Evaluation of the impacts of natural disturbances and anthropogenic activities on river ecohydrology and water quality in multiple watersheds

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Content

- Simulation of ecosystem service responses to multiple disturbances from an earthquake and several typhoons
- Quantification of land use/land cover impacts on stream water quality across Taiwan

An ecosystem is a dynamic complex of plant, animal, and microorganism communities an d the nonliving environment, interacting as a functional unit (MA, 2005).

Ecosystem Services

Provisioning Services

Products obtained from ecosystems

- Food
- Fresh water
- Fuelwood
- Fiber
- Biochemicals
- Genetic resources

Regulating Services

Benefits obtained from regulation of ecosystem processes

- Climate regulation
- Disease regulation
- Water regulation
- Water purification
- Pollination

Cultural Services

Nonmaterial benefits obtained from ecosystems

- Spiritual and religious
- Recreation and ecotourism
- Aesthetic
- Inspirational
- Educational
- Sense of place
- Cultural heritage

Supporting Services

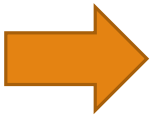
Services necessary for the production of all other ecosystem services

- Soil formation
- Nutrient cycling
- Primary production

(MA, 2005)

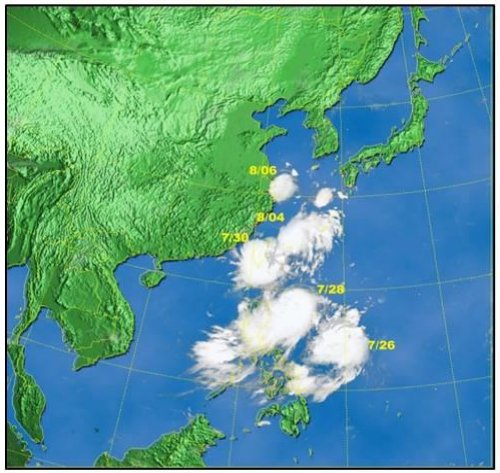
Impact of disturbances on an ecosystem

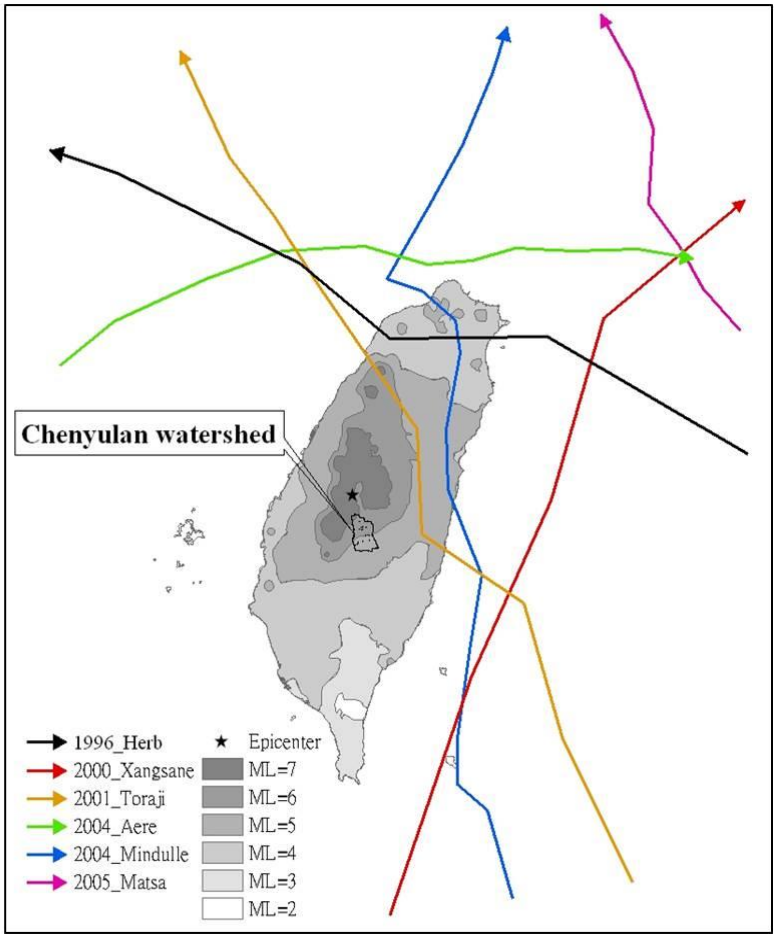
- A previous disturbance can significantly affect an ecosystem's response to a new disturbance (Paine et al., 1998; Turner, 2010), possibly altering the ecosystem resilience further.
- Ongoing environmental disturbances (e.g., climate variation and anthropogenic activities) alter an ecosystem gradually over time.
- Sudden large disturbances (e.g., typhoons and earthquakes) can have a significant and immediate impact on landscapes and ecosystem services.



Four ecosystem services (water yield production, water purification, soil conservation, carbon storage) and biodiversity were simulated by using the InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) model to analyze the spatiotemporal changes in the ecosystem.

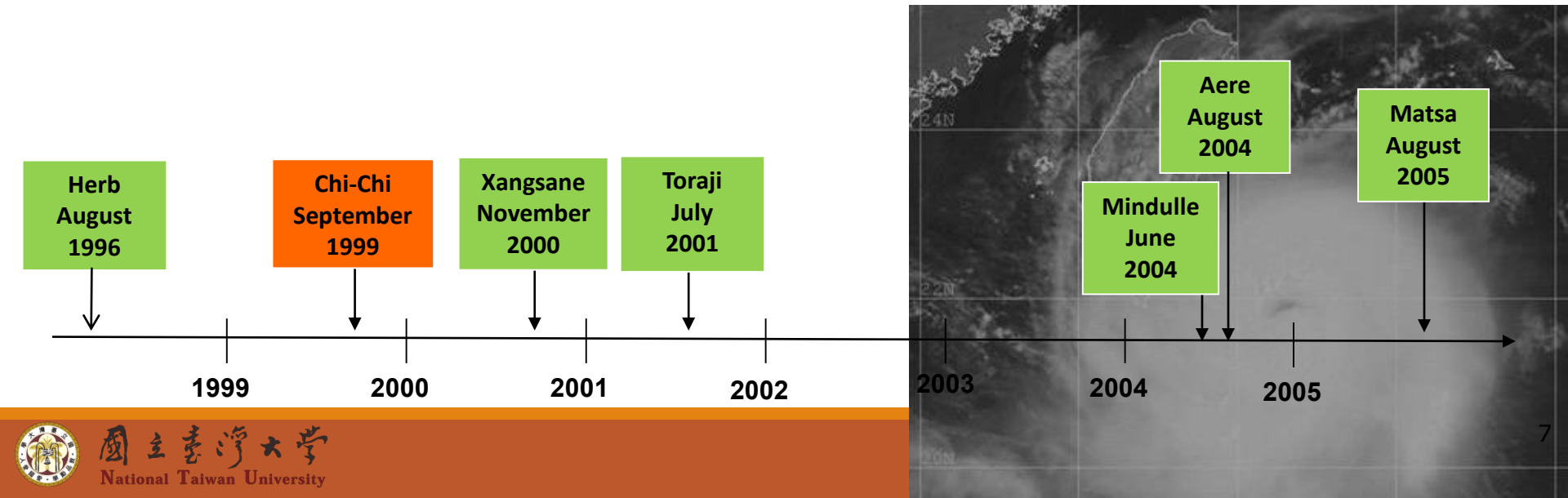
Case study: Chenyulan watershed, Taiwan



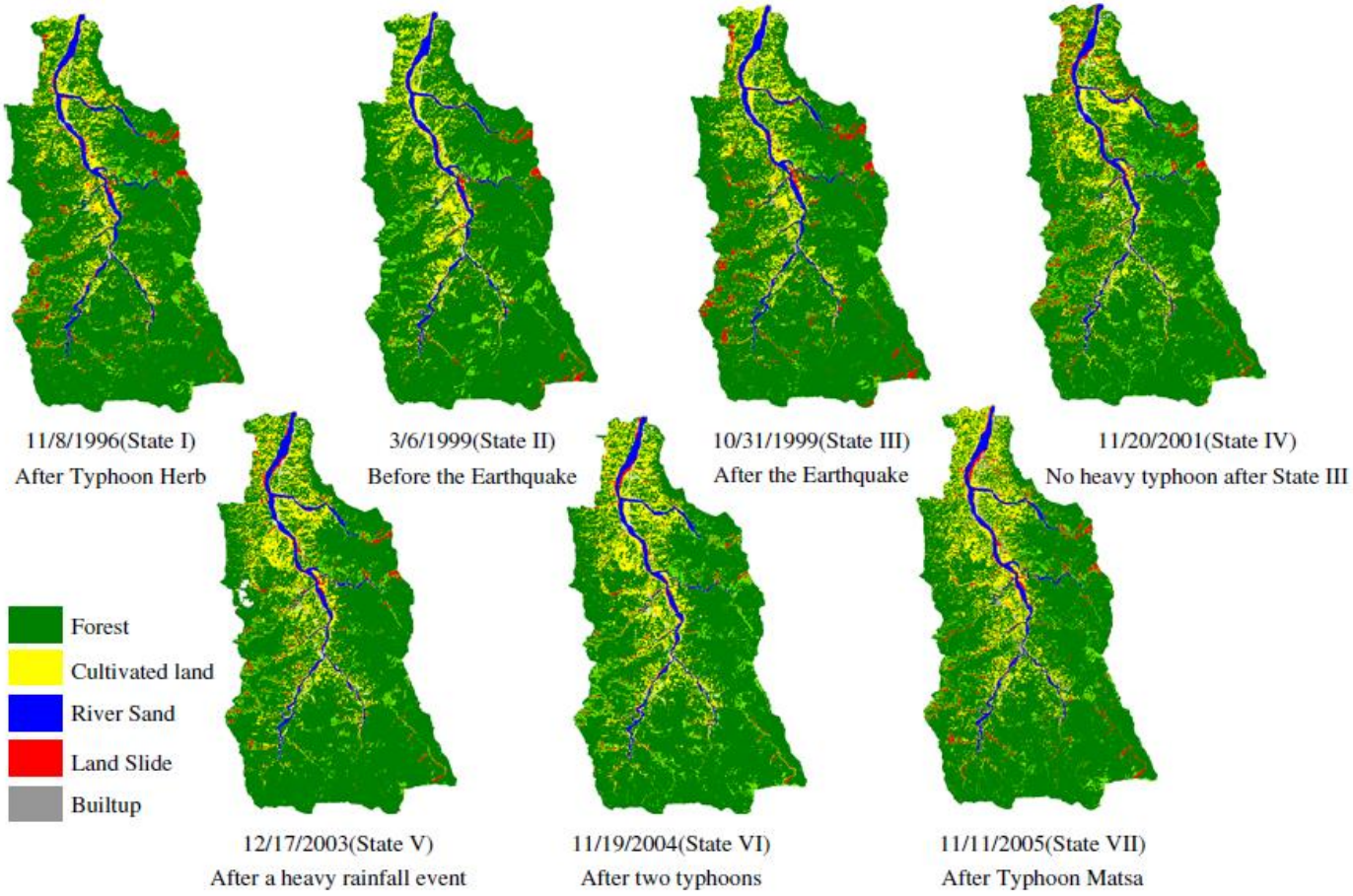


Multiple large disturbances

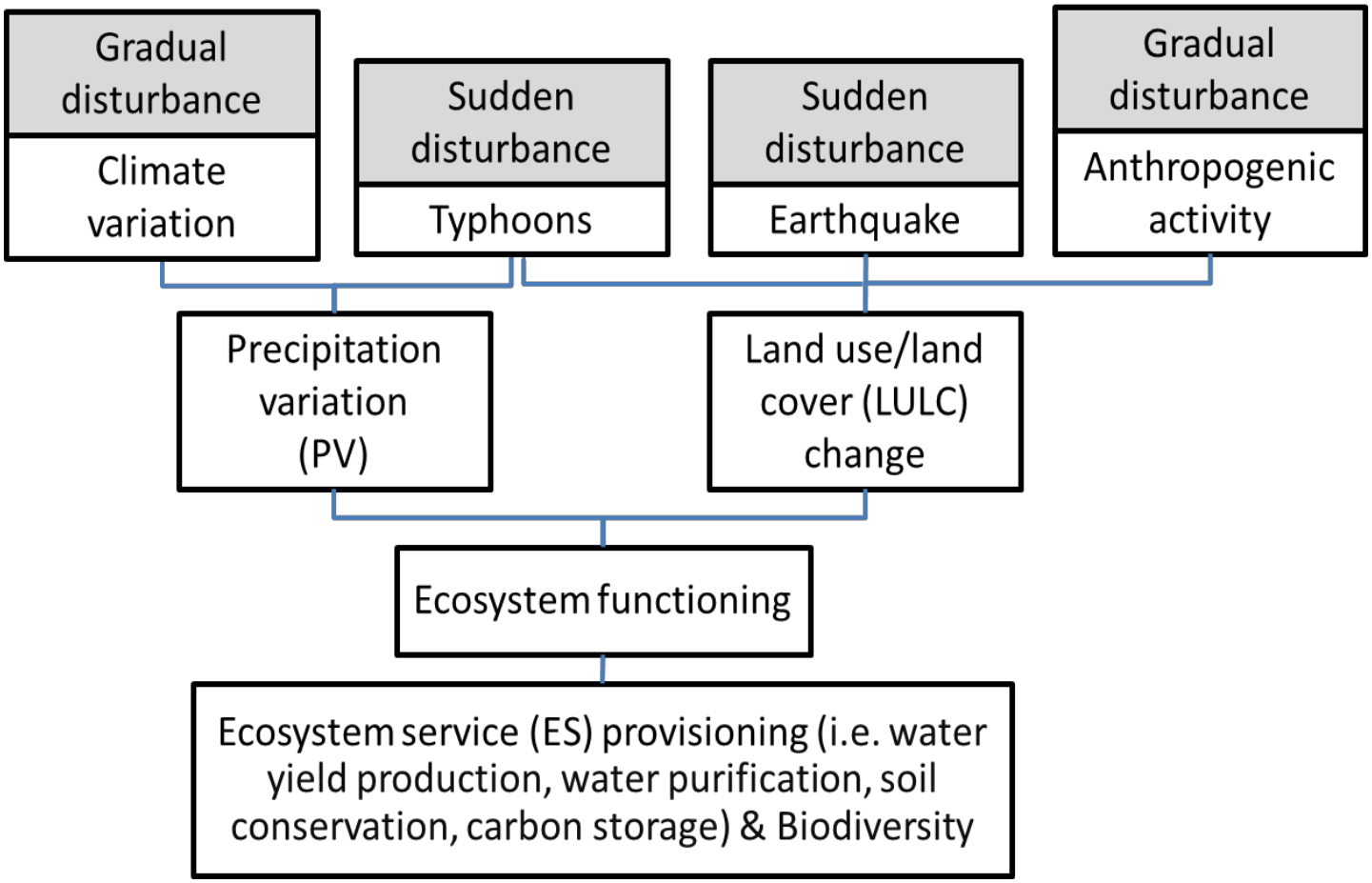
- During 1996–2005, large disturbances impacted central Taiwan: (1) typhoon Herb (August 1996); (2) the Chi-Chi earthquake (September 1999); (3) typhoon Xangsane (November 2000); (4) typhoon Toraji (July 2001); (4) typhoon Mindulle (June, 2004); (5) typhoon Aere (August 2004) and (6) typhoon Matsa (August 2005).



Landscape change during 1996-2005



Identify different impacts on ecosystem services



InVEST model

- Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) was developed by the Natural Capital Project (Tallis et al., 2011).
- InVEST consists of a suite of models that use land use/land cover patterns to estimate the levels and economic values of ecosystem services, biodiversity conservation, and market value of commodities provided by a landscape (Nelson et al., 2009).

Parameters for simulation of nutrient retention, soil conservation and carbon storage in the InVEST model.

Ecosystem service	Parameters	Land use/land cover (LULC) classes						
		Riparian	Grass	Built-up land	Cultivated land	River sand	Landslide	Forest
Nutrient retention	N load (kg/ha)	1	1	3.5	16	3.5	3.5	1.6
	N retention efficiency (%)	50	50	0	5	0	10	80
	P load (kg/ha)	0.1	0.1	0.5	0.5	0.5	0.5	0.25
	P retention efficiency (%)	50	50	0	5	0	10	80
Soil conservation	USLE_C	0.01	0.01	0.01	0.1	1	1	0.01
	USLE_P	1	1	1	1	1	1	1
	TSS retention efficiency (%)	40	40	5	30	5	5	60
Carbon storage	C above (Mg/ha)	1	1	0	3	0	1	200
	C below (Mg/ha)	1	1	0	2	0	1	130
	C soil (Mg/ha)	0	10	0	10	0	10	130
	C dead (Mg/ha)	0	0	0	0	0	0	65

Note: C above = carbon in aboveground biomass; C below = carbon in belowground biomass; C dead = carbon in dead organic matter; C soil = carbon in soil.

Hotspot definition

- Hotspot were those that provided a large amount of a single service and those that provided a large number of various services.
- Single-service hotspots were those areas with the highest 20% of a provision value (level) among the pixels for each service (Bai et al., 2011).
- Ecosystem services–habitat quality (ES-HQ) richness hotspots were defined as the areas of overlap of at least three ES hotspots.

