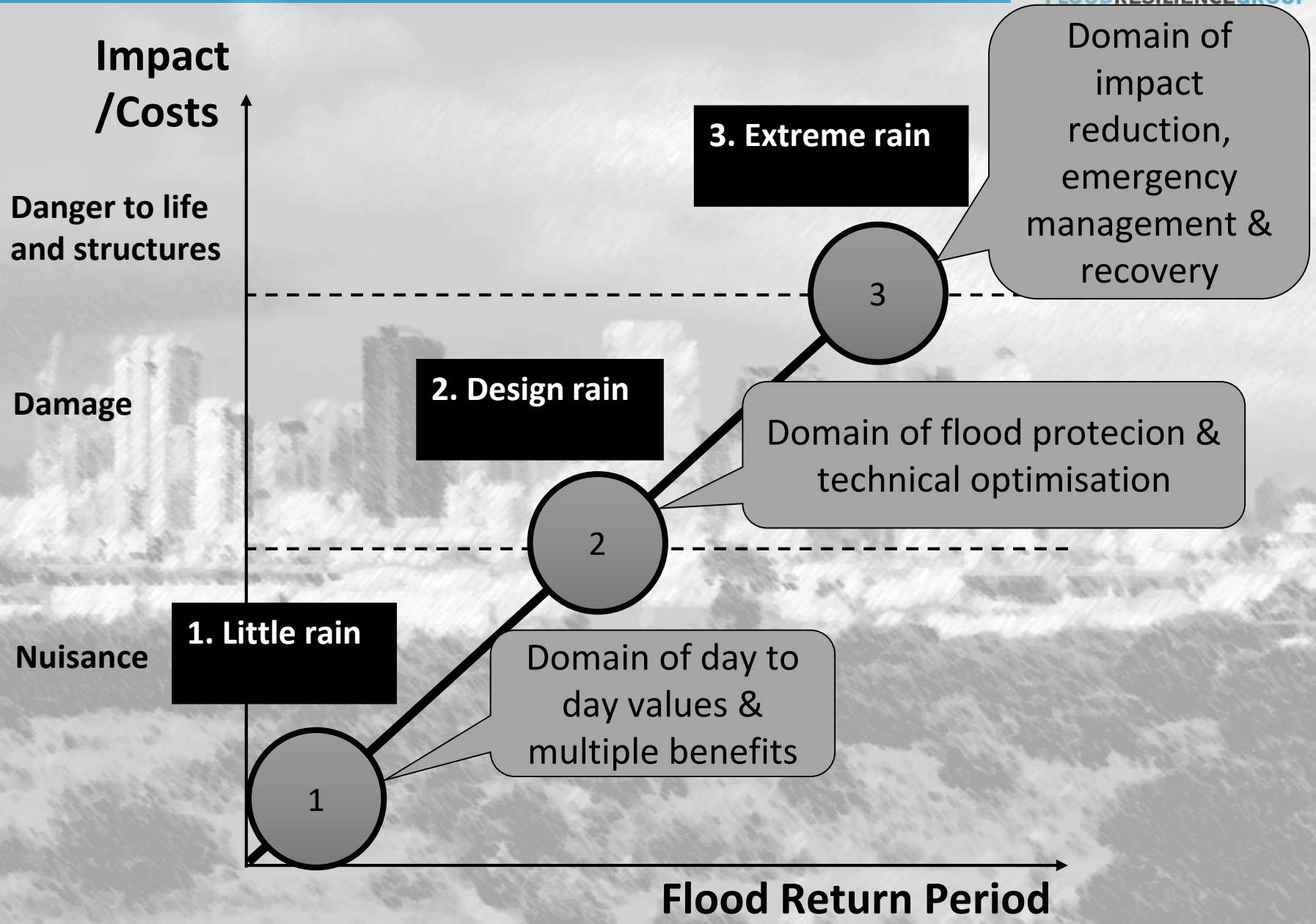
Systems behaviour



Blue-green infrastructure:
increasing serve as flood exceedance pathways designed to cope when the formal drainage systems are overloaded.

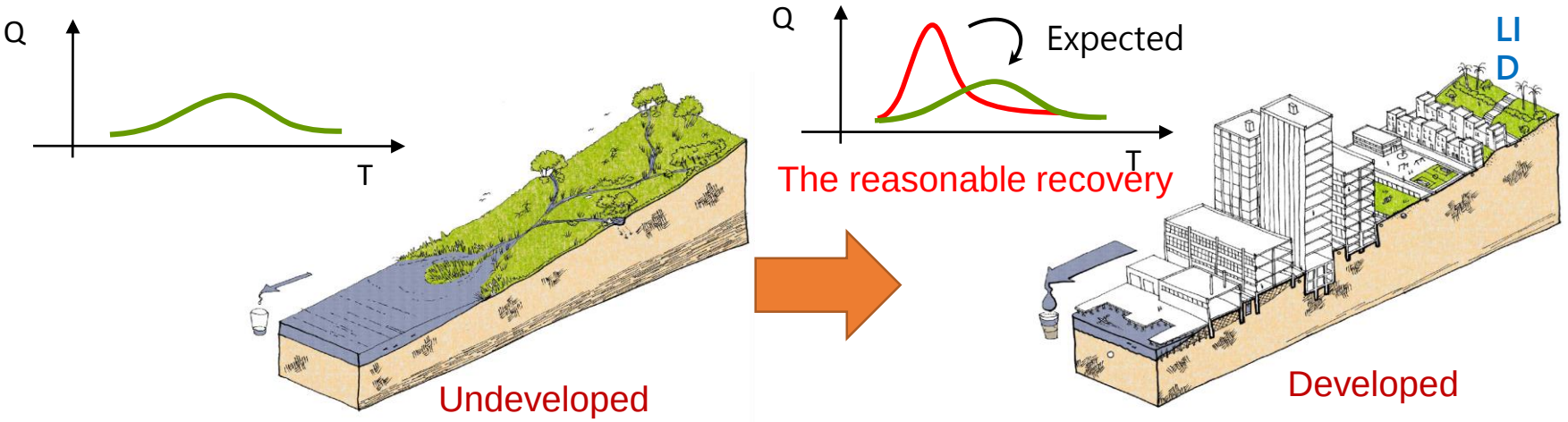
What is possible? How do we account for the benefits and should we?




Impact /Costs
Danger to life and structures
Damage
Nuisance
3. Extreme rain
2. Design rain
1. Little rain
3
2
1
Domain of impact reduction, emergency management & recovery
Domain of flood protecion & technical optimisation
Domain of day to day values & multiple benefits
Flood Return Period

The role of Low Impact Development (LID)

- **Urbanization causes hydrological change and increases storm water runoff volumes and reduces the infiltration**
- **LID techniques attempt to mimic the natural site hydrology before development**



Based on the characteristics of rainfall, urban development and target analysis in Taiwan, LID facilities can only reduce small floods and provide the function of water retention for high frequency and intensive rainfall, but can not reduce the peak amount of heavy rain.

The functions of LID facilities

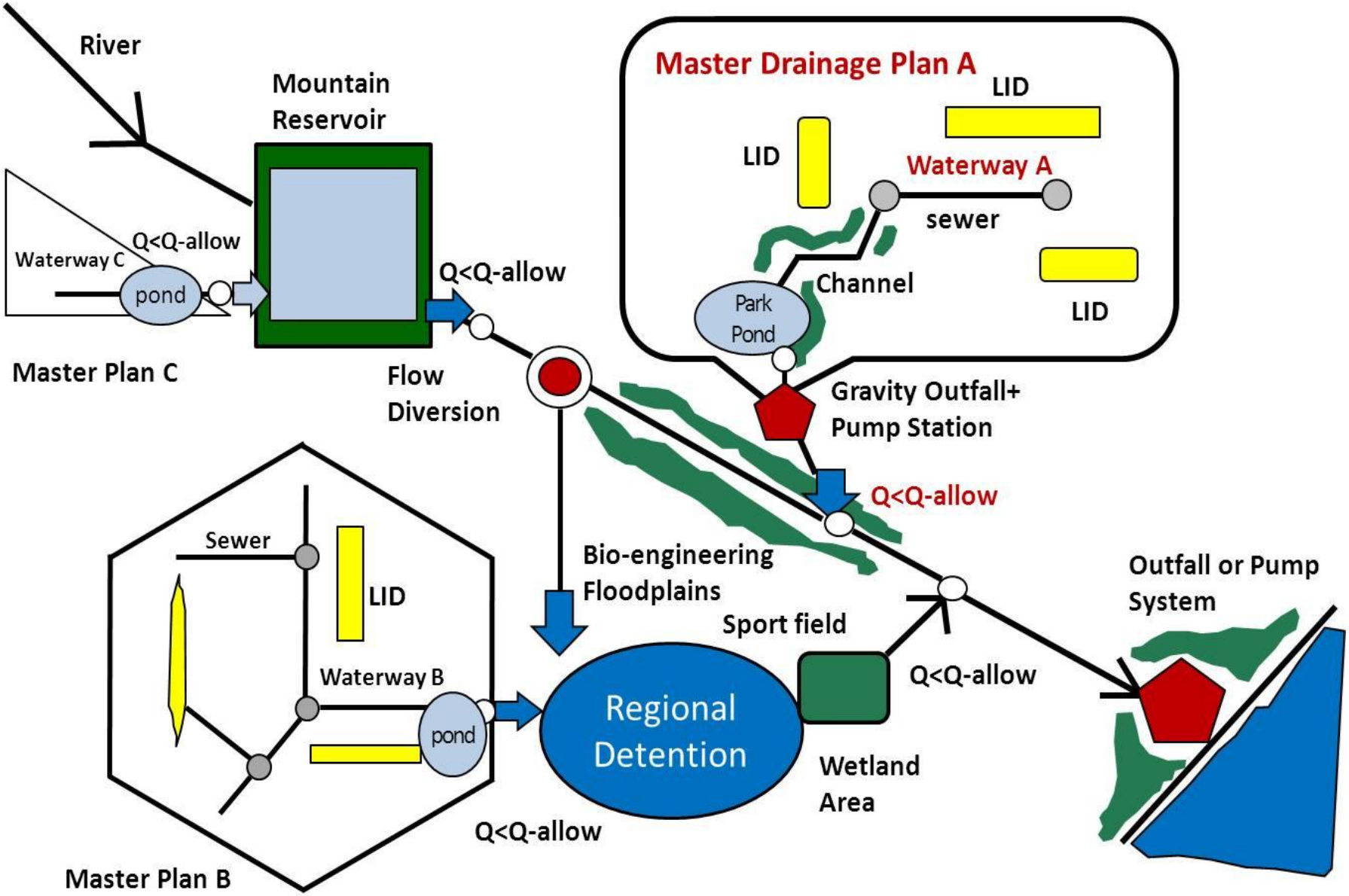
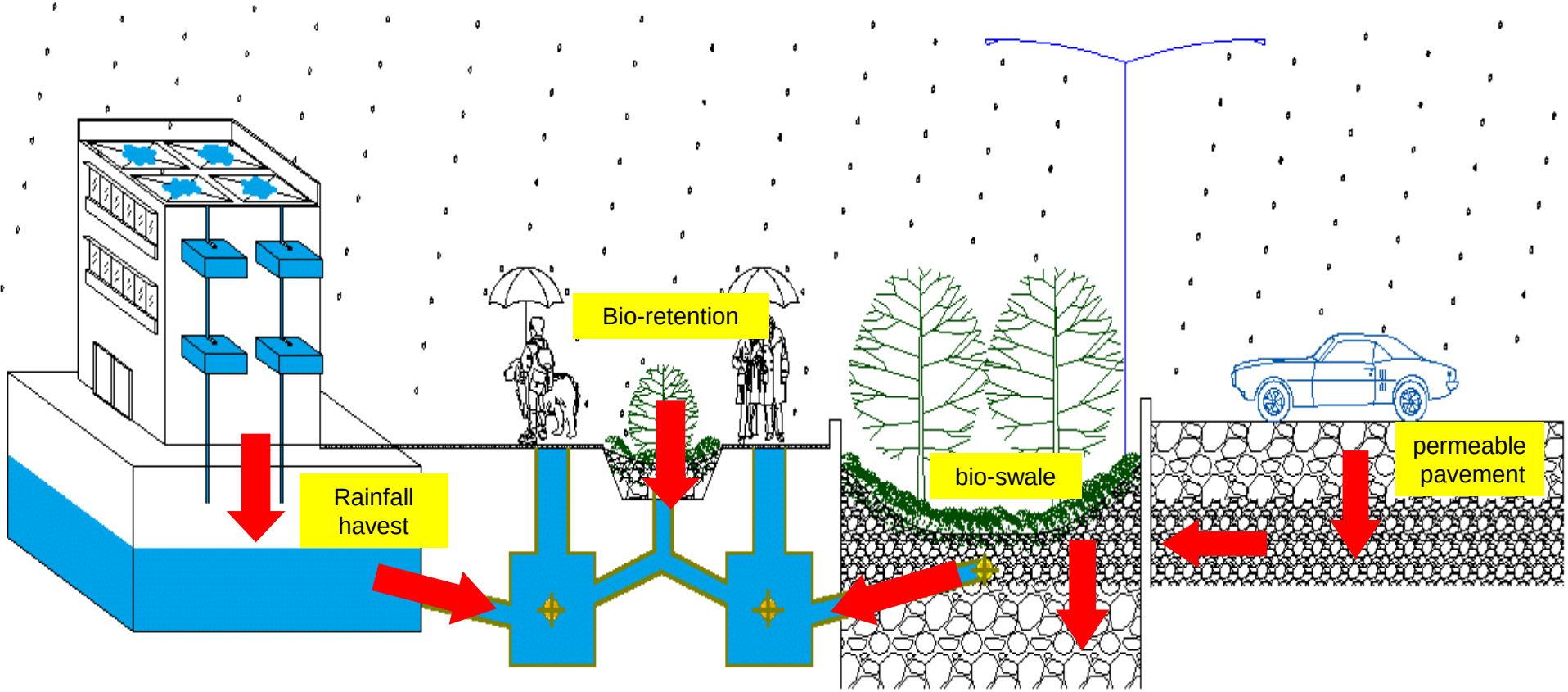