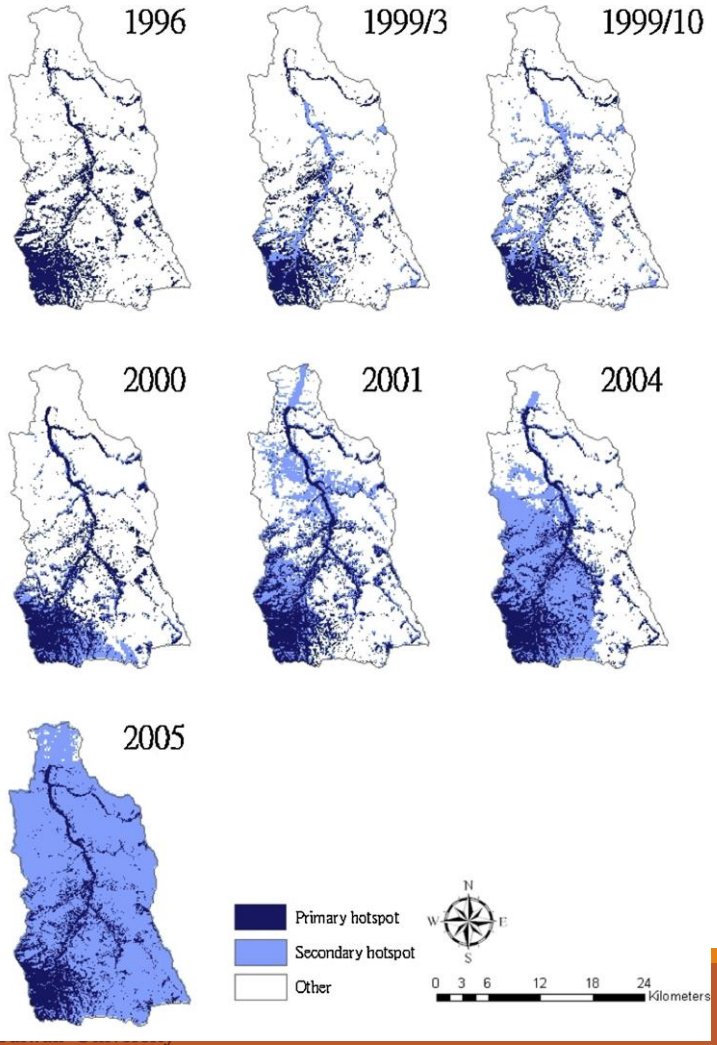
Differentiation of impacts of climate change and landscape change on ecosystem services

- **Assumption**: human activities have relatively low impact than the impact of sudden and high intensive natural disturbances.
- **Baseline**: land use and annual precipitation in 1996
- The ecosystem services for all years were modeled with the dynamic (corresponding precipitation) and fixed (1996 precipitation) climate condition.
- Based on the hotspots of habitat quality and five ecosystem services (i.e., water yield, N, P and sediment retention, and carbon storage), a map of ES-HQ richness by super imposing the six hotspot maps was developed.

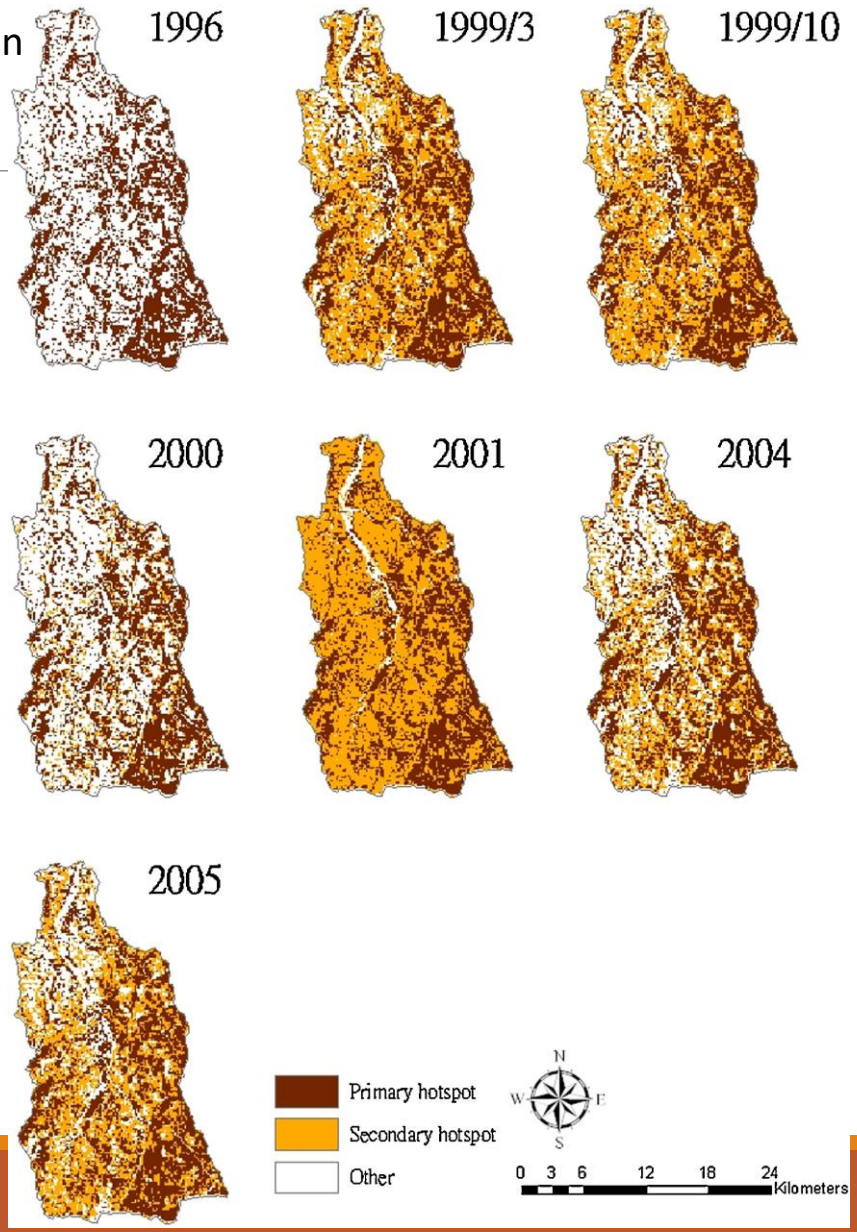
Ecosystem Services hotspots

- Primary hotspot under baseline climate condition
- Secondary hotspot under corresponding climate condition

Water yield hotspot

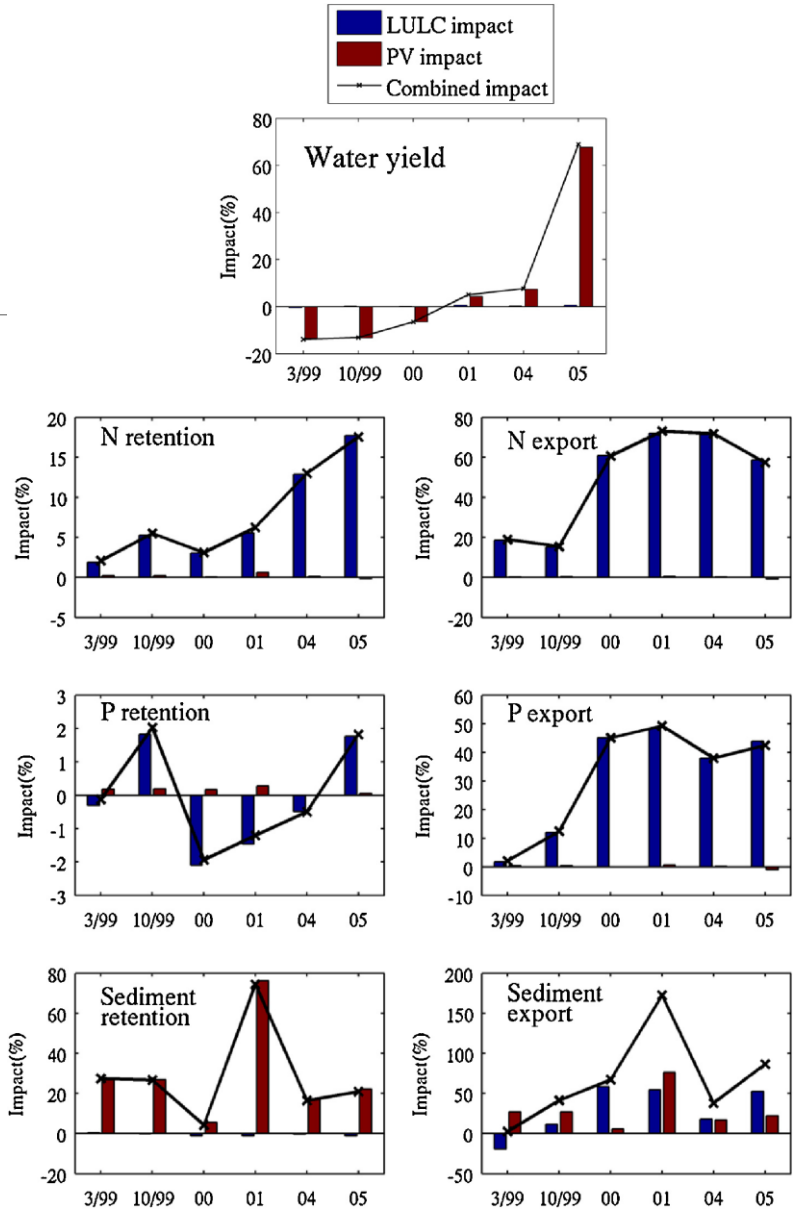


Sediment retention hotspot



Individual impacts on ecosystem services

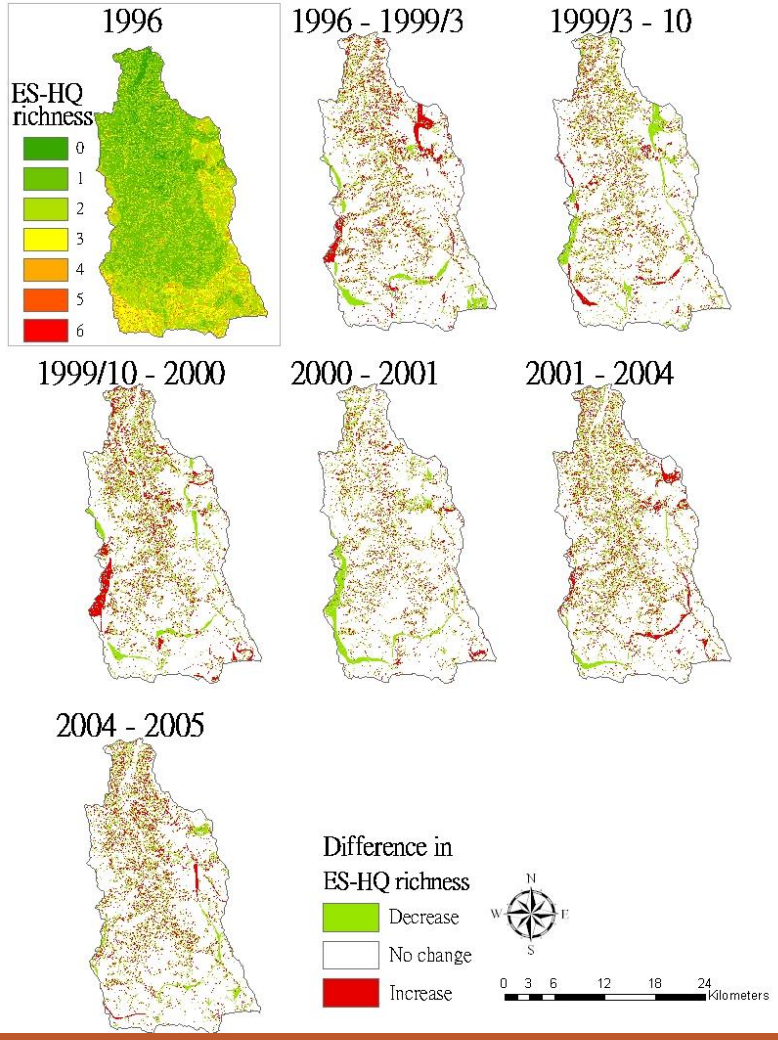
- Comparing with the 1996 baseline climate condition, it revealed a 6.5–13.4% decrease in the water yield before 2001 and a 4.4–67.8% increase after 2001, with the highest water yield in 2005, mainly due to the variation in annual precipitation.
- Unlike the extent to which the PV significantly impacted the water yield, the climate only slightly impacted the N and P retention.
- The cumulative impact of the LULC and climatic change on the amount of sediment exported was twice as high in 2001 than in 1996.



Land use/land cover (LULC), precipitation variation (PV) and combined impacts on ES during March 1999–2005.

Identification of ES-HQ richness for future landscape planning and management

- Those areas containing more than three hotspot types were areas warranting additional protection.
- The ES-HQ richness appeared to be relatively stable (white colored) over time in most of the areas of the watershed.
- The differences in the ES-HQ richness in any sequential year was between 7 and 12% (green and red colors denote decreased and increased ES-HQ richness), and these changes occurred primarily in grassland, cultivated land and forested areas.

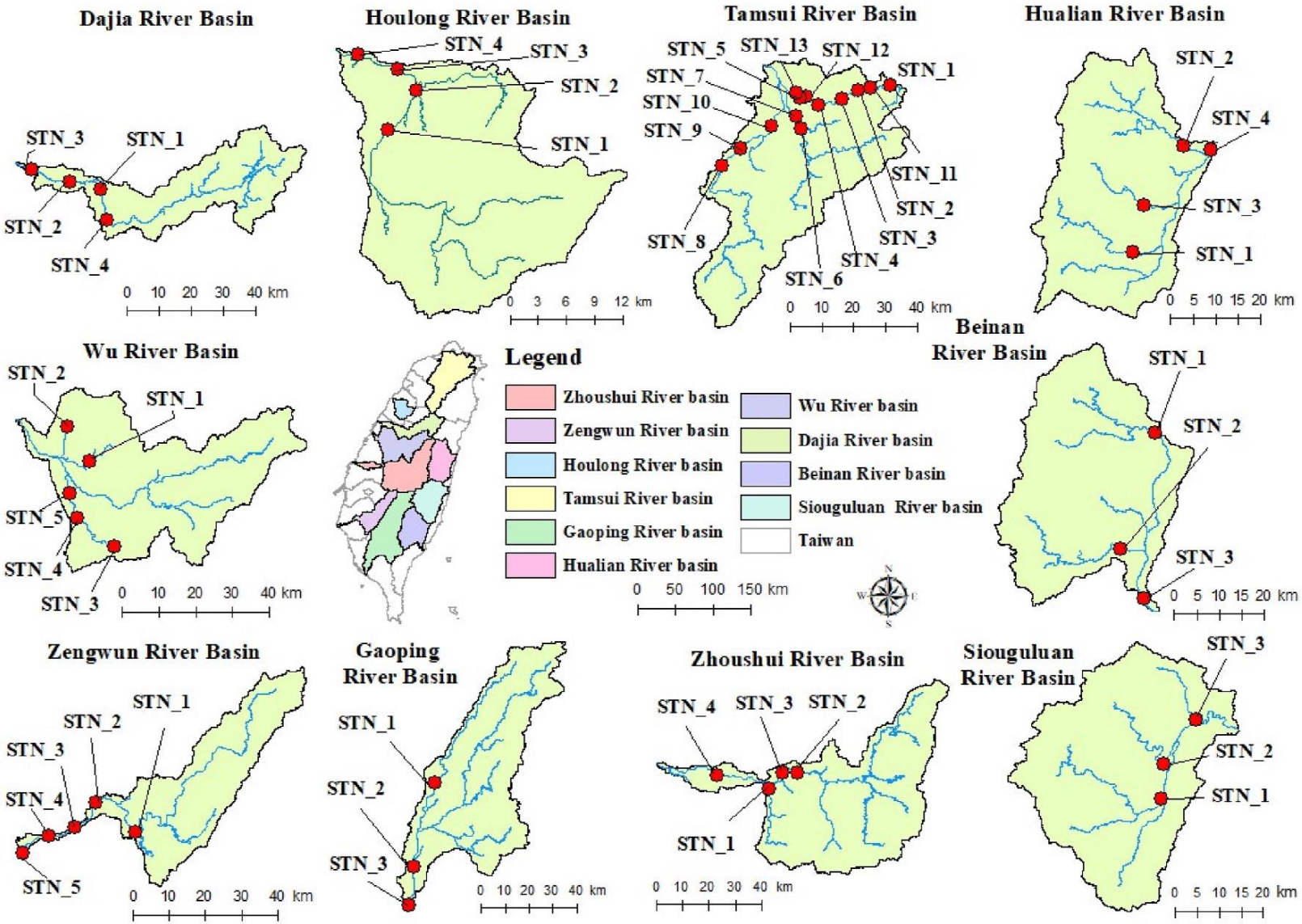


Impacts on ecosystem resilience

- The ES-HQ richness can serve as an indication of the number of ecosystem services operating at high levels in an area.
- Before the earthquake, the ES-HQ richness was lower yet relatively stable. However, the Chi-Chi earthquake resulted in a more complex ecosystem with a higher diversity and greater spatial variations.
- Our results confirm the results of Lin et al. (2006), who found that the typhoons and earthquake increased the complexity of the land cover in terms of a more scattered landscape pattern after 2000.
- Notably, the subsequent typhoons impacted the ecosystem less than did the earthquake.