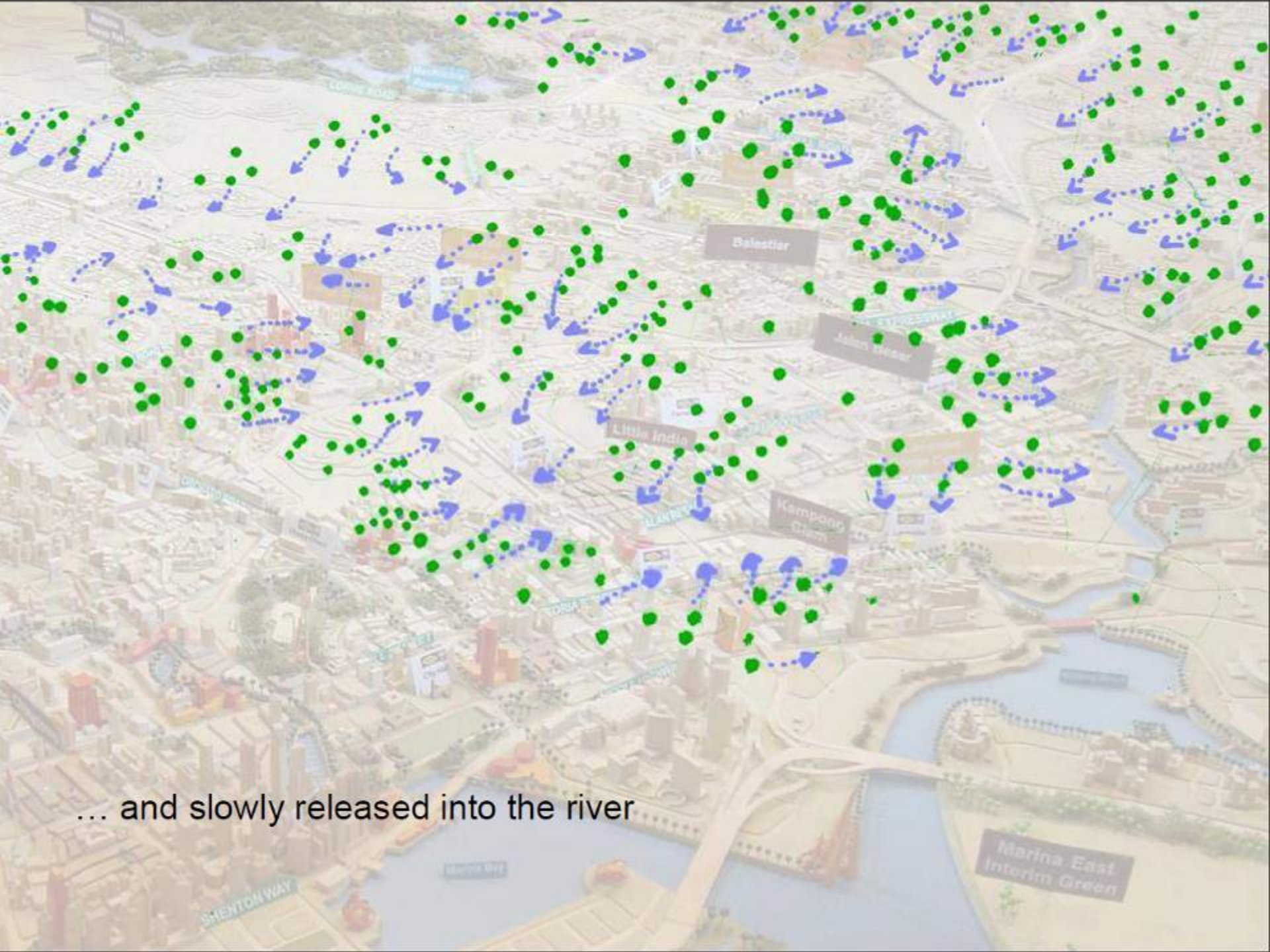
Figure modified from James Guo


Bio-retention
Rainfall
havest
bio-swale
permeable
pavement

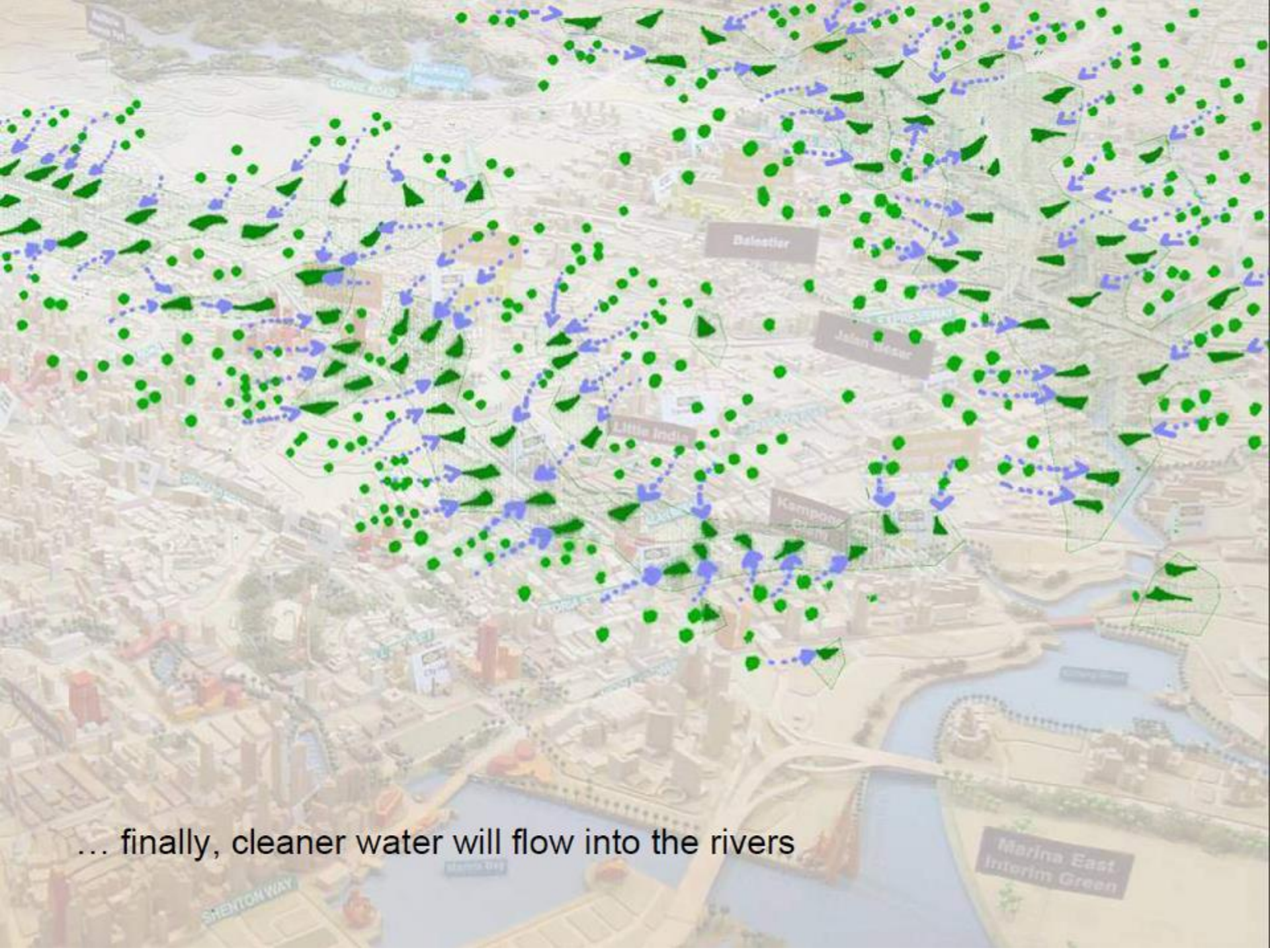
What happens with the rain today?

What happens with the rain today?
Every drop goes into pipes and straight into the canal

A better way of managing rain water:
Every drop will be treated on site …

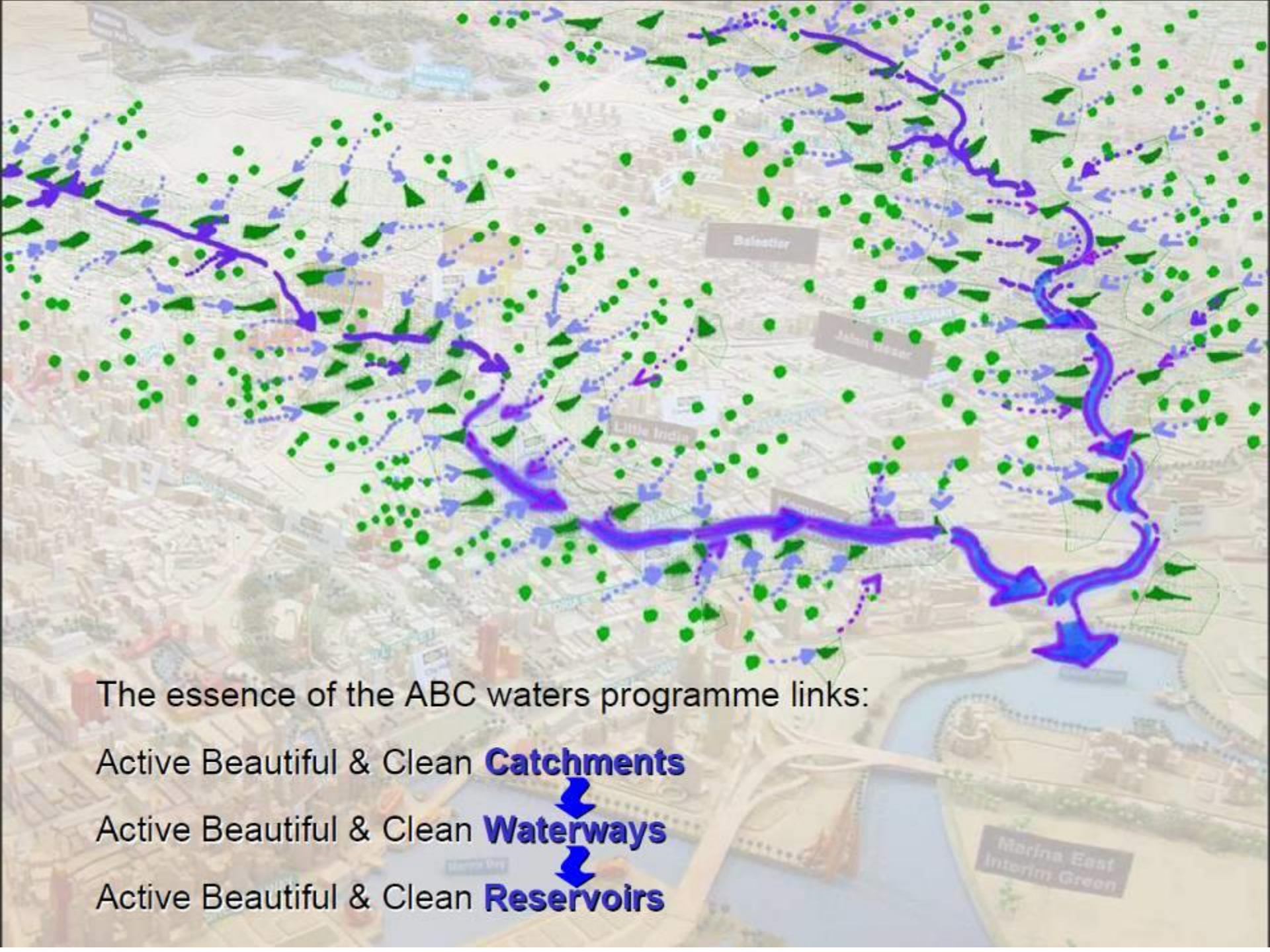


… and slowly released into the river



… finally, cleaner water will flow into the rivers


Little India
Marina East
Interim Green
SHENTON WAY



The essence of the ABC waters programme links:

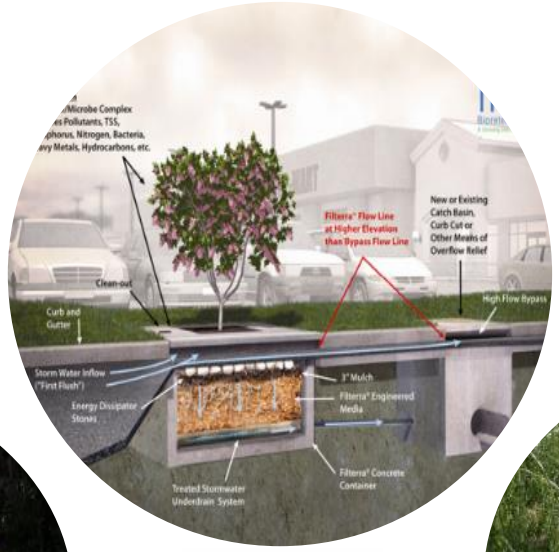
Active Beautiful & Clean **Catchments**

Active Beautiful & Clean **Waterways**

Active Beautiful & Clean **Reservoirs**

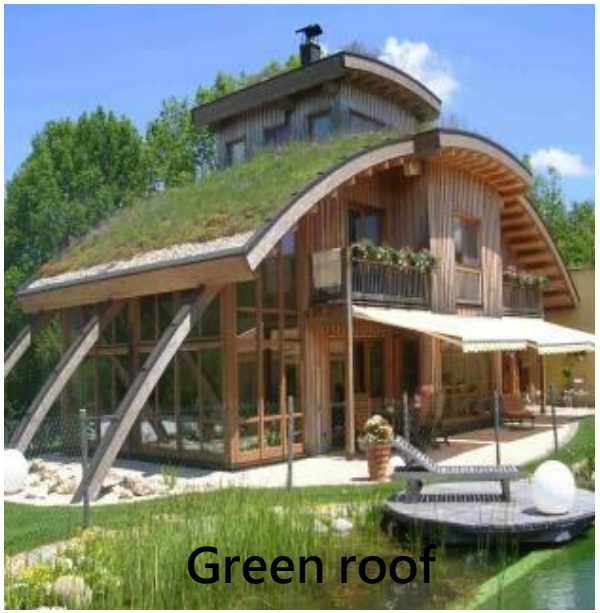
The benefits of rainfall infiltration underground the city