Quantification of land use/land cover impacts on stream water quality

- Change in water quality is seen as a reflection of change in terrestrial and aquatic ecosystems that are degraded by anthropogenic activities, including inappropriate land use management, deforestation, and urbanization.
- 48 water quality stations within 10 basins across Taiwan are investigated to identify the relationships among various water quality indices, land use/land cover, and landscape metrics at two different time periods.


Dajia River Basin
STN_3
STN_1
STN_2
STN_4
0 10 20 30 40 km
Houlong River Basin
STN_4
STN_3
STN_2
STN_1
0 3 6 9 12 km
Tamsui River Basin
STN_5
STN_13
STN_12
STN_1
STN_7
STN_10
STN_9
STN_11
STN_2
STN_8
STN_3
STN_4
STN_6
0 10 20 30 40 km
Hualian River Basin
STN_2
STN_4
STN_3
STN_1
0 5 10 15 20 km
Wu River Basin
STN_2
STN_1
STN_5
STN_4
STN_3
0 10 20 30 40 km
Legend
Zhoushui River basin
Zengwun River basin
Houlong River basin
Tamsui River basin
Gaoping River basin
Hualian River basin
Wu River basin
Dajia River basin
Beinan River basin
Siouguluan River basin
Taiwan
0 50 100 150 km
N
W
E
S
Beinan River Basin
STN_1
STN_2
STN_3
0 5 10 15 20 km
Zengwun River Basin
STN_1
STN_2
STN_3
STN_4
STN_5
0 10 20 30 40 km
Gaoping River Basin
STN_1
STN_2
STN_3
0 10 20 30 40 km
Zhoushui River Basin
STN_4
STN_3
STN_2
STN_1
0 10 20 30 40 km
Siouguluan River Basin
STN_3
STN_2
STN_1
0 5 10 15 20 km

Water quality data

- Water quality data during 1990–2017 were collected from 48 stations of Taiwan Environmental Protection Administration (EPA) and parameters used for analysis include: water temperature (Temp), pH, electric conductivity (EC), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended sediment (TSS), total phosphorus (TP), ammonia nitrogen (NH3–N), nitrate nitrogen (NO3–N), nitrite nitrogen (NO2–N), and total nitrogen (TN).

- The water quality data were divided into two periods (1990–2002 and 2003–2017) during which the water quality was possibly influenced by the land use change during 1993–1995 (denoted as 1994 land use) and 2006–2009 (denoted as 2007 land use), respectively.

Landscape metrics

- The software FRAGSTATS v4, developed by the USDA to quantify the composition and spatial configuration of land cover types (McGarigal et al., 2012).
- To quantify the relationships between landscape metrics and water quality indices, linear regression was applied to the selected landscape metrics (i.e. CONTAG, SHDI, IJI, PD, LPI, GYRATE_AM, SPLIT, and AI) and water quality indices (i.e. BOD, EC, NH3–N, and NO3–N) in the river basins.

List of selected landscape metrics at the class and landscape levels.

Landscape metrics	Abbreviation	Description
Patch density	PD	The number of patches per unit area (number per 100 ha)
Largest patch index	LPI	The area of the largest patch of the patch type divided by total landscape area (unit: %)
Edge density	ED	The total length of all edge segments of the patch divided by the total landscape area (unit: m/ha)
Area-weighted mean radius of gyration	GYRATE_AM	The sum of the radius of gyration multiplied by the proportional abundance of the patch (unit: m)
Mean shape index	SHAPE_MN	Mean patch perimeter divided by the minimum perimeter of the corresponding land use area (unitless)
Area-weighted mean patch fractal dimension index	FRAC_MN	Area weighted mean fractal dimension index (unitless)
Mean Euclidean nearest neighbor index	ENN_MN	Distance to the nearest neighbouring patch of the same type based on the edge-to-edge distance (unit: m)
Splitting index	SPLIT	The number of patches obtained with subdividing the landscape into equal-sized patches based on the area-weighted mean patch size (unitless)
Interspersion and Juxtaposition index	IJI	Measures the extent to which patch types are interspersed, with the highest value occurring when the corresponding patch type is equally adjacent to all other patch types (unit: %)
Aggregation index	AI	Number of like adjacencies involving the corresponding land use type, divided by the maximum possible number of like adjacencies involving the corresponding land use type (unit: %)
Contagion[a]	CONTAG	Tendency of land use types to be aggregated (unit: %)
Shannon's diversity index[a]	SHDI	A measure of diversity in community ecology; indicates the patch diversity in a landscape (unitless)

[a] Calculated at landscape level only.

Spatial variation in landscape metrics for different watersheds

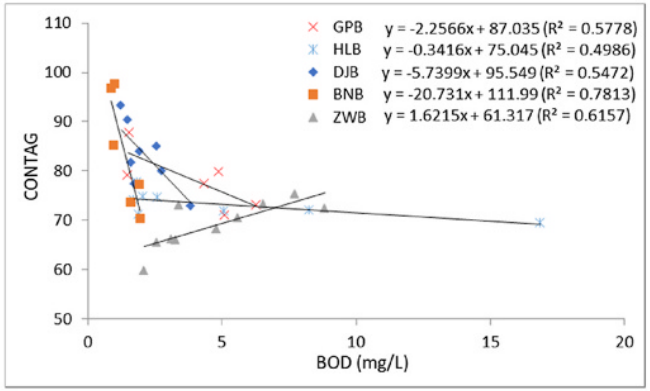
- Wide ranges of PD, LPI and ED were found indicating a large variation in landscape of each basin.
- The Wu River basin has the largest PD, ED, SPLIT and SHDI with smallest LPI GYRATE_AM, and CONTAG, showing that the Wu River basin has the most fragmented and dispersed landscape compared to the other basins.
- Generally, the IJI and AI values are similar for all basins, indicating similar characteristics of interspersion and aggregation.

Average values of selected landscape metrics for the basins.

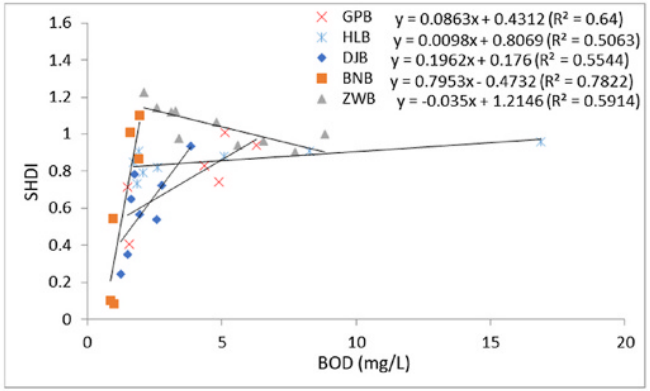
Basin\Metrics	PD	LPI	ED	GYRATE_AM	SPLIT	IJI	AI	CONTAG	SHDI
Tamsui River (TSB)	51.00	69.68	102.88	6664.07	2.35	71.40	94.83	76.74	0.74
Houlong River (HLB)	49.67	65.65	111.72	5103.68	2.37	67.95	94.41	73.32	0.86
Dajia River (DJB)	16.78	80.49	40.24	12444.77	1.59	65.74	97.96	83.14	0.60
Wu River (WUB)	145.71	21.56	238.86	1392.48	18.64	66.68	88.07	57.53	1.27
Zhoushui River (ZSB)	29.80	69.14	75.70	10201.38	2.34	63.28	96.21	77.87	0.74
Zengwun River (ZWB)	36.90	49.87	99.06	7285.09	4.54	66.51	95.03	69.10	1.05
Gaoping River (GPB)	23.00	73.47	54.13	16539.67	1.90	68.75	97.27	78.11	0.77
Hualien River (HUB)	9.49	85.72	27.62	7517.72	1.43	58.28	98.60	88.68	0.39
Beinan River (BNB)	5.26	57.59	22.96	7169.22	5.44	57.08	98.85	83.53	0.62
Siouguluan River (SGB)	13.88	76.83	37.97	8540.98	1.77	66.77	98.09	84.91	0.53
Average	44.28	64.39	91.53	7663.34	4.27	66.52	95.41	76.30	0.78

Spatio-temporal variation in the relationship among landscape metrics and water quality (1/2)

- Good relationships of BOD and CONTAG, and BOD and SHDI were found for the Houlong River basin (HLB), Dajia River basin (DJB), Zengwun River basin (ZWB), Gaoping River basin (GPB), and Beinan River basin (BNB) in Figs. (a) and (b).
- The negative relationship between BOD and CONTAG, and positive relationship between BOD and SHDI were found for these basins, except for the Zengwun River basin (ZWB).



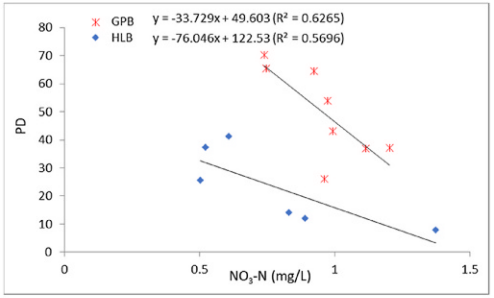
(a) BOD-CONTAG



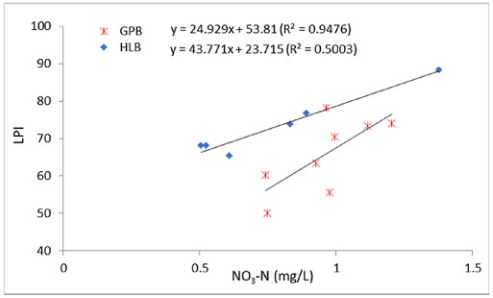
(b) BOD-SHDI

Spatio-temporal variation in the relationship among landscape metrics and water quality (2/2)

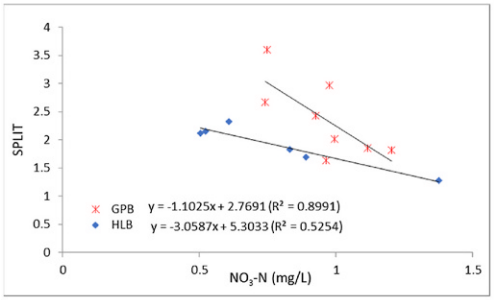
- Among the studied basins, both Gaoping and Houlong River basins showed significant relationships of NO3–N with PD, LPI, SPLIT, and AI in Figs. (g)–(j).



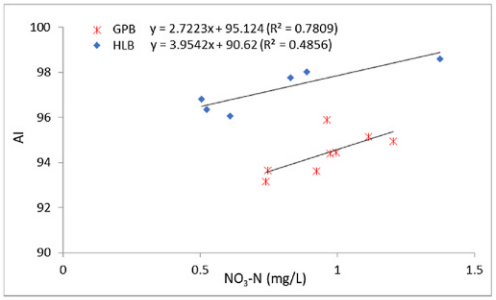
(g) NO_3-N-PD



(h) NO_3-N-LPI

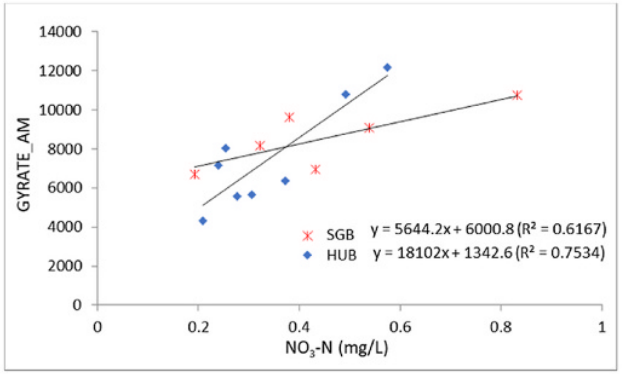


(i) NO_3-N-SPLIT



(j) NO_3-N-AI

- The positive relationship between NO3–N and GYRATE_AM found for the Siouguluan and Hualien River basins in Fig. (k), indicating that the basins may have more traversable AGRL patches to facilitate the NO3–N export.



(k) NO_3-N-GYRATE_AM

Conclusions (1/2)

- Both precipitation variation (PV) and land use/land cover (LULC) changes induced by multiple disturbances could affect the functioning of an ecosystem.
- The PV had greater impact on the water yield and soil retention than LULC, however, the latter impacted the nutrient retention more.
- Given the dynamic and non-equilibrium nature of the ecosystem, the changes in ES-HQ richness indicate the non-equilibrium states of the ecosystem due to the degradation of ecosystem resilience, particularly after the Chi-Chi earthquake.
- The ES-HQ richness can serve as an index to identify areas that provide at least three ecosystem services and/or habitat quality and areas that are sensitive to large physical disturbances.

Conclusions (2/2)

- The intercorrelation analysis of landscape metrics and water quality showed that LPI, CONTAG, and AI were significantly affected by the largest land use type, forest, in the river basins.
- The indices (i.e. PD, ED, and SHDI), which reflected the fragmentation and heterogeneity of the landscape patches in the river basins, showed more significant relationships in the land use types (i.e. HYDR, URBN, TRAN, RECR, MINE, and OTHR), which were pollution sources and located more dispersed in larger extents.
- Three (i.e. the Houlong, Gaoping, and Beinan River basins) out of 10 river basins had strong or moderate impacts of landscape variation on water quality, while the other 7 river basins showed slight impacts of landscape variation.

Thank you for listening.

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TAIWAN INT'L WATER WEEK

Sep. 10 ‣ 11
TICC台北國際會議中心

Water Towards Safety、Sustainable Environment and Prosperity

水與安全、環境、發展

Proponent: The 5th River Management Branch, WRA
Chief Construction Section Wu Chai Wei
水利署第五河川分署 工務科科長 吳嘉偉

Topic 1 - Experimental Coastal Defense Project in Dongshi, Chiayi (including Waisanding Sandbar)

嘉義縣東石地區(含外傘頂洲)海岸防護試辦工程

Topic 2 - Hoowave The Water Factory

虎尾鎮-虎尾水塘場

Topic 1

Experimental Coastal Defense Project in Dongshi, Chiayi (including Waisanding Sandbar)

嘉義縣東石地區(含外傘頂洲)海岸防護試辦工程

Outline

PART 1 Introduction (外傘頂洲簡介)

PART 2 Strategies of Sand Bar Protection(外傘頂洲防護策略)

PART 3 Engineering achievements (工程成果)

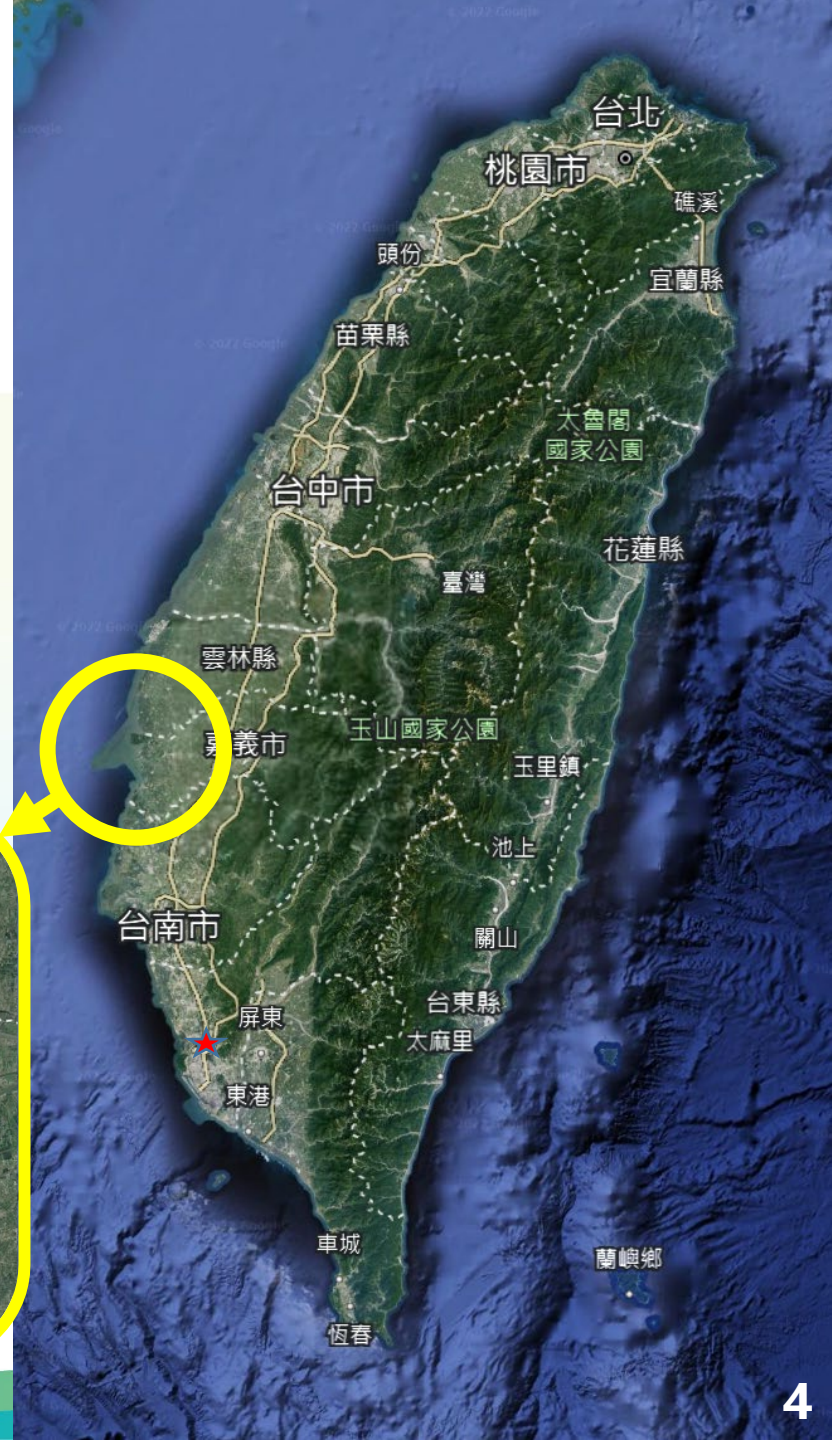
PART 4 Strategies of Shuangchun coast Protection
(雙春海岸防護策略)

PART 5 Conclusions and Further works （ 結論與未來工作)

外傘頂洲簡介(Introduction)


台灣永續聯盟舉辦「外傘頂洲一日遊」，參觀外傘頂洲上的竹篙寮。（記者廖淑玲翻攝）

竹篙寮右側的竹筒旁原本釘有門牌「口湖鄉蚵寮126之201號」。（記者廖淑玲攝）



外傘頂洲簡介(Introduction)

- Waisanding Sand Bar Scouring
- 2003 → 2021

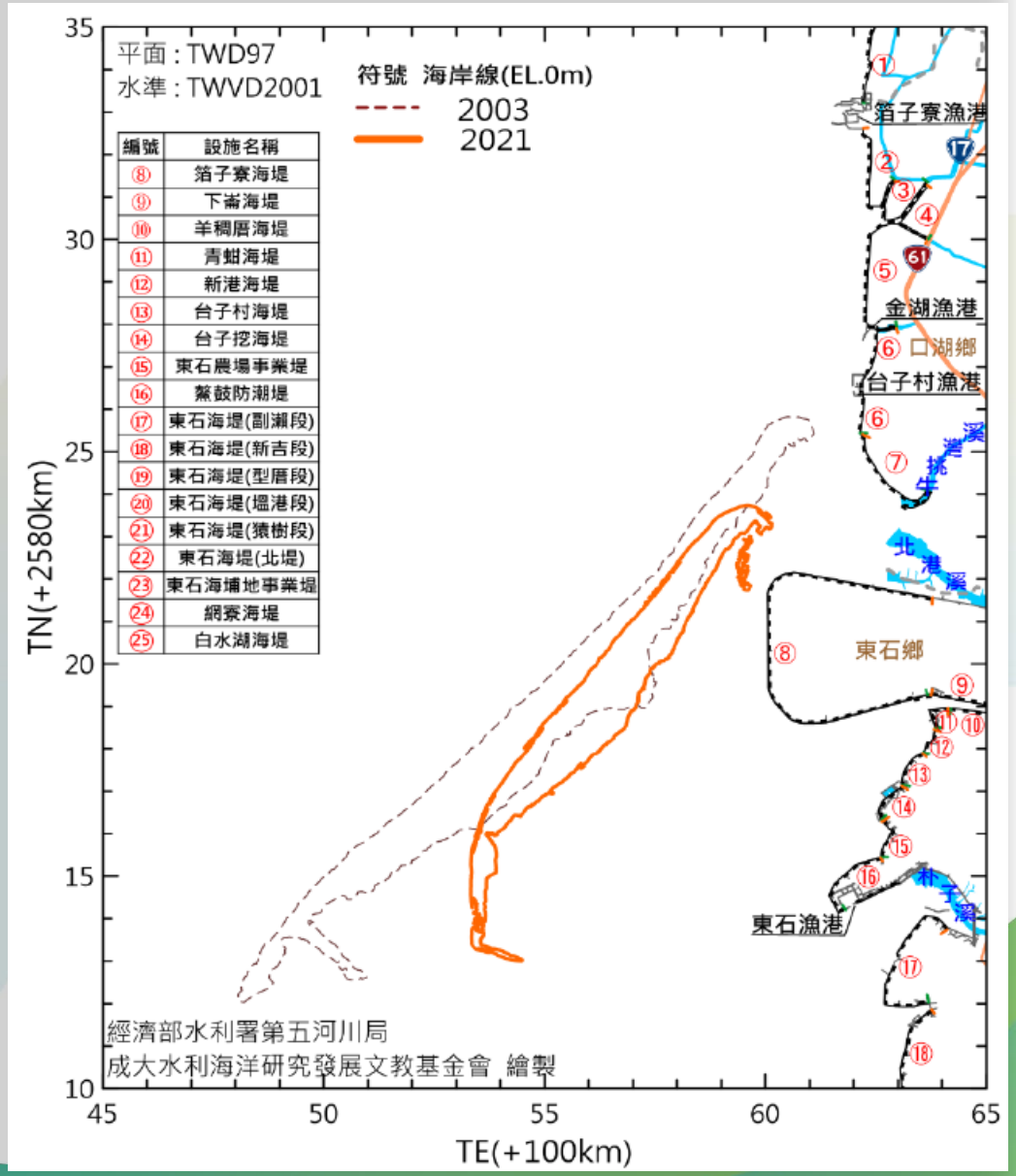
  Area decreasing 1,812 to 1,067 hectares (面積縮小)
- Sand bar moving south

  95 meters year average (南移平均95m/年)
- South side of sand bar

  Moving eastward 162 meters Year

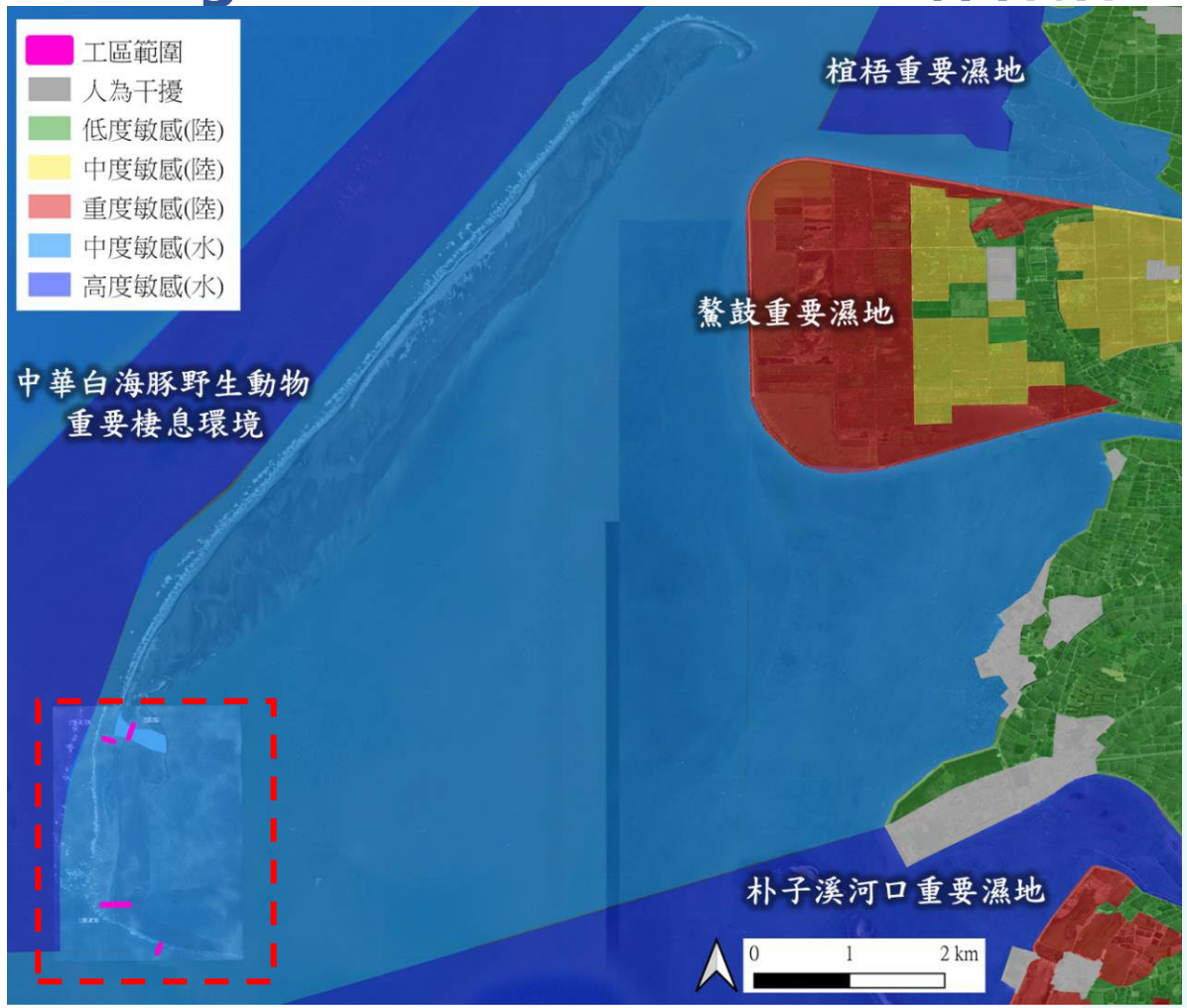
  average toward Chayi coast (往嘉義東移平均 162m/年)
- One direction sediment transport caused sand loss
- Some sediment transport goes into deeper sea on the west of sandbar
- Some sediment transport goes around the southern corner of sandbar, and moves into offshore area between Dongshi Country and mouth of Bazhang Stream.

近數十餘年，由於自然海岸漂沙源供應減少，以及海岸開發改變原有漂沙機制或而阻滯漂沙行進路線與量體，致使外傘頂洲規模不斷縮小、坍平與陸化現象



外傘頂洲防護策略(Strategies of sand bar protection)

Ecological conservation 生態保育措施



Principle (生態保育原則)

- **Avoid** (迴避)
- **Mitigation** (減輕)


Indo-Pacific Humpback Dolphin 中華白海豚


Black-faced Spoonbill 黑面琵鷺

Approach of Design (納入設計概念情形)

- **Avoiding Humpback Dolphin Habitats while Construction.**(施工時**避開**關注物種**中華白海豚潛在棲地**)
- **Reducing the construction area, Maintaining fixed construction routes, and designated material placement areas.**(限縮施工範圍，採固定施工路線及置料區)
- **Reducing underwater noise with phased onstruction.**
  (各工區整地採分段施工。降低工程施作之水下噪音)
- **Avoiding machinery oil leaks or marine debris entering the environment to preserve the integrity of natural habitats.**(避免船運及機具漏油或廢棄物進入水域，營造補償自然棲地之完整性)

外傘頂洲防護策略(Strategies of sand bar protection)

- **The main content of the project**
  (工程辦理內容)

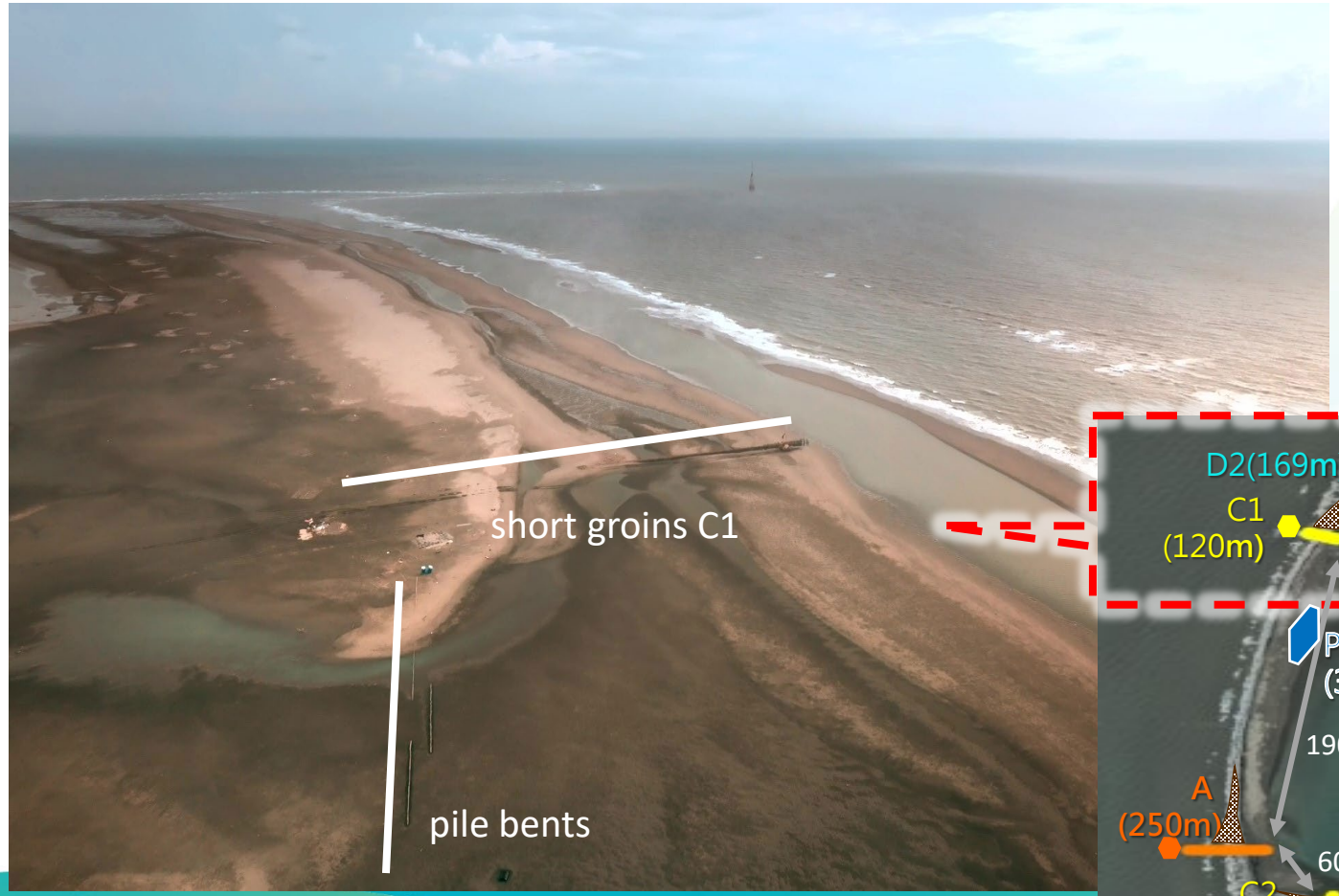
pile bents D1 (105m) 排樁D1
pile bents D2 (169m)排樁D1
short groins C1 (120m) 短突堤C1
long groins A (250m) 長突堤A
short groins C2 (80m) 短突堤C2

- **PPPs project 300m (公私協力辦理300公尺)**

工程成果(Engineering achievements)

Water Towards Safety Sustainable Environment and Prosperity 水與安全、環境、發展

Waisanding sand bar gap (range from groin C1 to pile D)
The siltation effect is about 400m long and 0.50-0.75m high for groin C1
破口區域 突堤C1-排樁D，初期落淤0.5~0.75公尺高約，範圍約400公尺

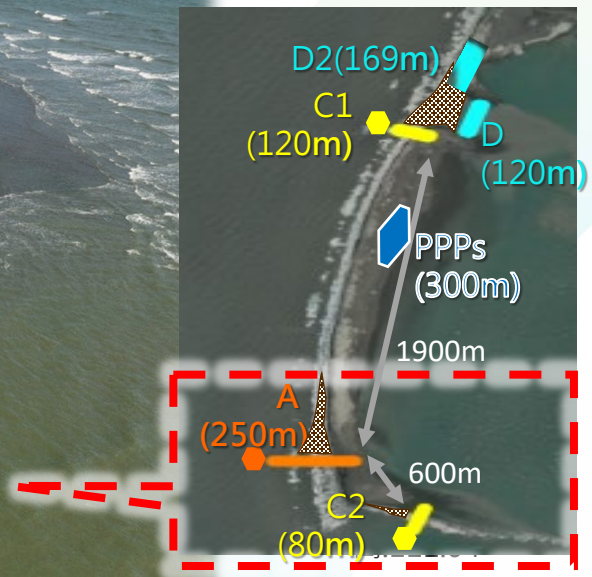


工程成果(Engineering achievements)

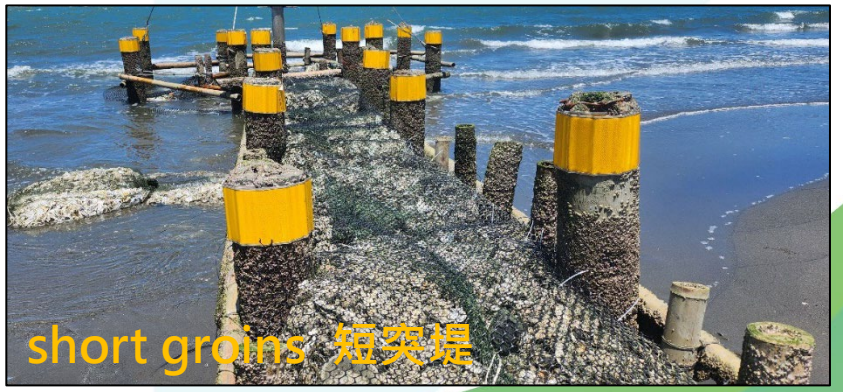
Water Towards Safety Sustainable Environment and Prosperity 水與安全、環境、發展

After groin A、C2 was completed (Amount of deposit for groin 50cm)

外傘頂洲男廁長突堤A-短突堤C2， 堤跟落淤約0.5公尺高



groins 長、短突堤



工程成果(Engineering achievements)