- Decrease surface runoff – Lengthen the time of runoff gathering to prevent floods
- The evaporation of water can decrease the temperature of city
- The groundwater recharge protects the environment, water inrush and increase the base flow of rivers



Filtration

The benefits of rainfall infiltration underground the city



Case Study for Singapore

Strategy plan for Singapore

ABC Water Program

- 親水(**A**ctive)、美化(**B**eautiful)及淨化水質(**C**lean water)
- Announcing **ABC Water Program** and **revising regulations** of developing lot runoff control(25~35%) and building development level

2010 European Green Capital-Stockholm

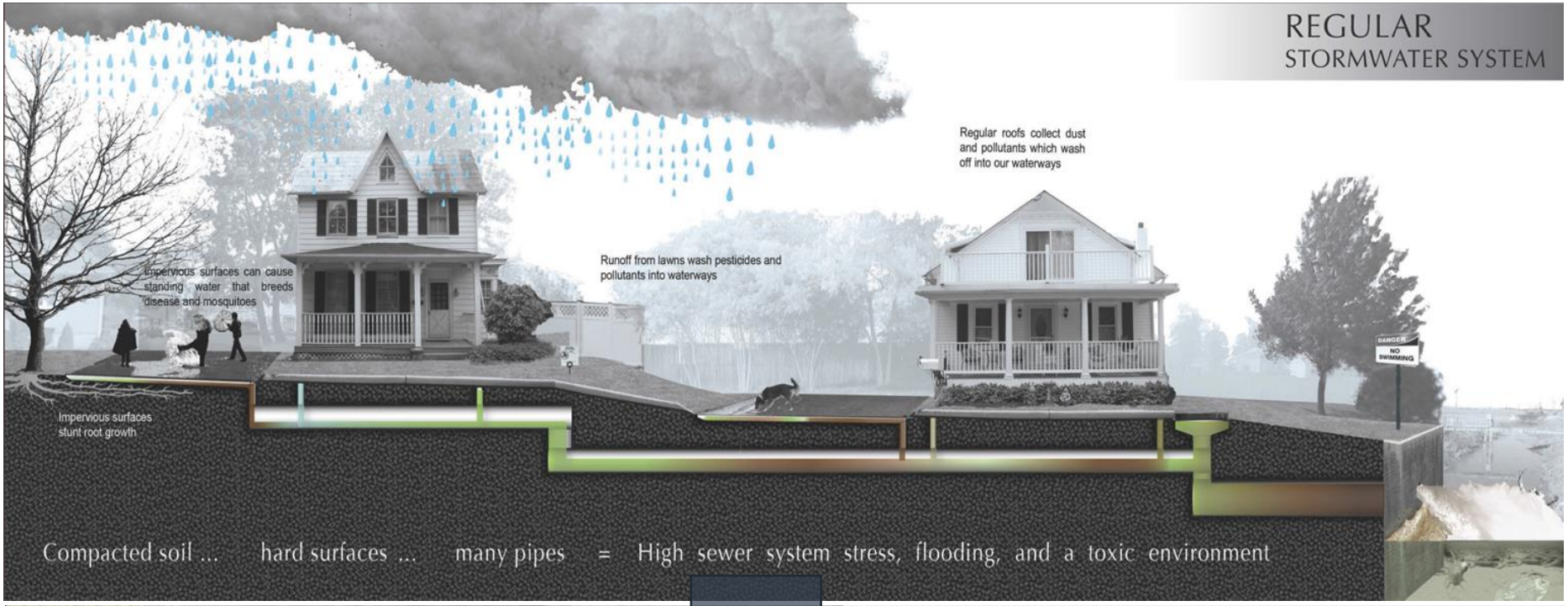
Storm Management + **Water Resource manager** + **Create Environment**

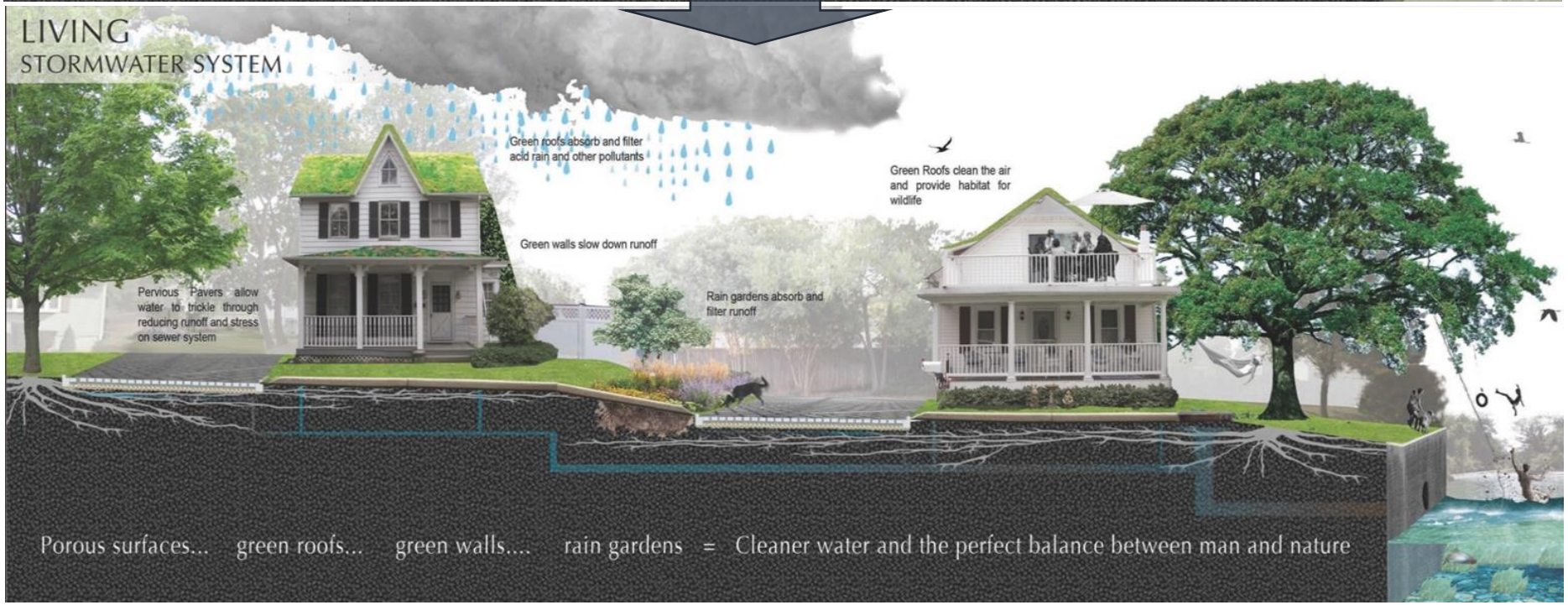
-Management of discharge system
-Land use plan

-Diversified water use strategy
-Recycle of water

-Creating green environment

- Ecological quality
- Microclimate regulation
- Adaption for climate change
- Urban landscape
- Living environment
- Land value


REGULAR
STORMWATER SYSTEM
Regular roofs collect dust and pollutants which wash off into our waterways
Runoff from lawns wash pesticides and pollutants into waterways
Impervious surfaces can cause standing water that breeds disease and mosquitoes
Impervious surfaces stunt root growth
DANGER
NO SWIMMING
Compacted soil ... hard surfaces ... many pipes = High sewer system stress, flooding, and a toxic environment


LIVING
STORMWATER SYSTEM
Green roofs absorb and filter acid rain and other pollutants
Green Roofs clean the air and provide habitat for wildlife
Green walls slow down runoff
Pervious Pavers allow water to trickle through reducing runoff and stress on sewer system
Rain gardens absorb and filter runoff
Porous surfaces... green roofs... green walls.... rain gardens = Cleaner water and the perfect balance between man and nature

SPOTLIGHT PLAN　CITY RENEWING

圖片來源：
http://www.wretch.cc/blog/sealpha/34656193

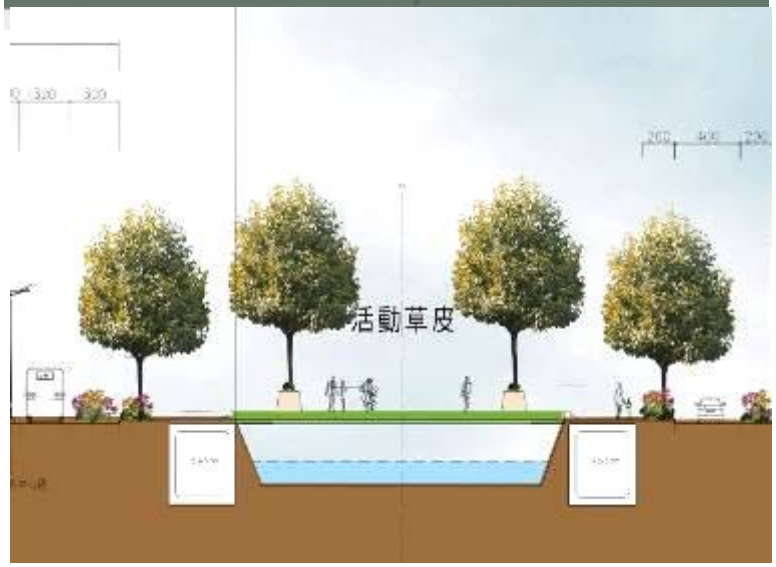
Public Construction
（New Taipei City – Zhong-Gang drainage canal）

Confluence Channel

2.3 km in total

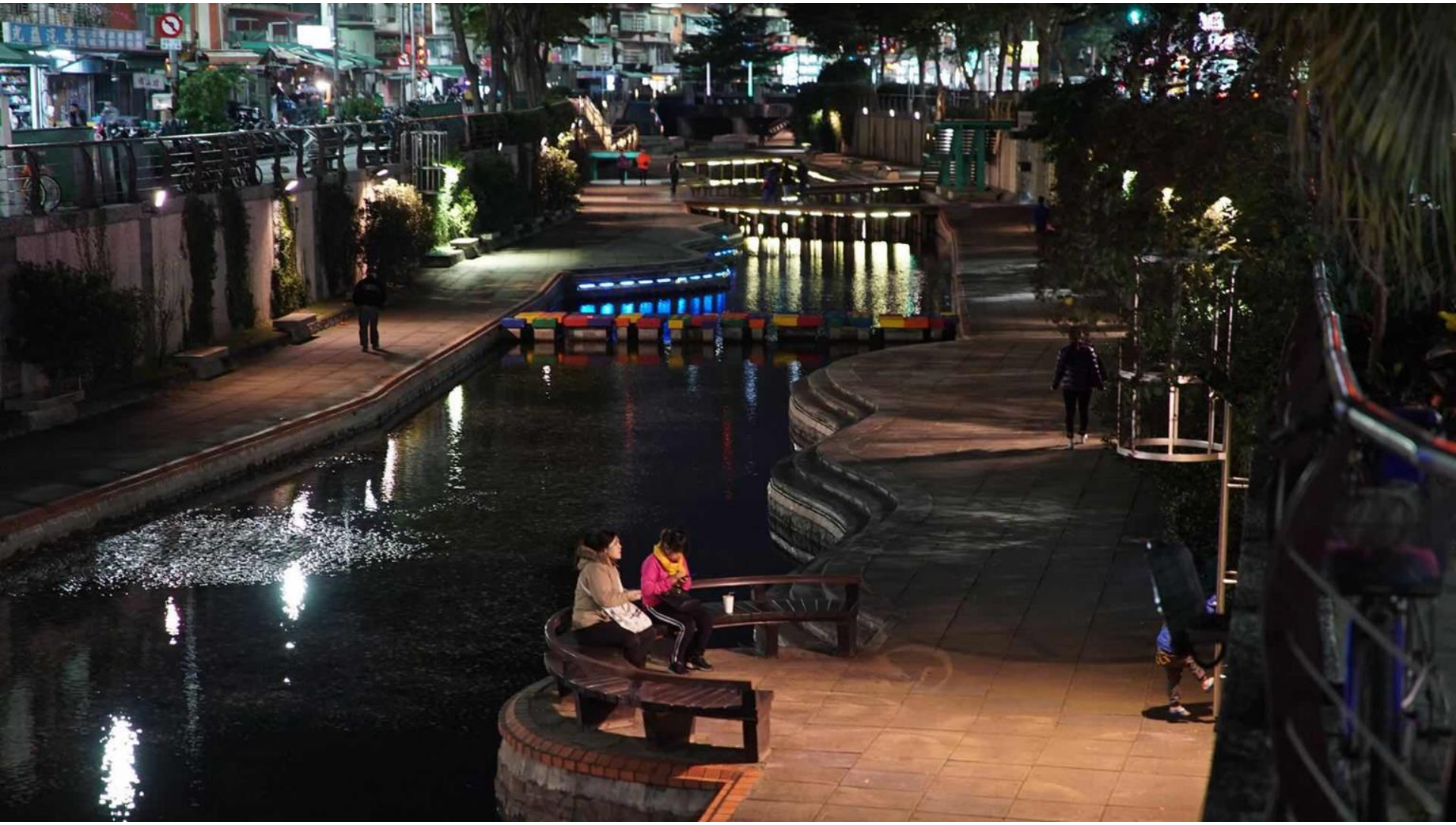
Before

1.Preventing wastewater 2.Preventing floods
3.Suppling clean water 4.Creating good environment



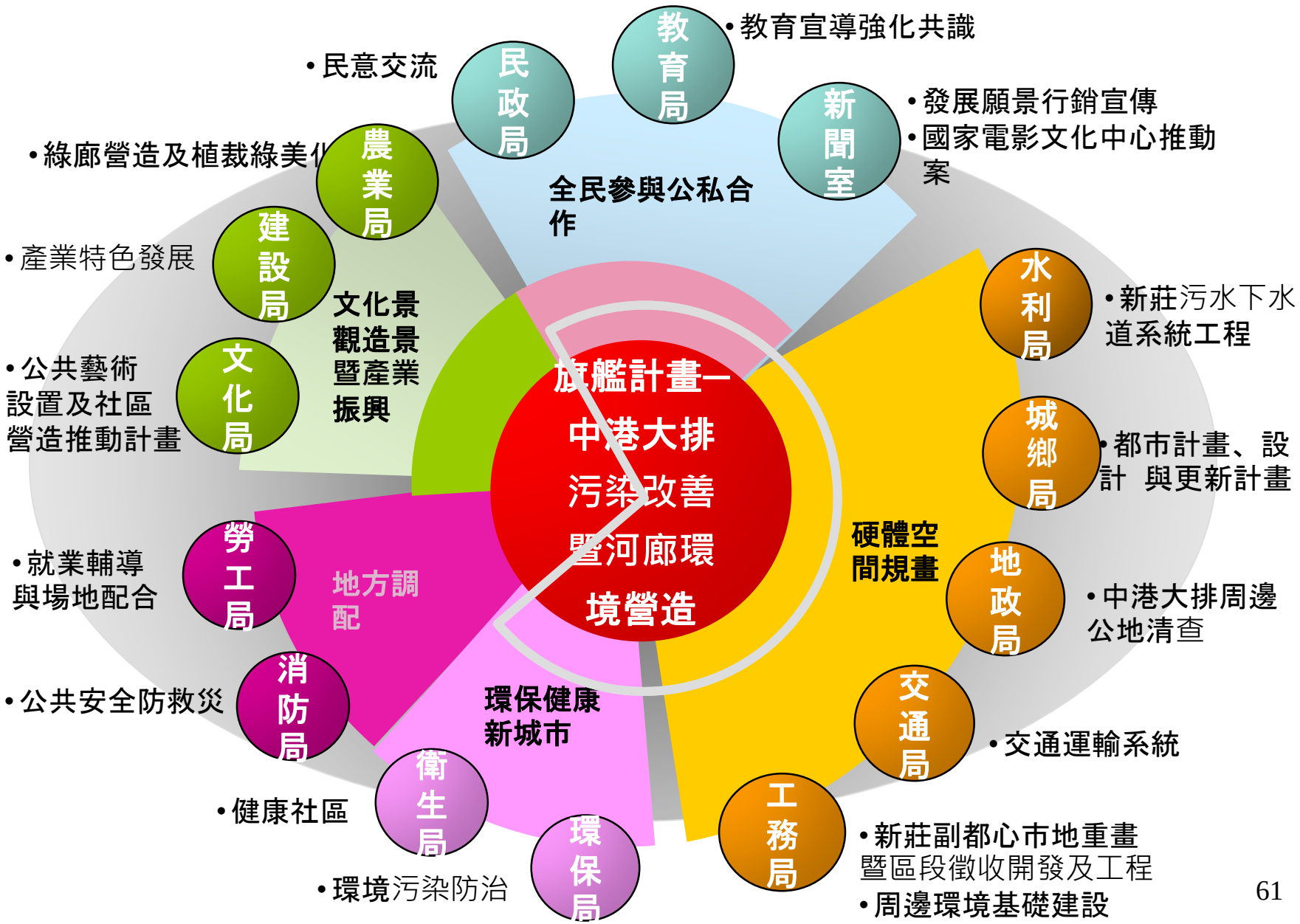
After Construction

After Construction



After Construction

Inter-discipline dialogue



Green Campus and Green Community Empowerment

- Pedestrian-friendly trail to school
- Campus green fence, green roof reconstruction
- Green Campus and the surrounding neighborhood park link
- More community public space
- Green campus as a starting point, start community-empowerment

Dialogue and Public Participation

Dialogue and Public Participation

公共溝通\資訊分享與平台建置 http://dreamriver.tpc.gov.tw

- 自96年七月上線，目前已成為各式工作坊、行銷活動及討論論壇的網路平台，提供活動訊息傳播及活動花絮紀錄的重要資料庫。

Learning Alliances

Hamburg LA platform

Alexandria
LA platform

Catchment

Univ'sty

Water Ut

Waste Ut

...