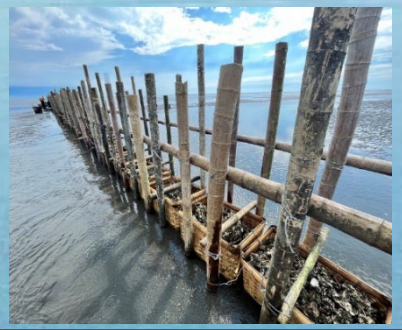
Water Towards Safety Sustainable Environment and Prosperity 水與安全、環境、發展

Sand Trapped works under PPPs 公私協力施作定沙設施

Union with local resident, and using waste oyster shed and oyster shells as material
與在地居民共同以廢棄竹樁及蚵殼施作

1
Sand Trapped with Bamboo Fence
竹樁攔沙

2
Sand Trapped with Bamboo Cages
竹籠固沙

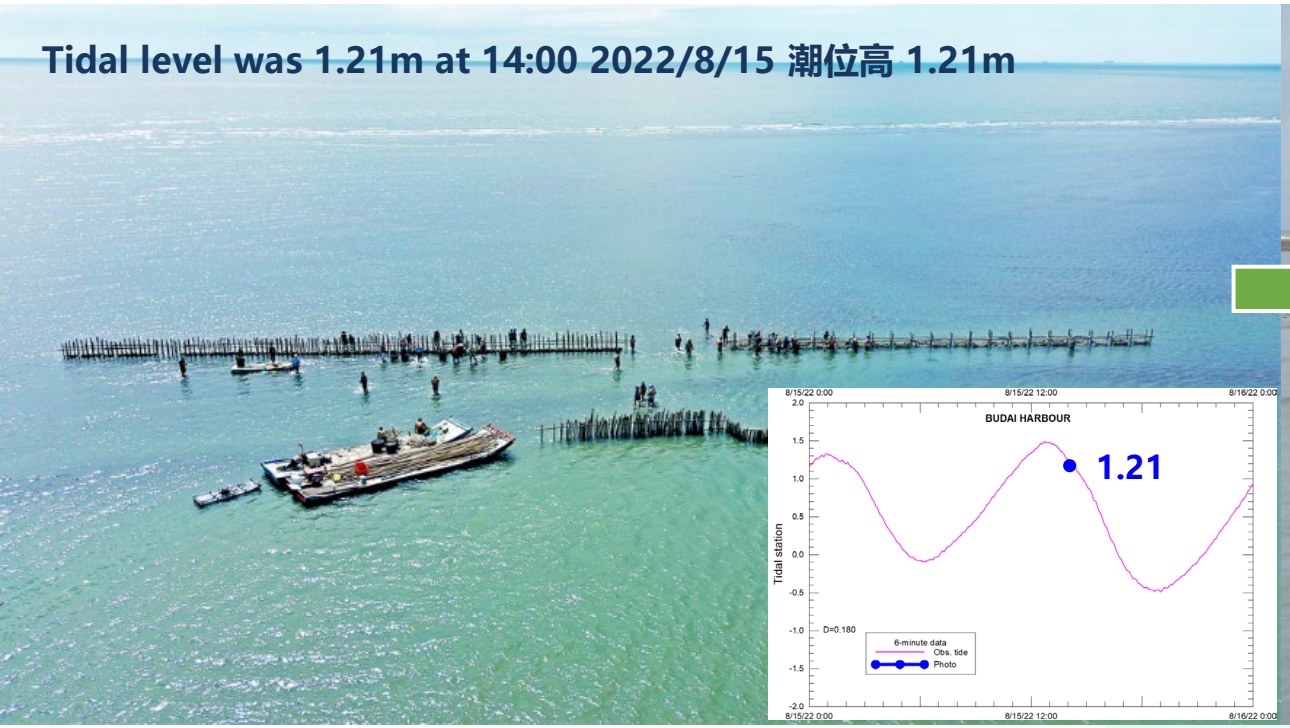


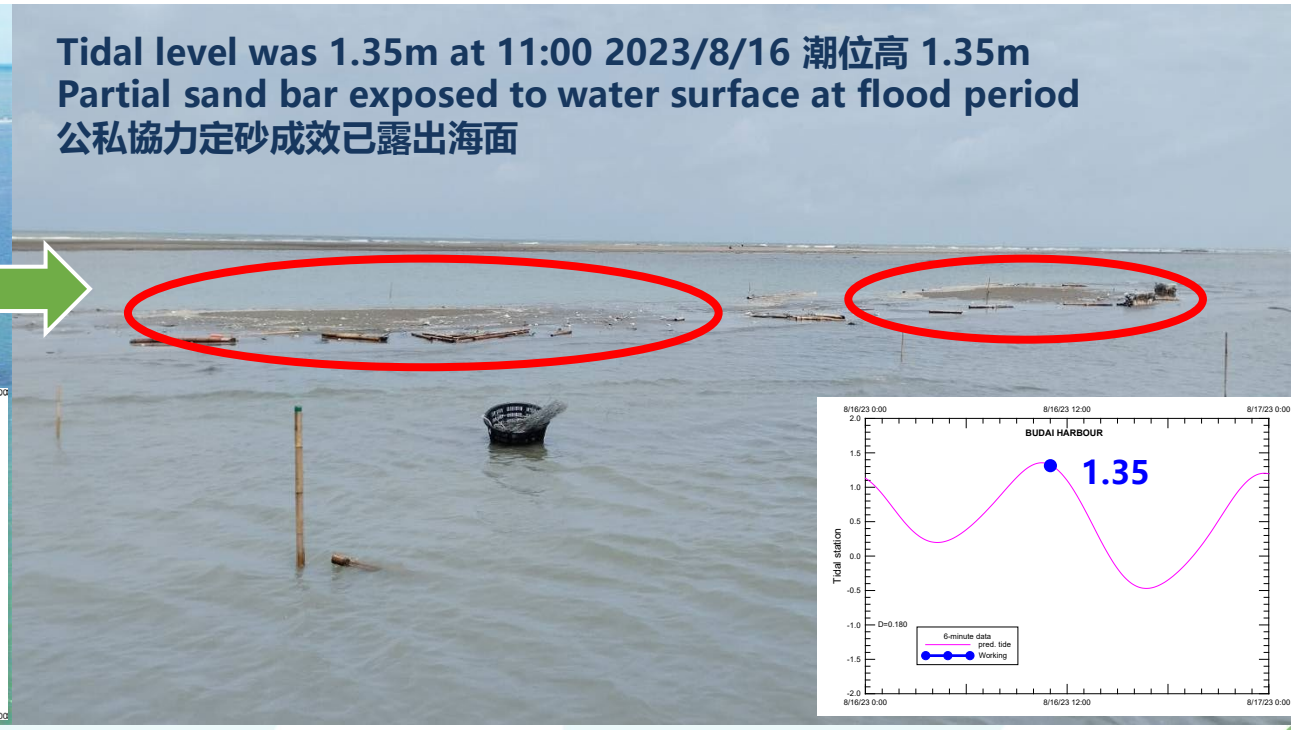
3
Sand Trapped with Oyster Strings
蚵殼定沙

工程成果(Engineering achievements)

Water Towards Safety Sustainable Environment and Prosperity 水與安全、環境、發展

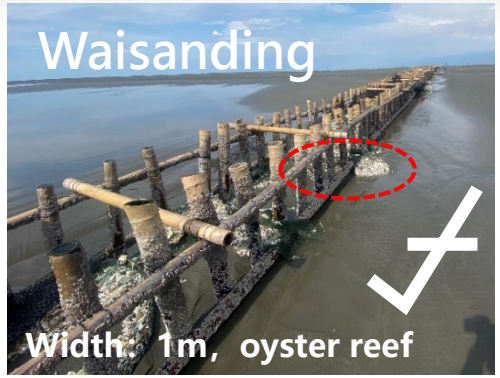
Sand Trapped works under PPPs 公私協力施作定沙設施





- The western area of bamboo cages had significant deposit, and exposed to water surface even in flood.
- It had significant deposit around the implementation area of temporary sand trapped facilities.

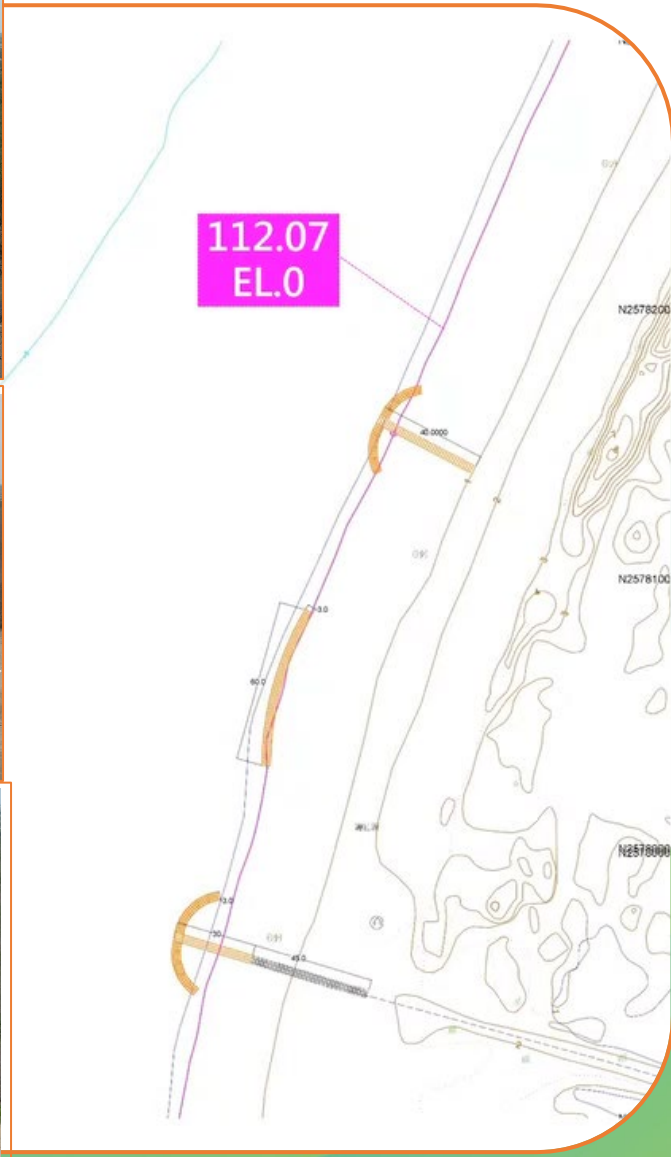
雙春海岸防護策略
(Strategies of Shuangchun coast Protection)



- **damage from marine debris**(受海洋廢棄物破壞)
- **Low permeability makes erosion easily.**(低透水性，堤身易有掏刷)
- **Overcrowded Oyster shells are prone to becoming brittle under the influence of waves.**(牡蠣礁自重，易造成牡蠣殼脆化)

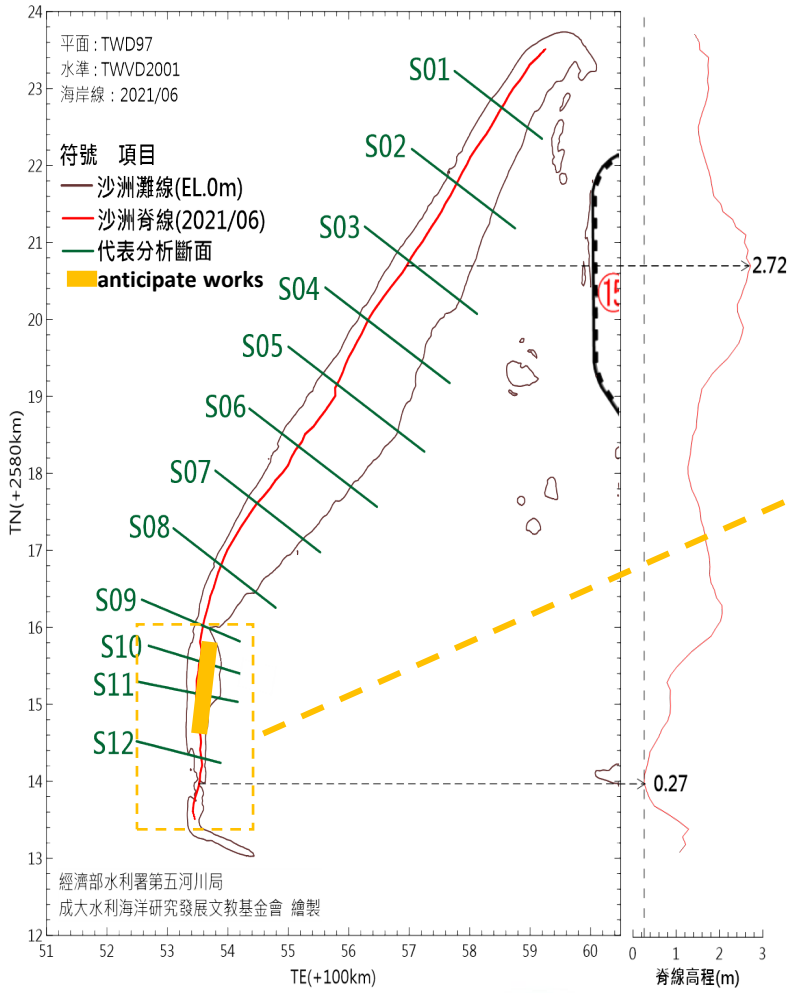
- **Soft Protecting Method (柔性工法)**
- **Strengthen embankment** (強化堤身保護)
- **Resisting erosion (防止沖刷)**

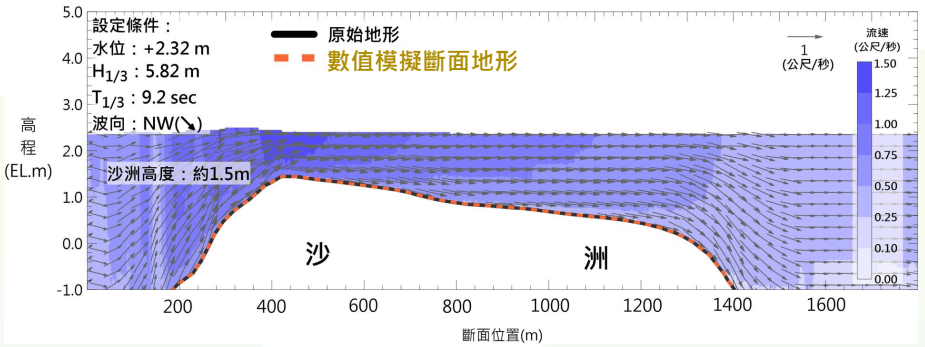
雙春海岸防護策略
(Strategies of Shuangchun coast Protection)

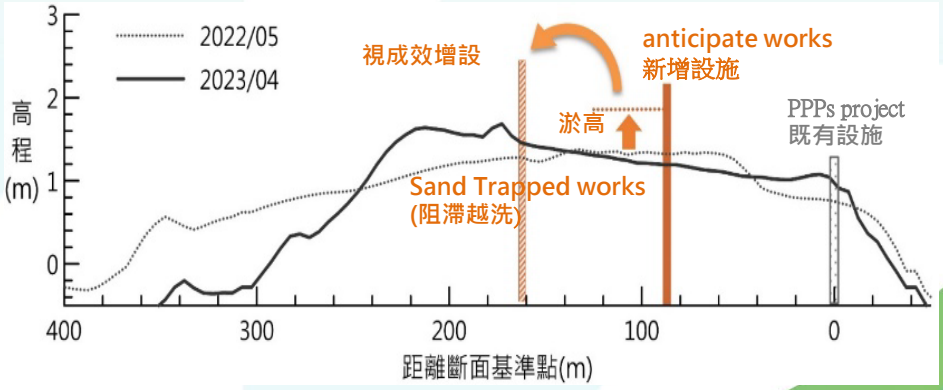


- The sand bar breach caused by the tide in August 2023,has been initially mitigated using NBS, resulting in the accumulation of sand and stabilizing the shoreline(112年8月大潮造成之破口，以自然工法防護，已有初步促使沙灘堆滯、穩定灘線現象)
- With monitoring the ongoing effectiveness, researching enhancement strategies, and employing environmentally friendly methods in order to alleviate coastal erosion (持續監測成效，研商精進方案，以友善環境的工法，減緩海岸侵蝕)

結論與未來工作(Conclusions and Further works)







Topic 2

Hoowave The Water Factory

虎尾鎮-虎尾水塘場

Outline

虎尾鎮人文 (Humanities of Huwei Town)

郡役所/雲林布袋戲館

郡役所官邸/雲林故事館

合同廳舍/誠品、星巴克

登記所/雲林記憶cool

涌翠閣

福民老街

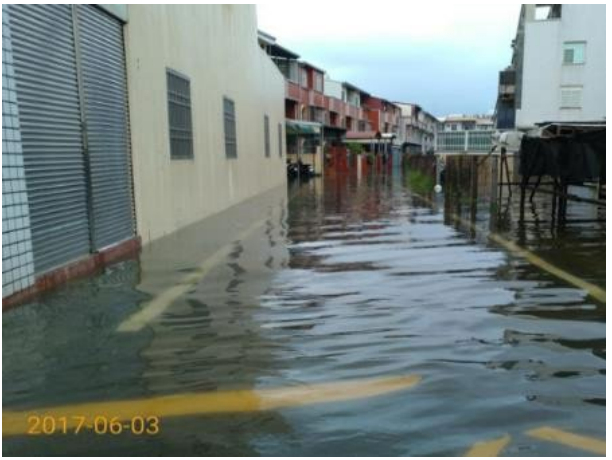
虎尾驛

虎尾糖廠

虎尾厝沙龍

虎尾水塔

虎尾鎮現況 (Situation of Huwei Town)



In extreme climates, typhoons and heavy rains cause flooding problems.