Planners

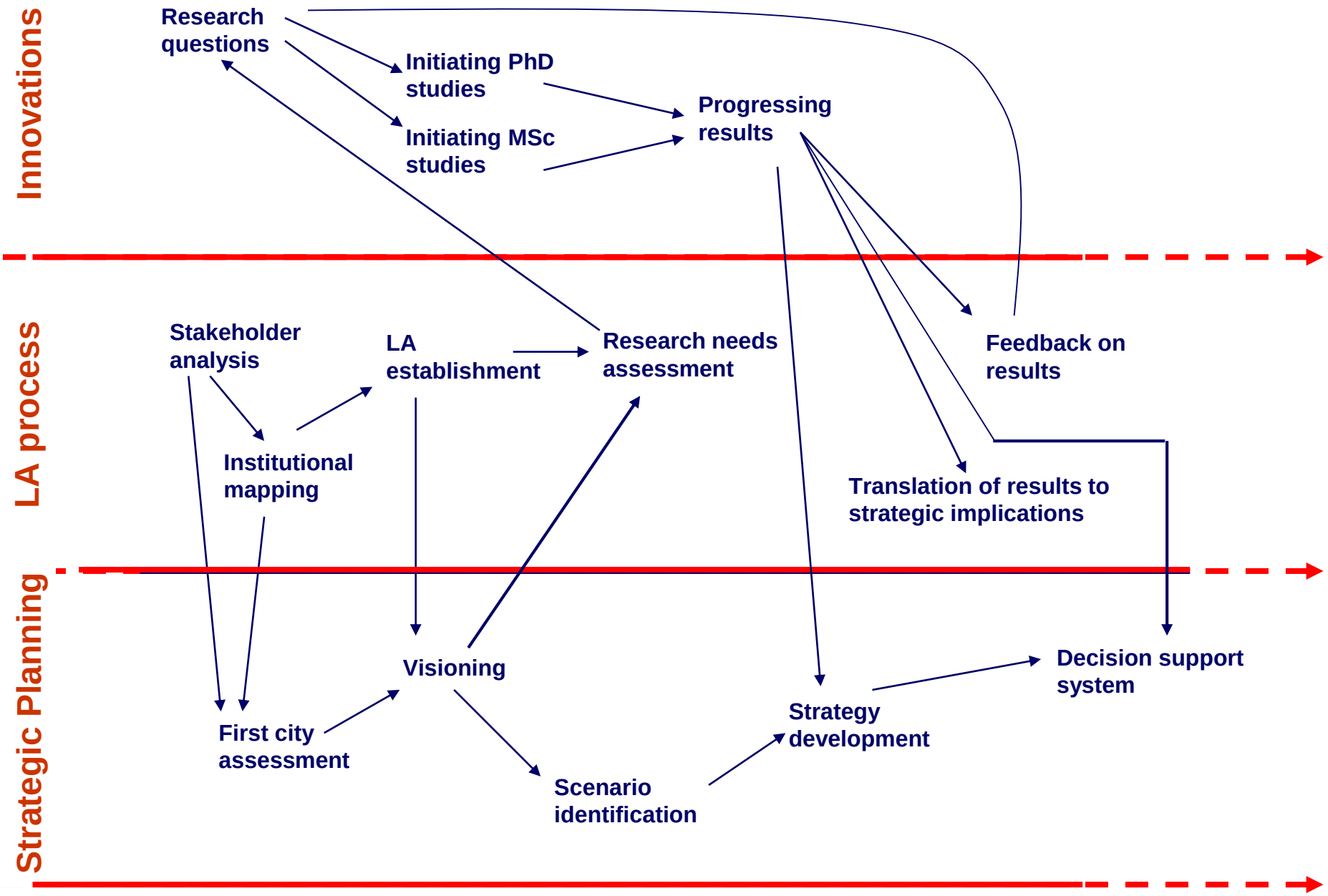
City

Belo Horizonte
LA Platform

SWITCH inter–city IUWM LA
platform for inter-city learning

Accra LA platform

Community


Innovations
LA process
Strategic Planning
Research questions
Initiating PhD studies
Initiating MSc studies
Progressing results
Stakeholder analysis
LA establishment
Research needs assessment
Feedback on results
Institutional mapping
Translation of results to strategic implications
Visioning
Decision support system
First city assessment
Strategy development
Scenario identification

臺中市政府水利局
TAICHUNG CITY GOVERNMENT WATER RESOURCES BUREAU

Riverine Environmental Improvement of the Tong-Tai Creek

Tong-Tai Creek – Drainage canal next to TungHai University

- 東大溪為南邊溪幹流，南邊溪收納東大溪後，流經高速公路後於筏子溪**右岸匯入**
- 東大溪於102年2月公告變更為**臺中市市管區域排水**

上位計畫指引

✓ 區域計畫及通盤檢討計畫定位筏子溪為**「生態景觀廊道」**並提供**民眾休閒遊憩**+**兼具生態觀察空間**

筏子溪各支流之水質改善為水域環境改善重要一環

✓ **東大溪為污染程度最高者**

✓ 上游104年設置**2,000CMD礫間淨化場**，晴天污水處理量僅**15%**左右

以東大溪上游 (東海夜市商圈下游約460公尺)作改善範圍

辦理東大溪水環境改善計畫，進行污水截流並研選礫間淨化場址進行水質淨化，改善東大溪10,000CMD晴天污水，一併進行鄰近區域環境改善，提升水環境品質

Public-Private Partnership: Environment Education

完整大學資源具公私
協力發展潛力

產、官、學投入
回應周邊環境需求

新舊都市發展完整
具開放空間需求

提供周遭學校環
境教育空間

觀光遊憩資源豐富
人潮活絡

營造優良生態水岸環
境，創造高典範特質

導入學校投入環境
營造與維護

串聯周邊國中小
發展環境教育

Planning Design for Tong-Tai Creek

Gravel-filter Waste Water Treatment

Plan

- Treatment Capacity：10,000CMD
- Treatment region area: 390m^3
- Water Quality: Severe polluted □ Light polluted

Removal rate：

Oil -97%
BOD -95%
SS -90%
NH_3 -84%

With 10,000CMD，daily remove:

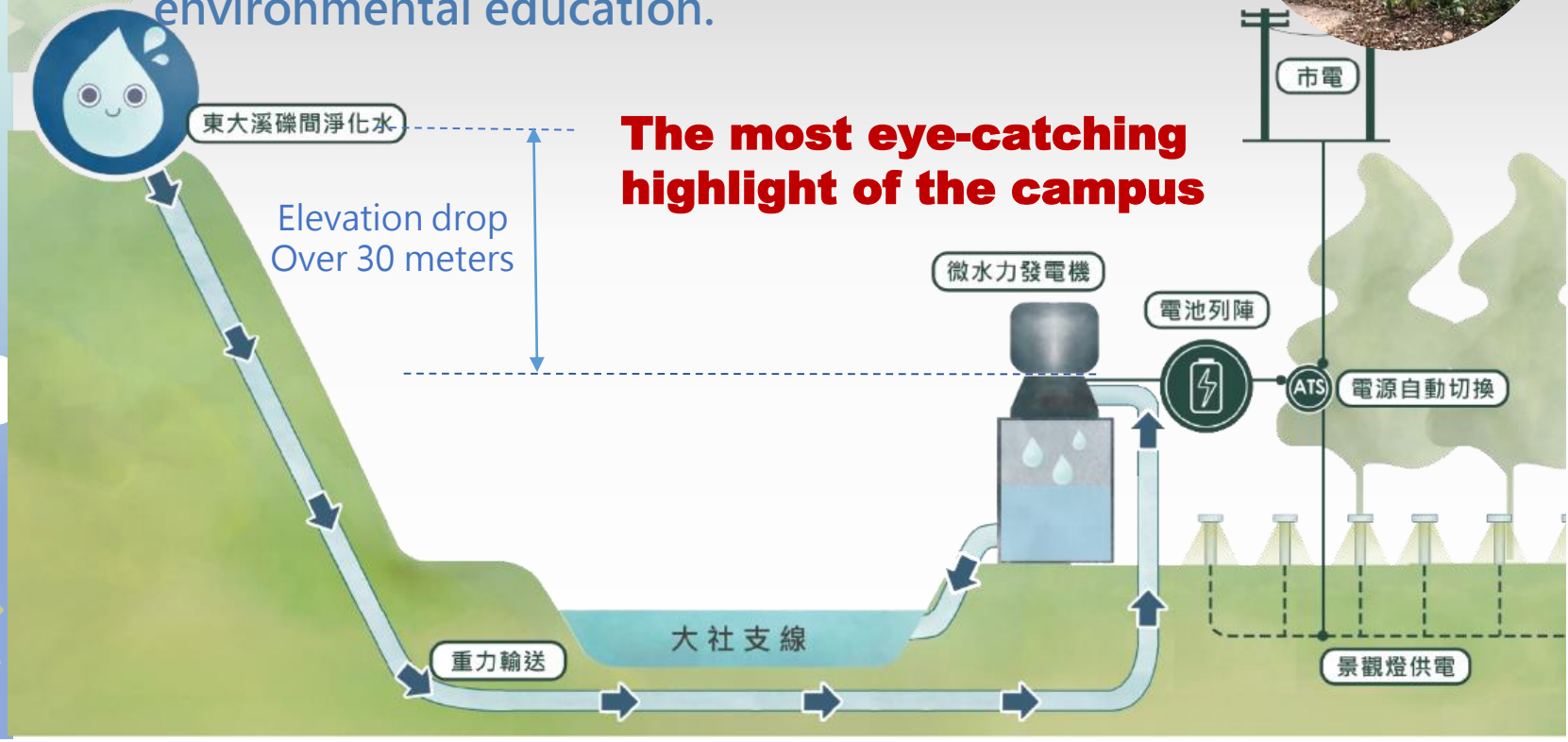
290 kg的Oil、1,900kg的BOD_5、900 kg的SS 、200 kg的NH_3。