極端氣候下，颱風豪雨造成淹水問題。

Anqing Town was affected by the discharge of domestic sewage and became a foul-smelling ditch.

安慶圳受生活污水排放影響，成為惡臭水溝。

The connection between the water environment and residents' lives is weak and lacks interaction.

水環境與居民生活連結薄弱，缺乏互動。

The rich humanistic resources have not been fully displayed.

豐富人文資源未能充分展現。

問題意識(Problem Statement)

Water Towards Safety Sustainable Environment and Prosperity 水與安全、環境、發展

/ 韌性的水與安全/

Resilient

/ 生態的水與環境/

Ecological

/ 通透的水與交通/

Connected

/ 文化的水與生活/

Cultural

- How to solve water environment problems and improve residents’ quality of life?
  如何解決水環境問題，提升居民生活品質？
- How to activate waterfront space and promote interaction between people and water?
  如何活化水岸空間，促進人與水的互動？
- How to integrate water environment and local culture to create tourism development potential?
  如何整合水環境與在地文化，創造觀光發展潛力？

計畫背景 (Project Background)

Water Towards Safety Sustainable Environment and Prosperity 水與安全、環境、發展

- The international competition introduces innovative thinking to establish a model for the spatial aesthetics of river design.
  國際競圖導入創新思惟, 建立河川設計空間美學範例。

- With the goal of waterfront integration, Huwei is being developed into an attractive and resilient waterfront town.
  以水岸縫合為目標願景,將虎尾鎮營造為具有魅力的水岸韌性城鎮。

水與安全

Using the strategy of "runoff sharing and local flood retention" to reduce damage caused by water-related disasters in urban areas.

運用「**逕流分擔、在地滯洪**」策略，以減少城鎮因水患所造成的災損。

水與環境

Shaping a resilient water environment and establishing a model of eco-friendly design through low-impact strategies.

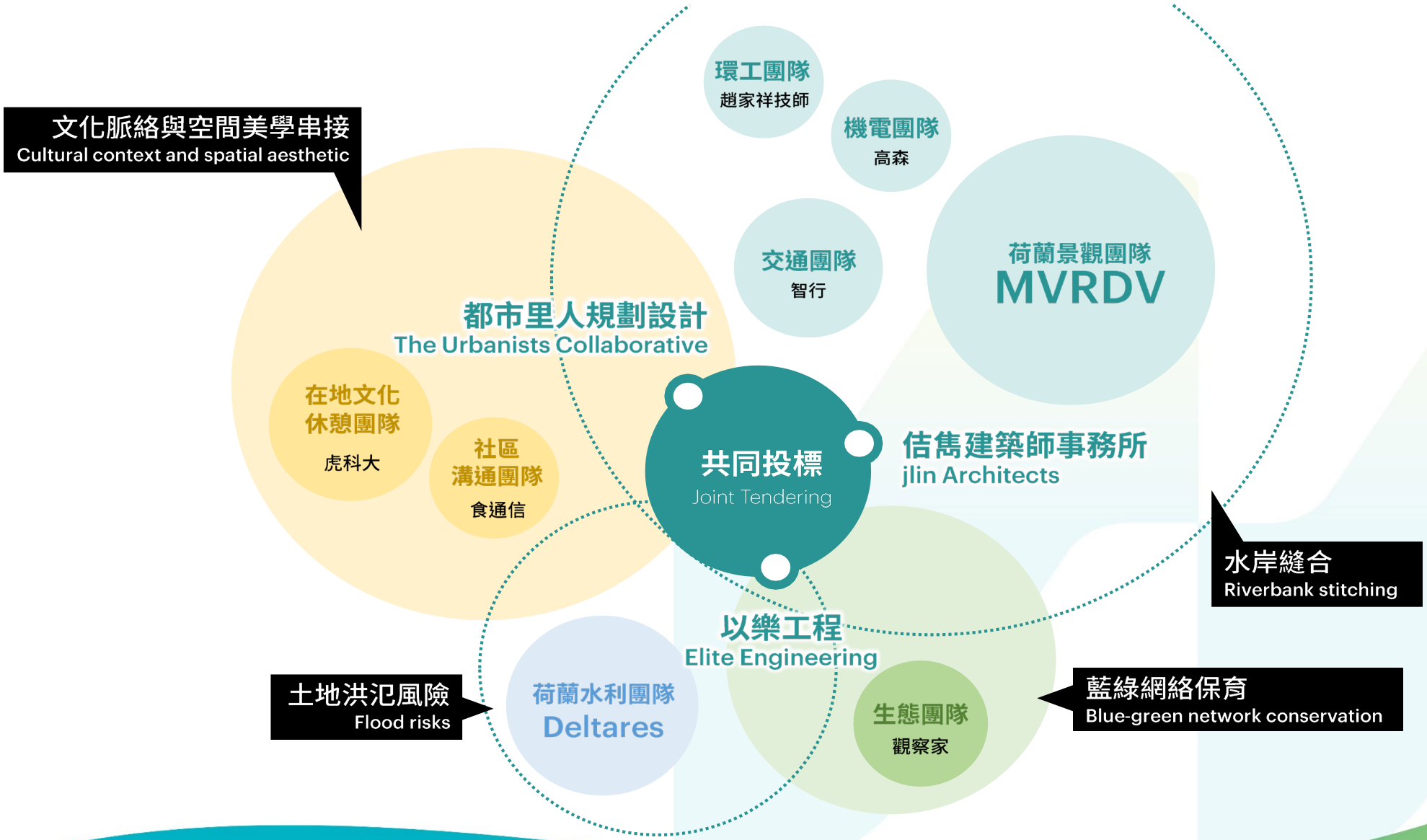
形塑**韌性水環境**，並透過**低衝擊**策略，建立友善生態設計典範。

水與文化

Integrating local history and culture with water culture to shape the town's unique character.

整合**地方歷史人文**，結合水文化形塑城鎮特色。

團隊 (Team)


文化脈絡與空間美學串接
Cultural context and spatial aesthetic
環工團隊
趙家祥技師
機電團隊
高森
交通團隊
智行
荷蘭景觀團隊
MVRDV
都市里人規劃設計
The Urbanists Collaborative
在地文化
休憩團隊
虎科大
社區
溝通團隊
食通信
共同投標
Joint Tendering
佶雋建築師事務所
jlin Architects
水岸縫合
Riverbank stitching
以樂工程
Elite Engineering
土地洪氾風險
Flood risks
荷蘭水利團隊
Deltares
生態團隊
觀察家
藍綠網絡保育
Blue-green network conservation

四大主軸 (Four Major Pillars)

Resilient Water 防災的水

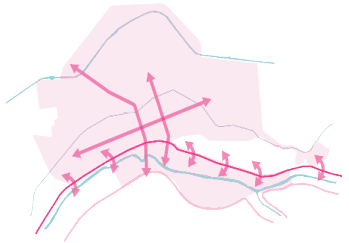
Improve disaster prevention capabilities through measures such as runoff sharing and regional drainage management.

透過逕流分擔、區域排水治理等措施，提升防災能力。

Ecological Water 生態的水

Focusing on ecological conservation and habitat creation, we will restore the ecology of the water environment.

以生態保育、棲地營造為核心，恢復水環境生態。



Accessible Water 親近的水

Construct a human-oriented transportation, bicycle/trail system, and create a water-friendly space.

建構人本交通、自行車/步道系統，創造親水空間。

Cultural Water 文化的水

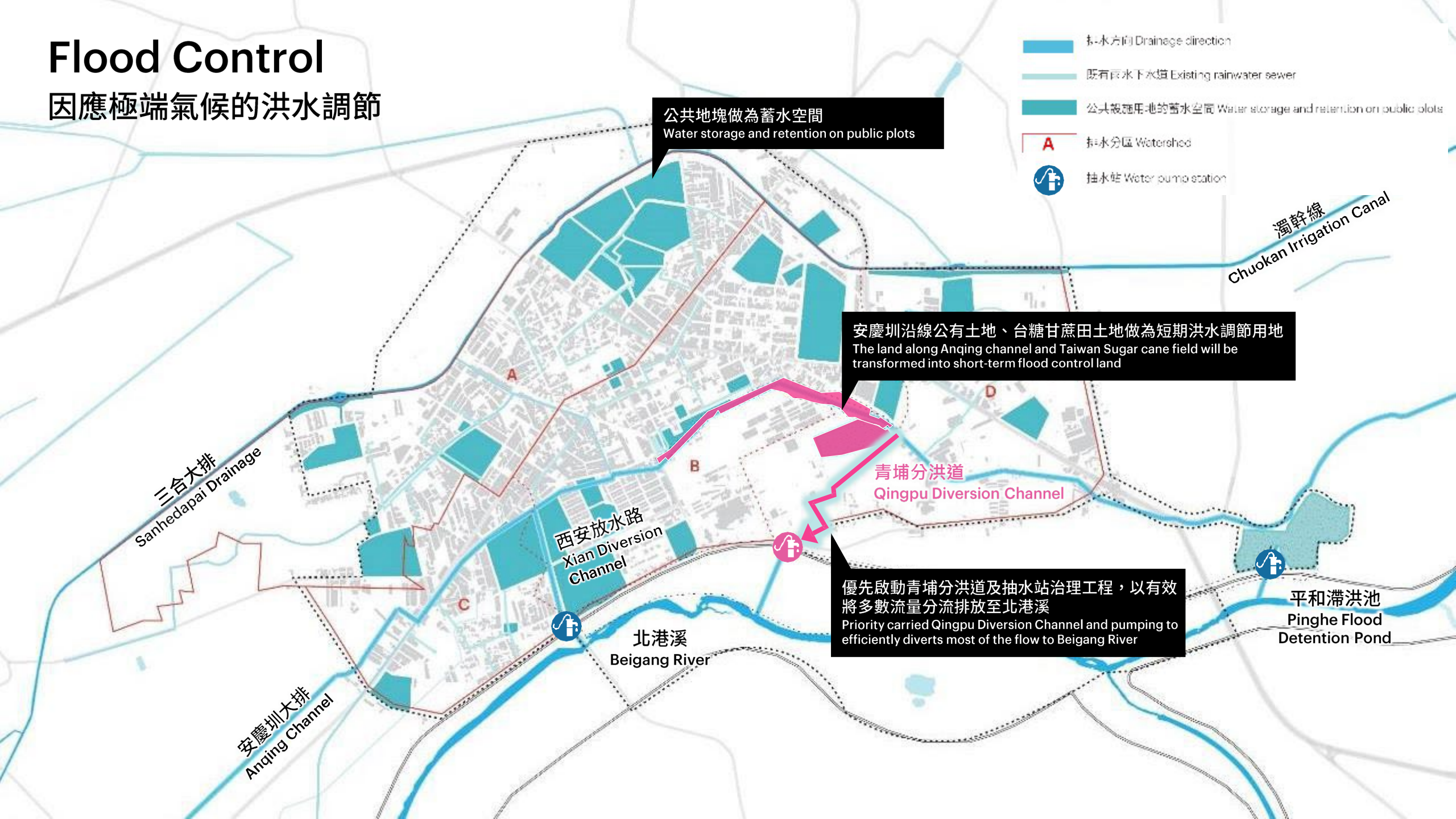
Combined with the revitalization of sugar mills and neighborhood culture, it shows the charm of waterfront culture.

結合糖廠振興、街區文化，展現水岸文化魅力。

Resilient Hoowave 韌性水網絡

Flood Control

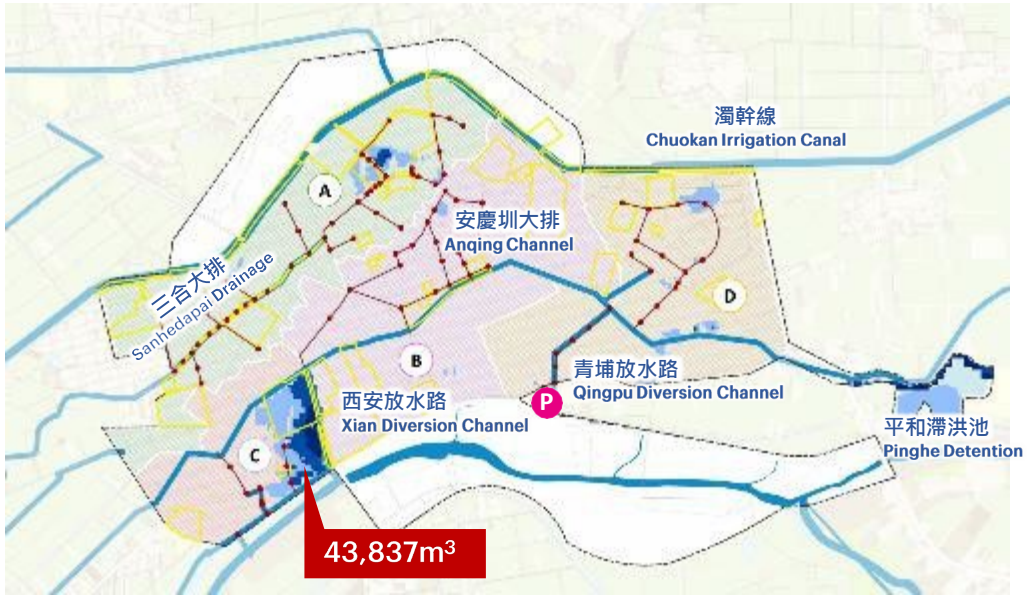
因應極端氣候的洪水調節



挑戰 Challenge

面臨氣候變遷工程有其極限，應有土地承擔策略

Traditional flood control infrastructure is unable to withstand challenges from extreme climates



Simulation

24hr500mm

安慶圳治理計畫完成狀態
進行淹水潛勢模擬

Simulation based on the completed state of the Anqing Channel treatment plan

淹水深度 Flood Depth(m) 0.1-0.3 0.3-0.5 0.5<

對策 Strategy

運用大型公私有土地與空間進行逕流分擔、在地滯洪

Use public plot and private lands for runoff distribution and local flood detention

EXISTING

PROJECTS

噴泉水廣場
Fountain mist retention plaza

淨化溼地
Purification wetland

下沉式遊樂場
Sunken playground

水貯存運動場
Water buffer sport fields

下沉式水劇場
Sunken water theatre

水貯存廣場
Water storage plaza

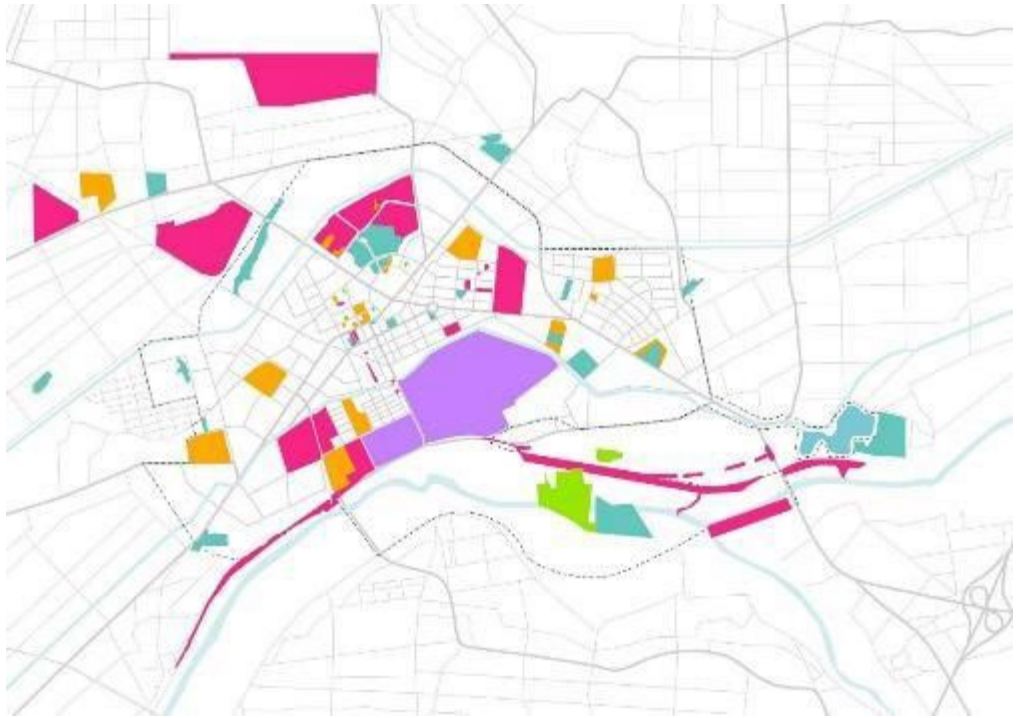
Local buffer and Store

城市尺度的水緩衝與貯存網絡

挑戰 Challenge

現況公共地塊與屋頂功能單一，空間未有效運用

Current public plots and roofs are mono-functional, and the space is not used effectively



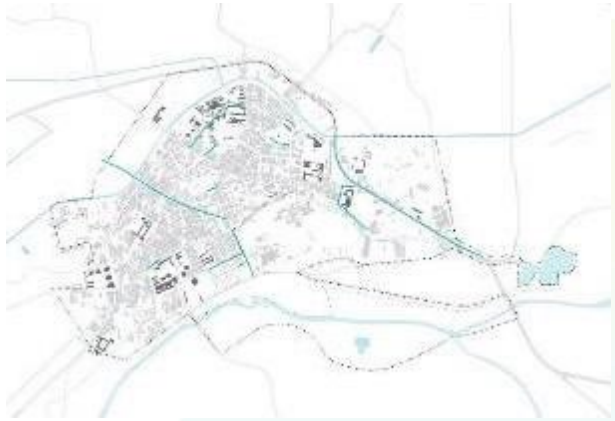
- 國有地 National
- 雲林縣有地 Yunlin County
- 虎尾鎮有地 Huwei Township
- 其他縣市共有 Other County Joint
- 虎尾糖廠 Sugar factory