科技創新、智能導入

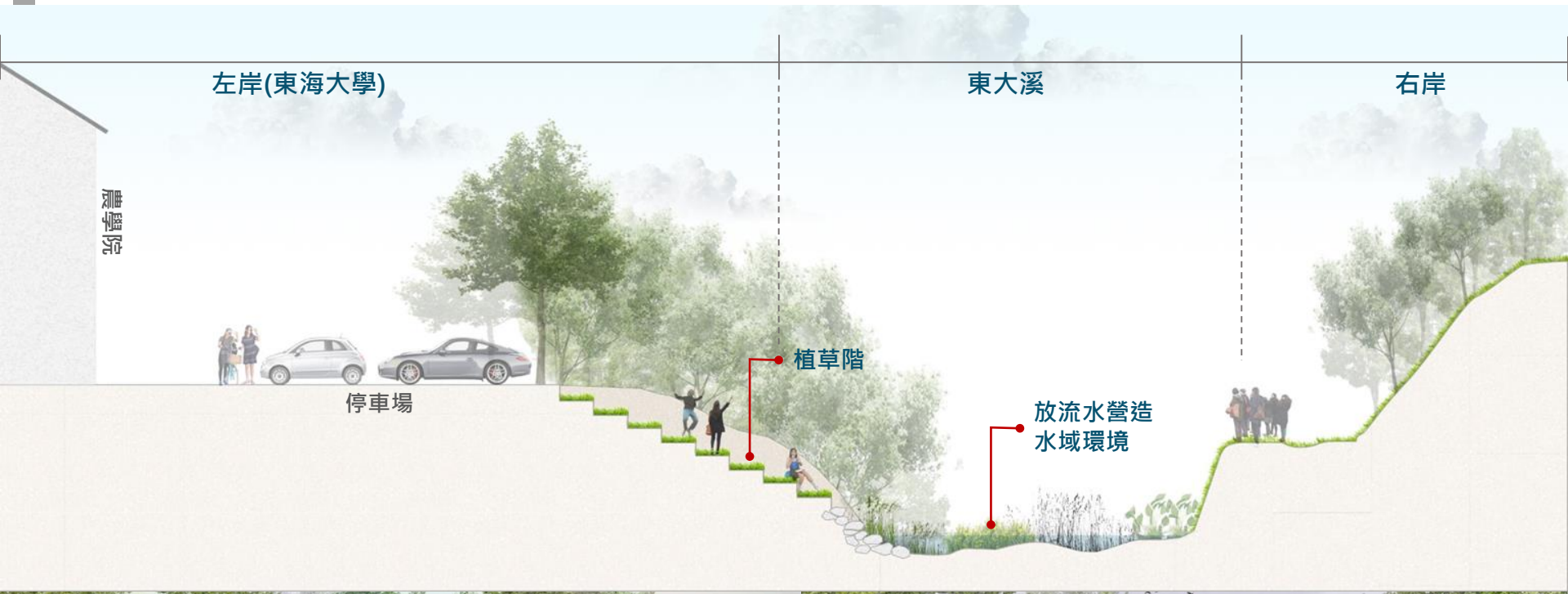
導入循環經濟及優質環境教育的素材

Micro-Hydropower

The facility is located next to the Harmonica Bridge, and can be used as a guide for school environmental education.



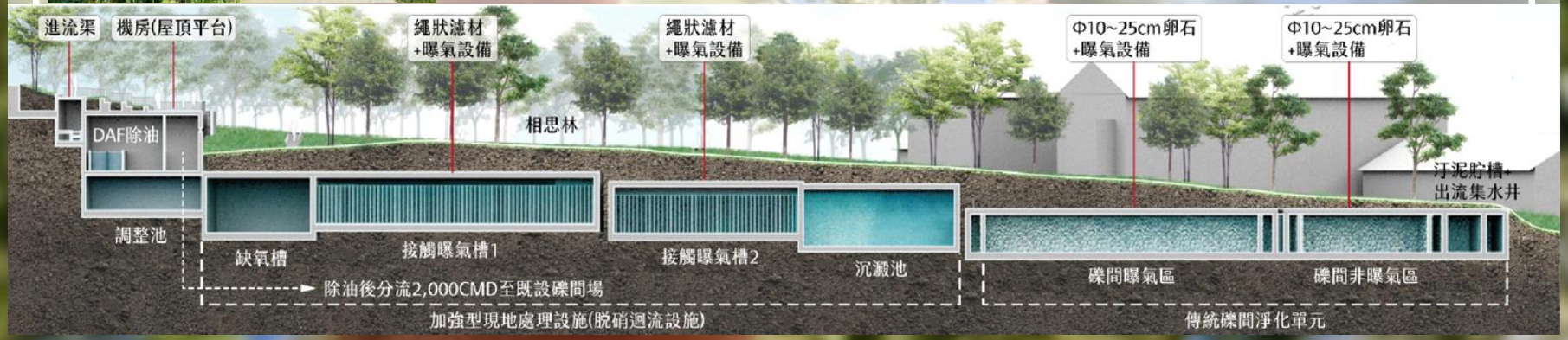
Estimated project funding of $10 million USD



Energy and Carbon Reduction for SDGs

Gravity drainage saving 108 ton carbon emission per year

Save about 537 kilowatt/hours per day



Before

After

Before

Before

After

After

Improve the surrounding environment

Public-Private Partnership

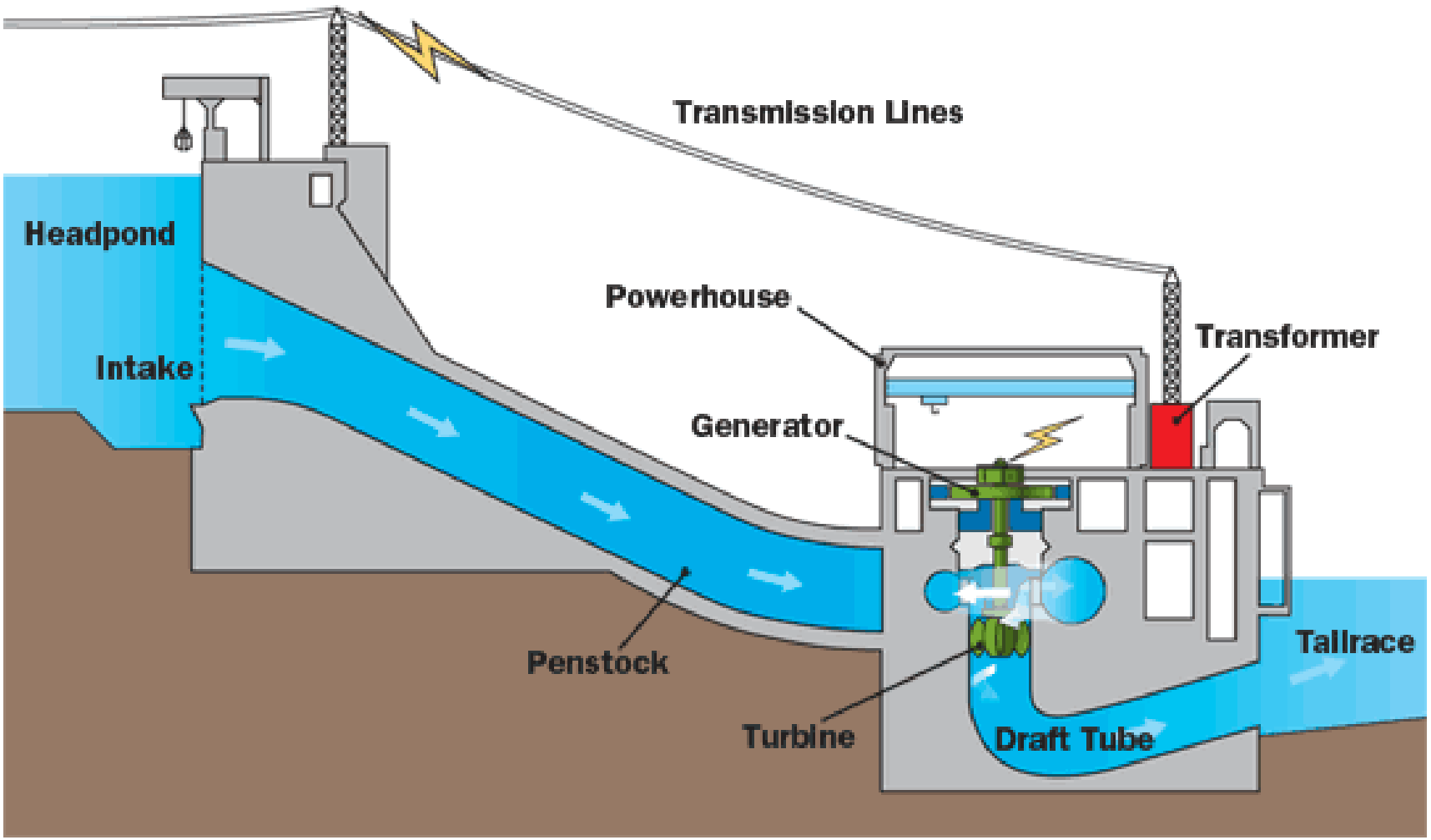
Sustainable Tong-Tai Creek

Water Purification+ Environmental Improvement + Ecological Rehabilitation + Sustainable Management