對策 Strategy

融合自然、生態、水質優化等功能，導入LID設施分散地表逕流

Use public plot and private lands for runoff distribution and local flood detention

EXISTING



PROJECTS

街道雨水花園
Street garden

屋頂花園
Rooftop garden

屋頂農園
Urban farming roofs

Anqing Drainage Channel Environmental Development Project

安慶圳大排整體環境營造工程

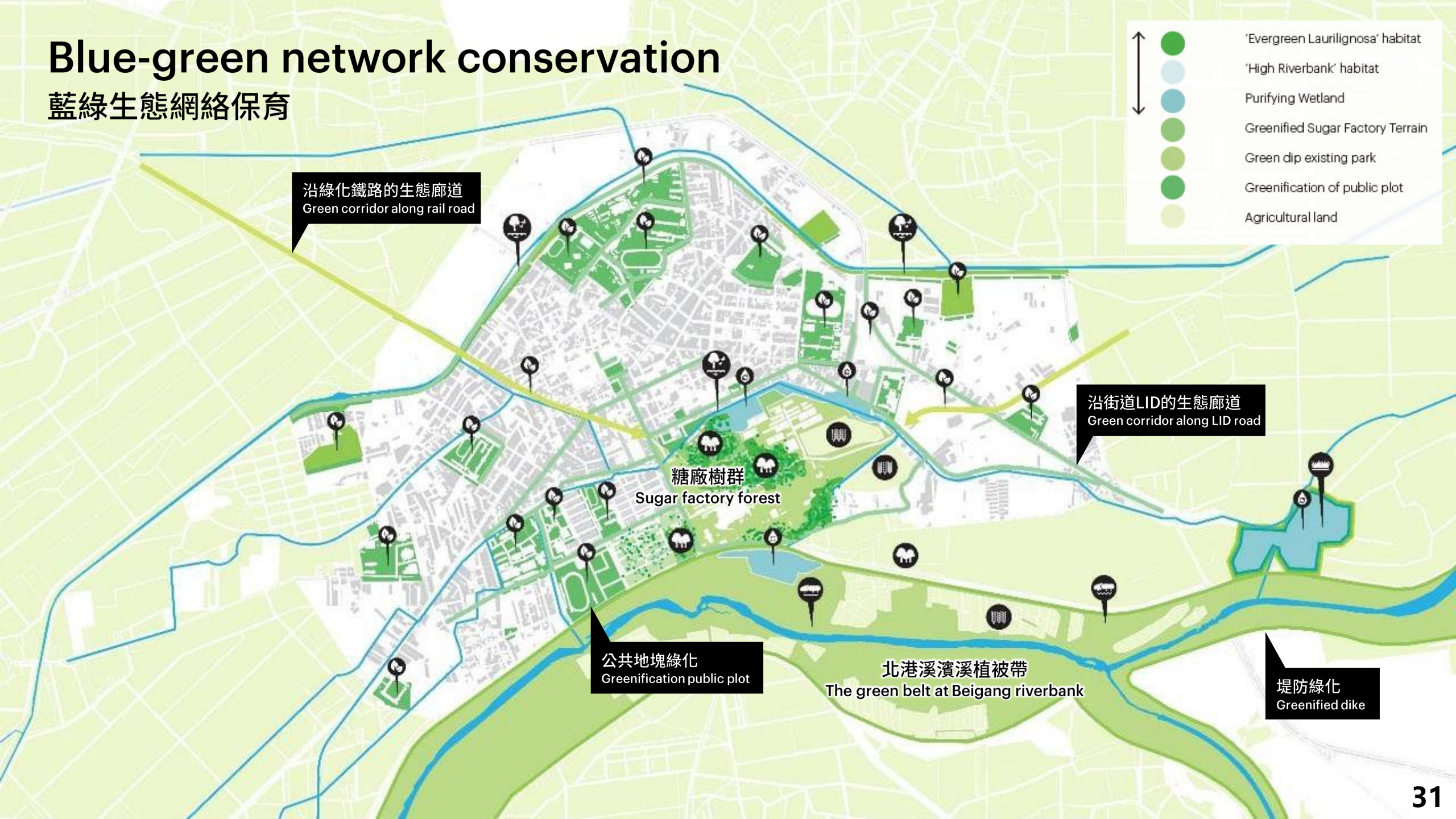
Environmental Development Project for the Huwei Section of the Beigang River

北港溪虎尾堤段整體環境營造工程

Ecological Hoowave 鏈結生態

Blue-green network conservation

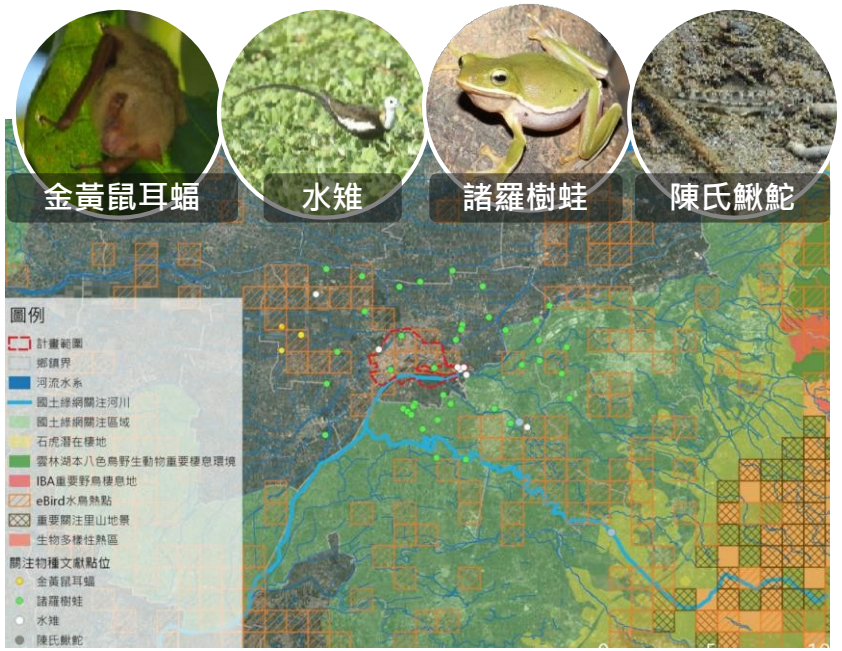
藍綠生態網絡保育



生態檢核(Ecological Checklist)

Water Towards Safety Sustainable Environment and Prosperity 水與安全、環境、發展

Ecological literature collection map overlay
生態文獻蒐集圖資套疊



- 生態背景資料蒐整
- 棲地影響評估
- 現場勘查掌握情報
- 確認棲地環境與關注物種

Ecological Supplementary Survey
生態補充調查

- 針對關注物種類群調查
- 棲地調查
- 棲地評估

Confirm ecological issues feedback design plan
確認生態議題回饋設計方案

- 生態關注區域圖繪製
- 研擬生態保育措施：
  迴避、縮小、減輕、補償(優化)
- 共同討論設計方案

關注物種(Conservation Status)

金黃鼠耳蝠(國家易危-VU)

紀錄 北港溪水域。樹林、大樹為潛在日棲點

白鼻心

紀錄 北港溪高灘地、糖廠樹林、酒精槽

陳氏鰍鮀(國家瀕危-EN、保育類II)

紀錄 北港溪上游之崙子溪口調查到

環頸雉(保育類II級、國家極危CR)

紀錄 北港溪高灘地

水雉(保育類II級、國家易危VU)

紀錄 平和滯洪池

鳳頭蒼鷹(保育類II級)

紀錄 北側高灘地、虎尾糖廠

斑龜

紀錄 北港溪、安慶圳

Habitat creation and corresponding species

棲地營造與對應物種

500-2000m
周圍農田
Farmland

安慶圳林間濕地 Anqing channel forest wetland

❶ **營造**具遮蔭的林間濕地
❷ **營造**多樣水域環境(緩流、瀨)
❸ **增加**水際線親水性草本植物

糖廠甘蔗田 Sugar cane field

❶ **既有**蔗田為燕鴴繁殖棲地
❷ **增設**猛禽棲架供鳥類停棲

平和滯洪池 Pinghe Detention Pond

❶ **營造**岸際淺水草澤(挺水植物)
❷ **插立**枯枝鳥踏
❸ **調整**湖中島砌石為**緩坡**
❹ **增加**浮葉植物(水雉)

糖廠樹林 Sugar factory forest

❶ **既有**複層樹林
(動物居所或庇護所)

北港溪高灘地 Beigang high riverbank

❶ **既有**樹林及農墾地
❷ **既有**高灘地濱溪植被、高草叢
❸ **既有**林地底層落葉層及積水窪地
❹ **營造**濕地
❺ **營造**堤防原生植栽綠帶

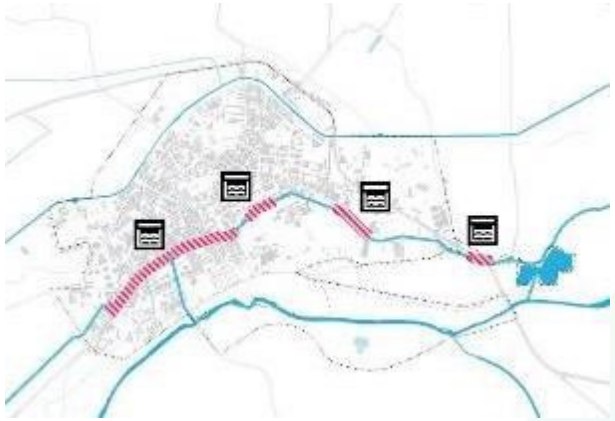
安慶圳現況構造物形式不利於生物棲息及親水活動

Existing Anqing Channel structure is not conducive to habitat and aquatic activity

打開安慶圳，以NbS(Nature-based Solutions)概念營造多樣的棲息環境

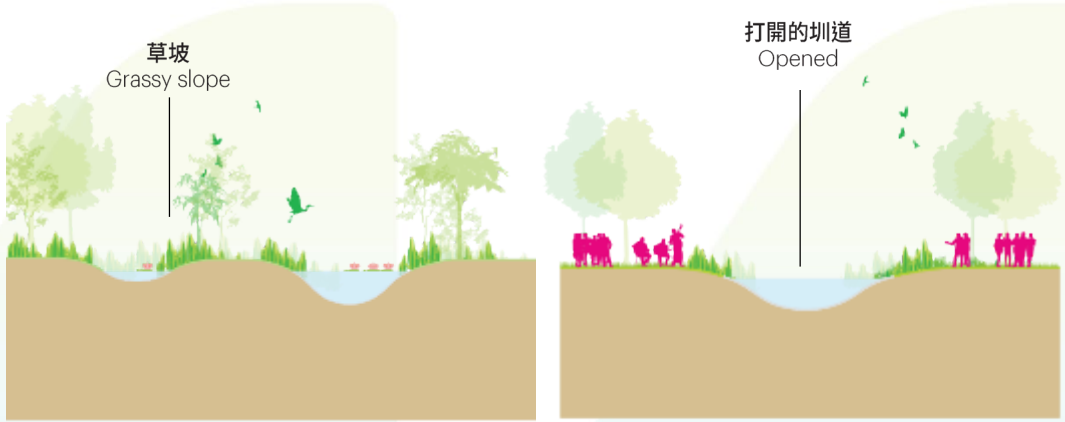
Open Anqing channel, Create diverse habitats with the NbS concept

EXISTING



PROJECTS

1.自然圳道再生 River and stream Renaturation



2.多樣性的棲地環境營造 Create diverse habitats

林間濕地
Forest Wetlands

淺水區草澤
Grass swamp of transitional water

潭、瀨與及緩流
Pool, Riffle and Slow Run

挑戰 Challenge

人為發展造成棲地減少，綠地間連接性低、棲地破碎化

Habitat decrease due to human development and habitat fragmentation due to low connectivity between green spaces

棲地間距離較遠，
且受到堤防及建物的阻隔

北港溪灘地

對策 Strategy

保留現有綠地空間，並增加及營造周邊綠地環境，提升棲地品質及連接性

Preserve existing green space. Develop more green space in the area and improveenvironment. Enhance habitat quality and connectivity.

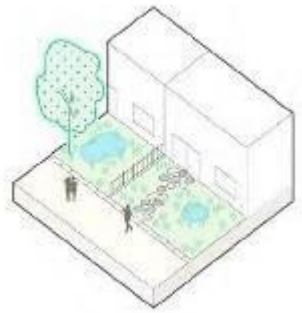
EXISTING

PROJECTS

保育既有核心棲地
Conserve core habitats

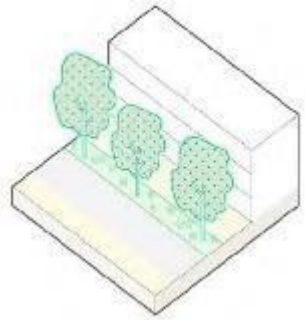
- 糖廠樹林
- 北港溪灘地的濱溪綠帶

公共地塊綠化
Greening of public patch



- 公園綠地
- 廣場、學校

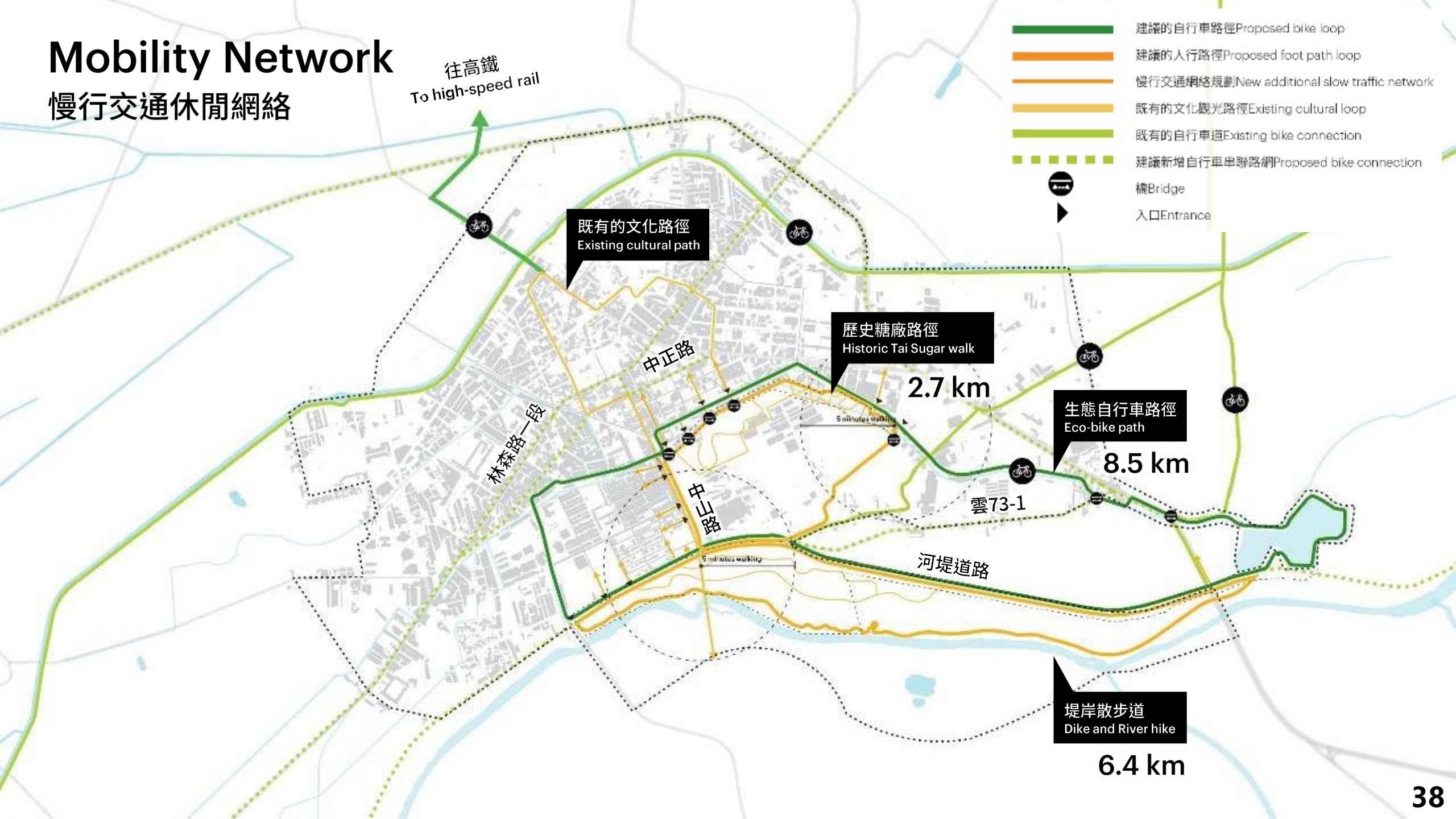
廊道連接
Corridor connection



- 街道、堤防
- 林蔭大道

Connected Hoowave 縫合水與生活場域

Mobility Network
慢行交通休閒網絡



挑戰 Challenge

堤防阻隔了居民親近北港溪和高灘地的機會

The dike blocks the people of Huwei from experiencing the Beigang River and the floodplains.

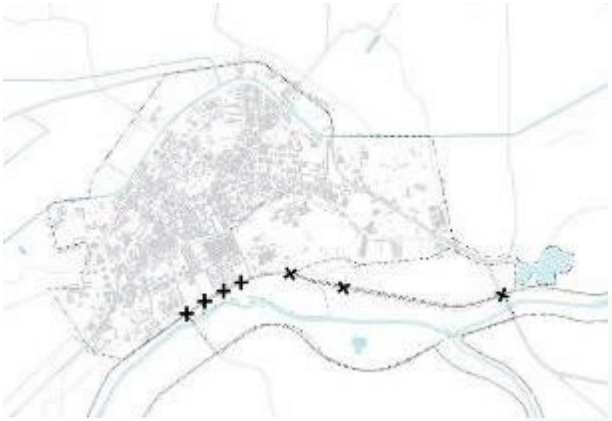
北港溪堤岸僅有少數緩坡及階梯可連結至堤內高灘地

對策 Strategy

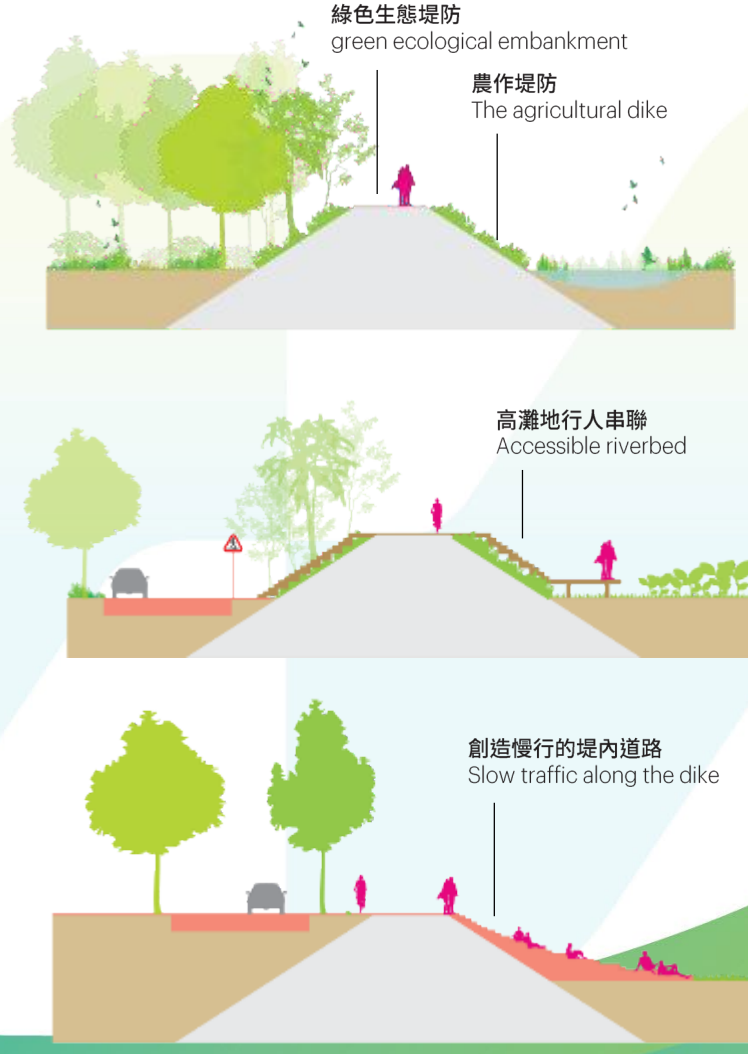
營造慢行的堤內道路，連結豐富多元的堤外休憩活動功能

Create a slow-moving road inside the embankment to connect the rich and diverse recreational and sports functions outside the embankment.

EXISTING



PROJECTS



挑戰 Challenge

水域空間與生活圈連結薄弱，缺乏互動與可親近性

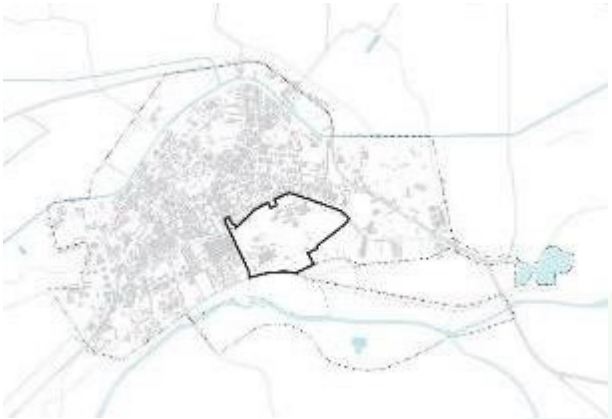
Weak connection between urban waters and local living sphere. Lack of interaction and accessibility

對策 Strategy

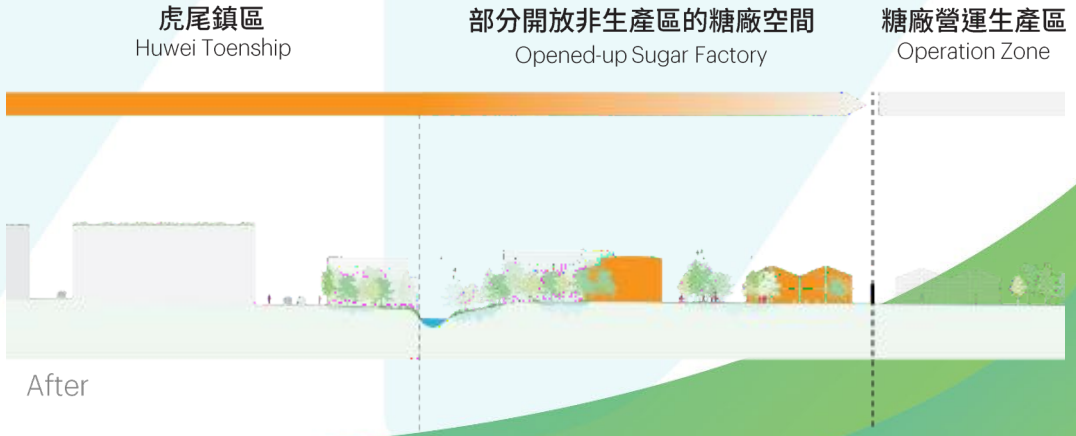
運用糖廠非生產區，加強安慶圳、糖廠及社區的連結性

Increase the links between Anqing Cannel, sugar factory and communities

EXISTING



PROJECTS



挑戰 Challenge

虎尾豐厚的人文資源未能充分彰顯與展現，機能各自獨立

Huwei's rich human resources are hidden and not fully manifested, with different functions being independent.

發展早街道較為狹窄，彼此間串聯不易，使得資源未能有效串接形成文化特色路徑

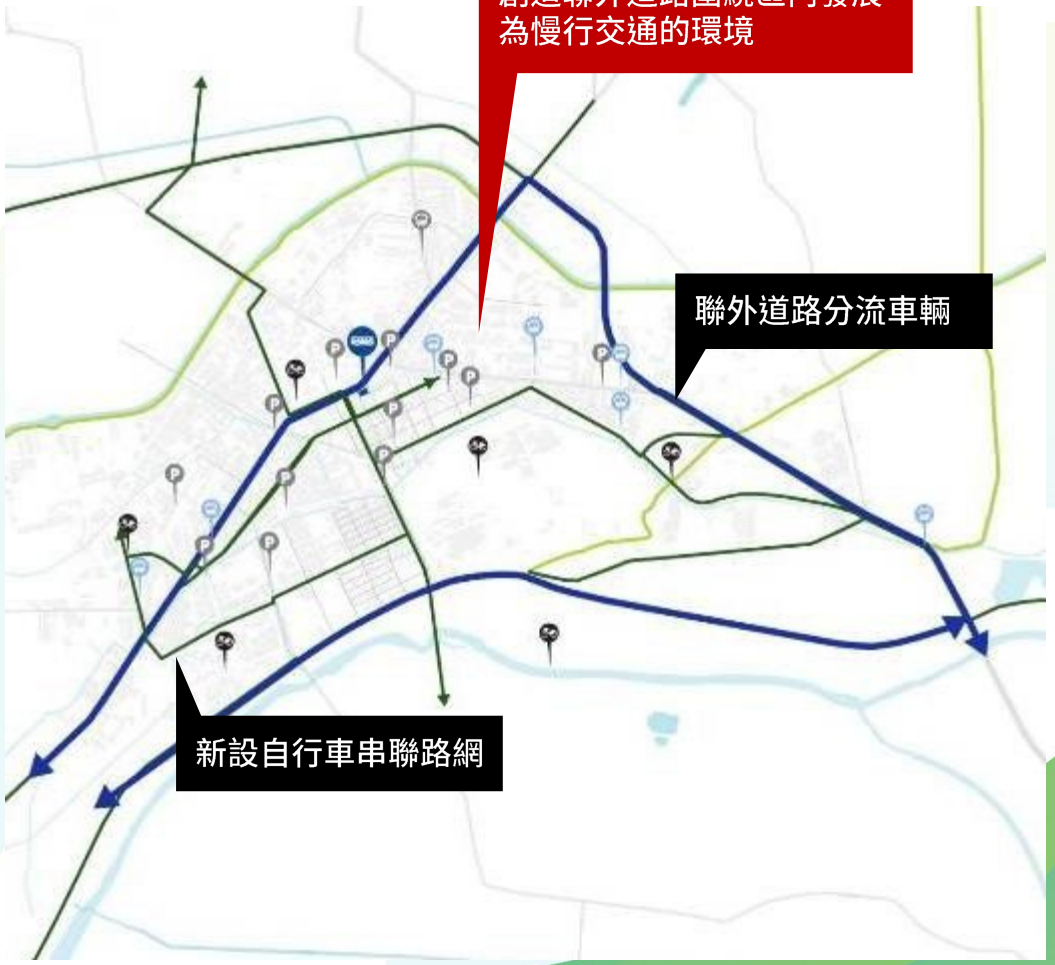
對策 Strategy

慢行交通串聯在地生活及觀光元素，建構新的城市休閒路網

Active mobility links local life and tourism to create a new urban communication and activity system.

EXISTING

PROJECTS

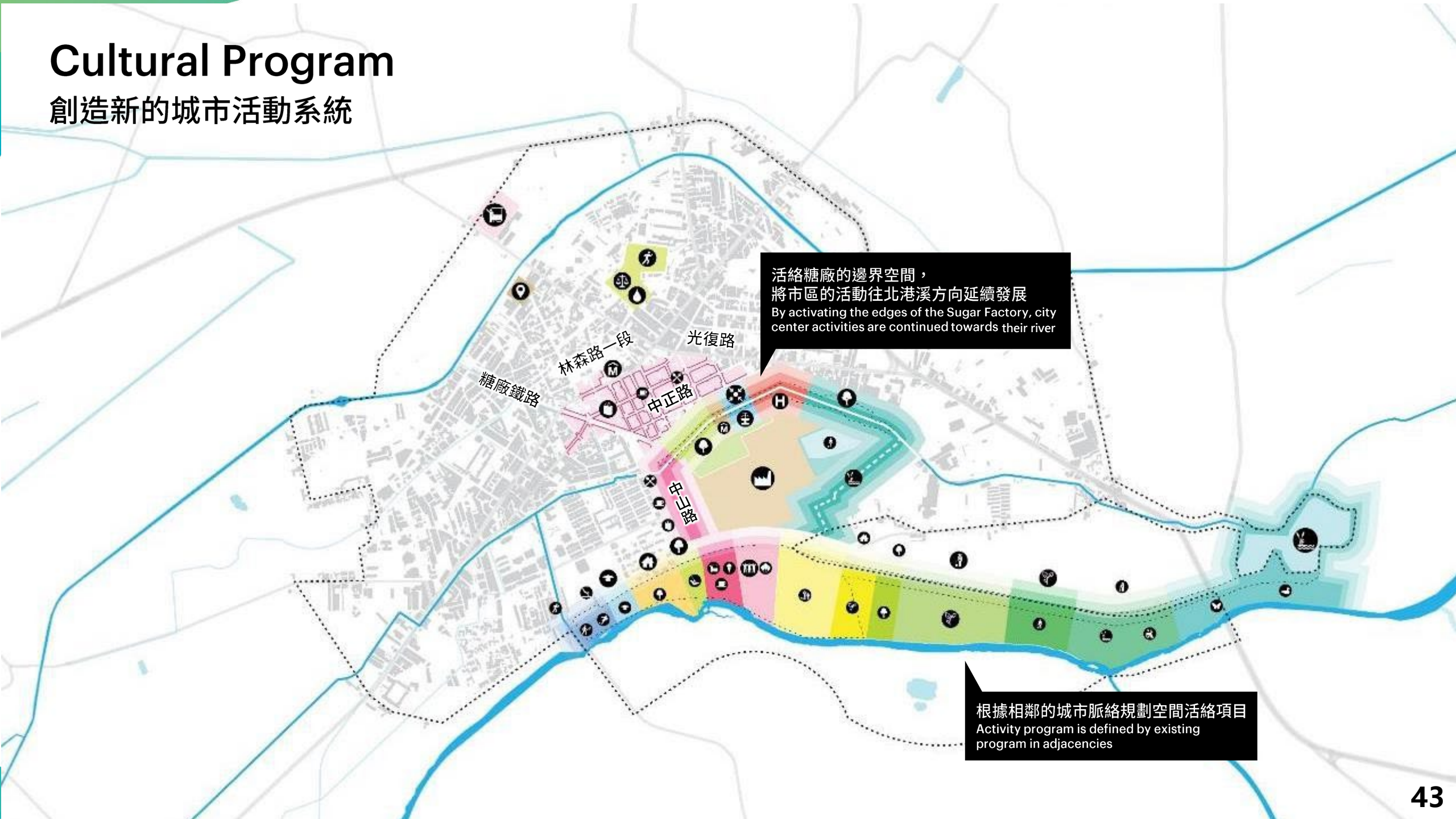


自行車租借站 Bike rental station　公車站牌 Bus station

Cultural Hoowave 活躍魅力地景

Cultural Program

創造新的城市活動系統



虎尾鎮開放空間相對缺乏

Lack of open space in Huwei Township

公園 Park

運動空間 Sports space

商圈 Business district

早晚市街販 Street vendor

廟宇 Temple

活化水岸高灘地，創建新的城市活動節點

Revitalize waterfront embankment, create a new city event node

EXISTING

PROJECTS

Q10 **Urban** Higly programmed

Q1 **Nature** Lightly programmed

挑戰 Challenge

封閉的虎尾糖廠造成城市活動的斷裂

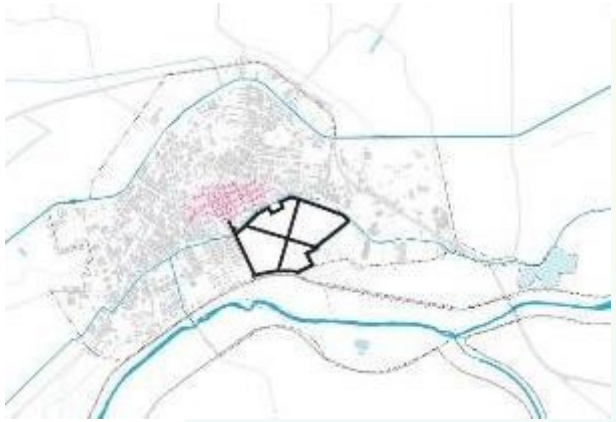
The closed Huwei sugar factory creates rupture in urban activity

對策 Strategy

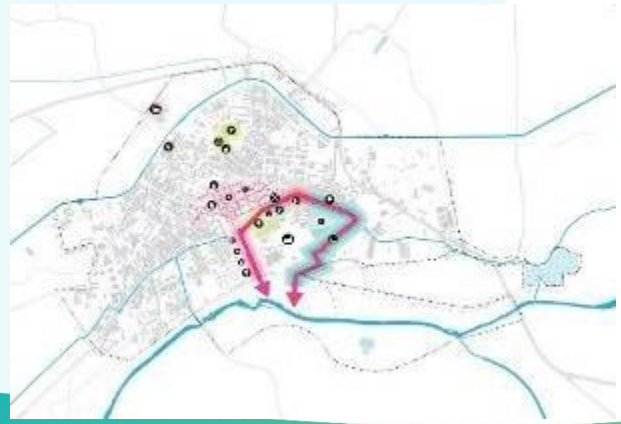
活絡糖廠邊界空間，將糖廠做為串接城市的重要樞紐

Activating the boundary space of the sugar factory, making the sugar factory an important hub connecting the city

EXISTING



PROJECTS



Closer to the old city

Closer to Beigang river

再利用規劃糖廠非生產區土地，配合圍橋的打開，設置多處入口，串接周邊的城市文化活動

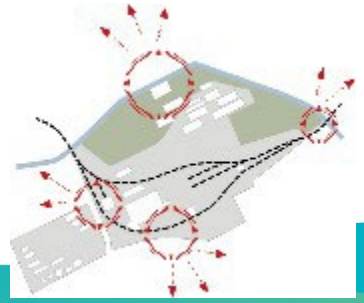
Reuse the non-production area of sugar factory, open the wall and set up multiple entrances to connect with the surrounding activities

文化再現
Cutural Representation

五分車復駛
Rerun of sugar factory mini-train

環境再生
Environmental Regeneration

非生產區
non-production area



打開糖廠
Open Factory

節點連結
Nodes connection

Thank you for your time