Bio-friendly Habitat

打造東大溪完美生態，串聯大肚溪與筏子溪綠網，許在地生態一個未來。透過大尺度棲地營造，將東大溪與大肚山氣地串聯，提供生態健全發展的空間。

Small Hydropower for Tung-Tai Creek Project



Small Hydropower plans in neighborhood

Estimation of Benefit Assessment for Small Hydropower

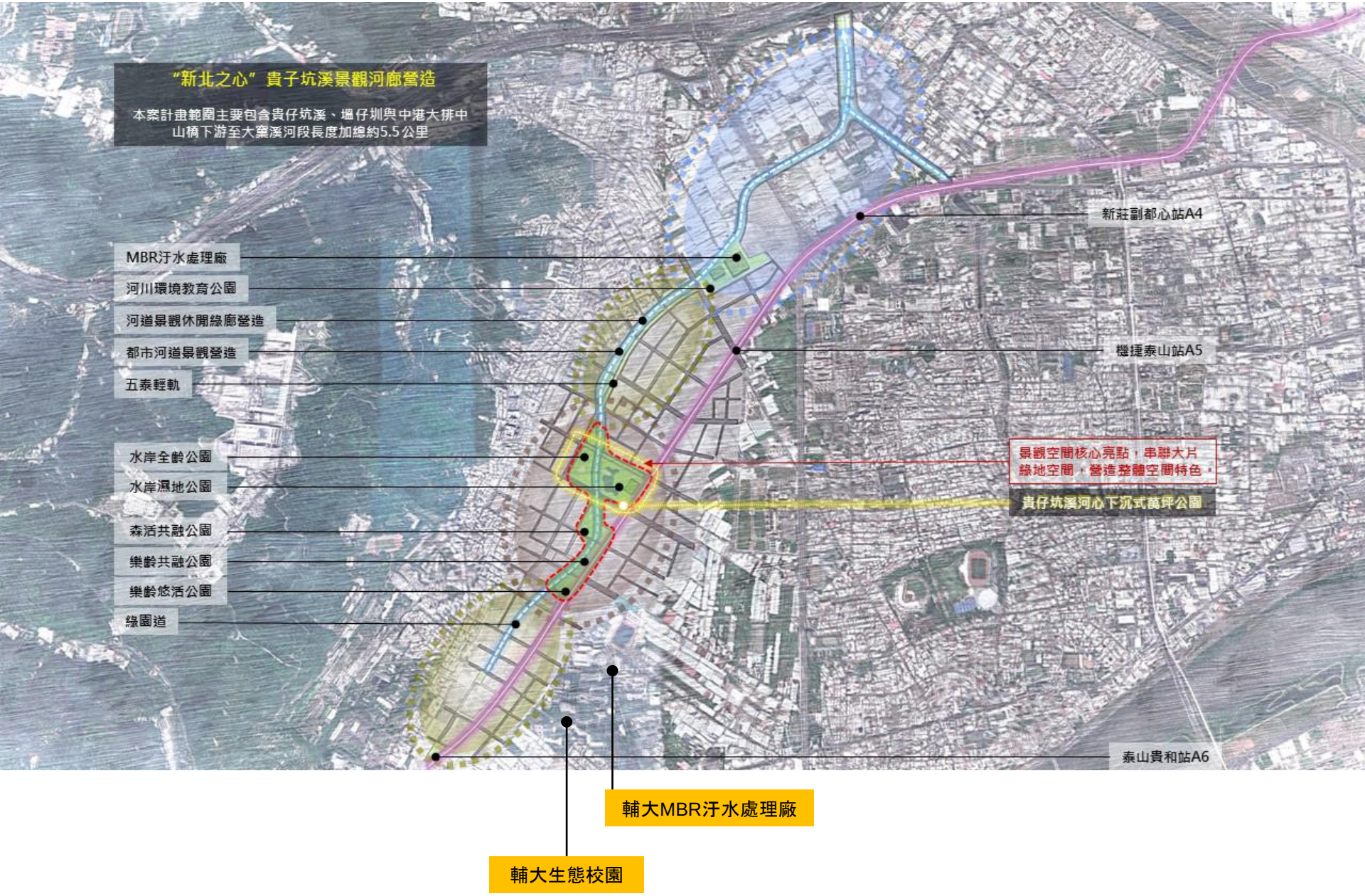
臺中市政府小水力發電第一階段開發預估效益統計表					
設置點位	發電潛力(KW)	每年發電度數	每年發電收入(元)	憑證數(張)	預估憑證售價(元)
食水嵙溪下游攔河堰	103	741,600	3,188,880	74	96,200
石岡水資源回收中心	13	102,960	442,728	10	13,000
雙翠水壩(食水嵙溪上游)	82	590,400	2,538,720	59	76,700
康橋(旱溪排水)	29	208,800	897,840	21	27,300
東大溪	9	64, 800	278,640	7	9,100
合計	236	1,708,560	7,346,808	171	222,300

- 每年發電日數：水資中心以330日計算，餘以300日計算
- 發電收入1度約4.3元，憑證1張預估售價約1300元

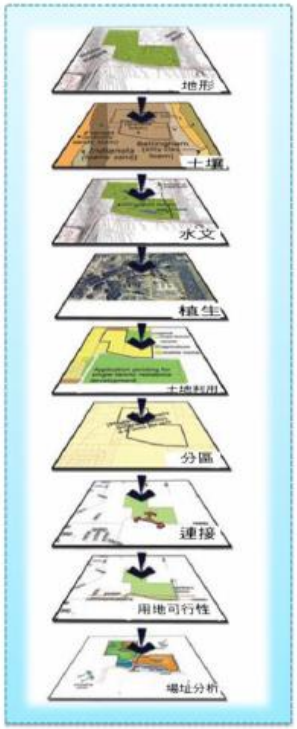
Fu-Jen Catholic University Eco Campus

Flooding issue

- LID
- MBR water recycling
- River restoration


"新北之心" 貴子坑溪景觀河廊營造
本案計畫範圍主要包含貴仔坑溪、堰仔圳與中港大排中山橋下游至大窠溪河段長度加總約5.5公里
新莊副都心站A4
MBR汙水處理廠
河川環境教育公園
河道景觀休閒綠廊營造
都市河道景觀營造
五泰輕軌
捷運泰山站A5
水岸全齡公園
水岸濕地公園
景觀空間核心亮點，串聯大片綠地空間，營造整體空間特色。
貴仔坑溪河心下沉式萬坪公園
森活共融公園
樂齡共融公園
樂齡悠活公園
綠園道
泰山貴和站A6
輔大MBR汙水處理廠
輔大生態校園

低衝擊開發設計流程➔ 水文分析



設計流程

確認實施場址範圍

基本資料蒐集與場址分析

決定設計目標
- 恢復開發前水文狀況
- 滿足出流管制目標

原狀態歷線
開發後歷線

低衝擊開發設施適用性評估與選擇

比較差異

低衝擊開發設施佈置規劃

採水理模式評估是否滿足設計目標

LID導入後歷線

是

低衝擊開發設施設計
- 減少場址總不透水面積
- 減少直接相連不透水面積
- 改善或增加排水路

監測與維護管理規劃

完成低衝擊開發設施場址設計

以雨量資料(IDF curve)、自行研發SWMM工具進行分析

設計暴雨
- 資料
- 雨型
- 頻率
- 延時

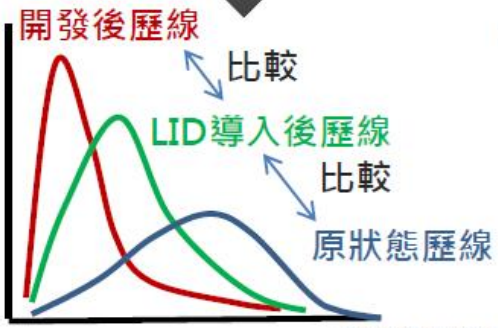
保水量 105 mm

地表逕流
- 漫地流流速
- 滯蓄洪

回復原出流歷線 or 逕流型指標

基地流出歷線
- 原始狀態
- 開發後
- LID導入

三條歷線



➔LID使用者了解使用後要達到多好的效果或要滿足什麼規定。

Institutional Problem

1. Can water resources agency solves the water problem in Taiwan?
2. Laws and Regulations
3. How to make decision under uncertainty?
4. Flexibility
5. Inter-discipline dialogue
6. Interagency coordination

In conclusion

- From local solution to integrated systems (networks)
- Calls for a new, resilient-based design approach
- Focus on system-wide services (performance)
- Three principles: day-to-day value, standardized events and failure

‘Five Golden Rules’ of flood risk management

1. Monitor and adapt

1. Do more with less

1. Seize the opportunity

1. Design for failure

1. Work in partnership

Key Message for science - policy co-op:

Climate change is not “a” problem waiting for “a” solution

An effective strategy to ensure sustainability in the context of climate change requires more than just good science and good communication … it requires …

✓ Trusted science

✓ Informed policy

✓ Motivated business

✓ Engaged public

WHAT NEEDS TO BE DONE ?

Quick and without loosing time

- Change the old patterns to think and live would help to solve problems of today
- Promote good intentions through **inspiring projects**
- Making new rules for the business and institutions
- Change ineffective system for renovated planning, design and decision making **creativity**
- Creating partnerships : **public－private－citizens**
- Create **new leadership** styles