# Redefining Bangkok's Inclusive Water-Based Society

## Flood Resilience Planning of Adaptive and Performative Hybrid Infrastructure Network

Krit Thienvutichai

# ABSTRACT

Perception and relation of people towards water in Bangkok have changed through time, from a way of living to threat of lives. Growth of urbanization from adaptive water-based society to land-based mega-polis has led to a major shift of urban infrastructures changing lifestyle and perception of people. Water is currently perceived in form of flood threatening various land-based developments by the interruption of daily systems. To reinforce the growth of land-based urbanization, Grey infrastructure solutions are heavily promoted, protecting the city from flood, in the same time, water get devalued and separated from people life. The indigenous socio-ecological living with water is vanished from the urban society and water, as valuable natural asset, is in the stage of decaying socially and ecologically.

In the rapid climate change era, on behalf of continuing to avoid and live against nature, Bangkok and the inhabitants are challenged to adapt reliving with water once again. The paper mainly focuses to transform the existing grey infrastructures into hybrid flood adaptive and performative resilience system of Bangkok, reducing flood risks and provoking socio-ecological transformation with water-based identity.



*Hybrid Infrastructure / Grey Infrastructure / Flood Adaptation / Evolutionary Resilience / Socio-Ecological System / Water-based Urbanization / Land-based Urbanization*

# ACKNOWLEDGEMENT

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I would also like to thank all of the experts and professors who were involved and encouraged me to do this thesis from the beginning. Without their participation and guidance, the project could not have been successfully conducted. I genuinely enjoy exploring Bangkok and love to share and discuss my ideas with all of you.

Last but not the least, I would like to thank my family and my friends for supporting me spiritually throughout this thesis and providing quality time catching up about our lives. The past 2 years was very fun and I sincerely thank all of you for it.

# CONTENTS

# Water

# INTRODUCTION

Bangkok, the Thai capital was once known as “The Venice of the east” by the water-based lifestyles along network of canals for centuries before the founding of the royal city in 1782. The city featured with over 1,682 canals connecting to the Chao Phraya river which “indigenous water management knowledge is documented in scores of social, ethnographic and historical accounts as a heart of the cultural and economic life of the Chao Phraya Delta” (McGrath & Thaitakoo, 2010).

However, with the major shift of urban infrastructure from canal and river networks to road systems, water roles have alternated to underground drainage and sewage system, apart from people life which result in a devaluation of people perception as water is rather perceived as threat in form of flood in the present day.

as a way of living

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as a threat of life

Fig. 1 (Left) The Golden Mount, Old Siam (The Golden Mount)
Fig. 2 (Right) Bangkok Flooding (The nation, 2017)

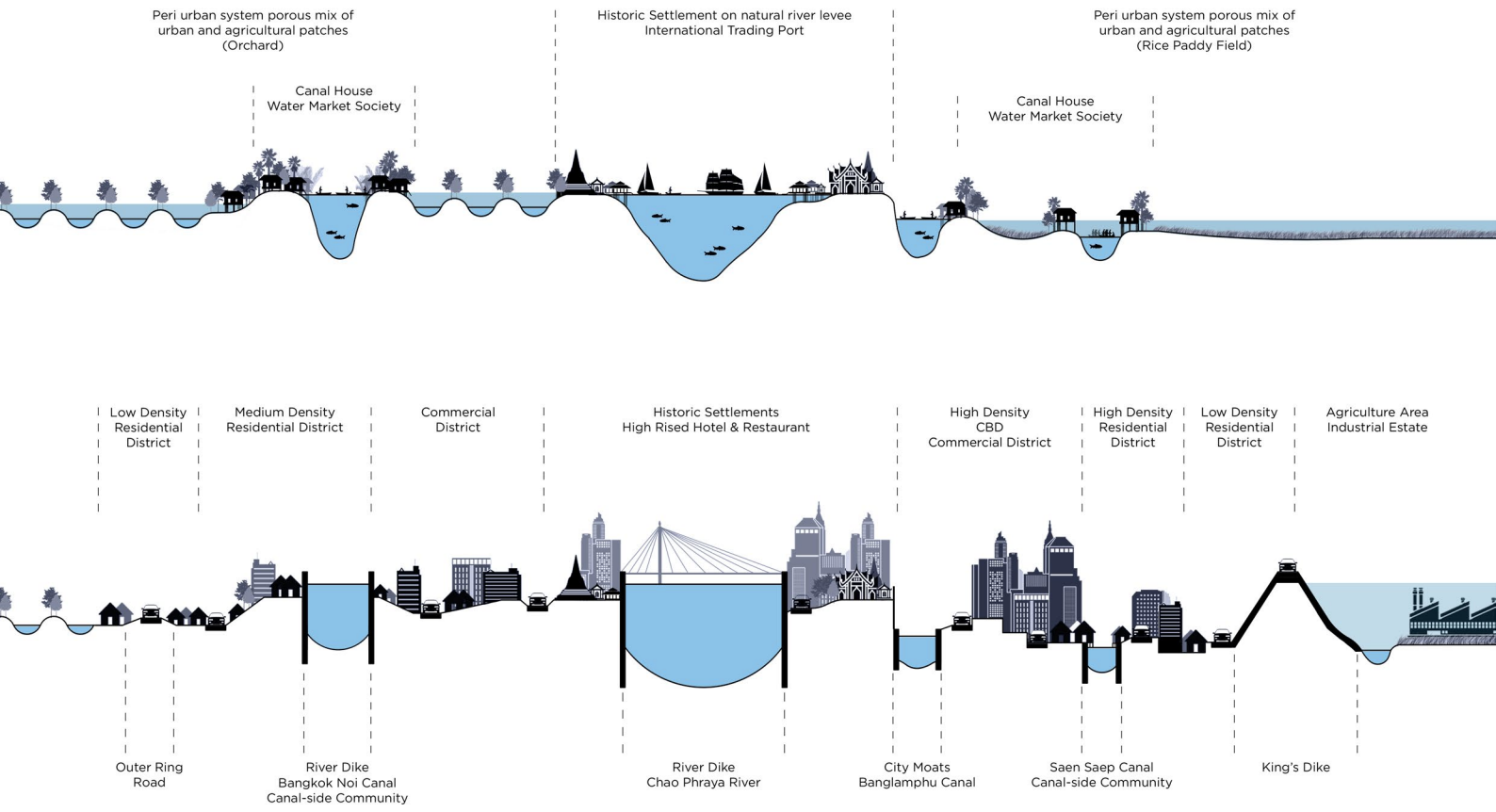



Fig. 3 Conceptual Transformation of Water-based Society to Land-based Megapolis drawn by author

## Problem Statement

"The city's rapid urbanization and increased population over the past 50 years brought a number of land-based infrastructure and other constructions that resulted in a rapid increase in built-up area at the expense of cultivated land and the hydrological matrix. The liquid network once considered a lifeline became much neglected and ignored, yet fragilely persists in many areas" (McGrath & Thaitakoo, 2010)

As Bangkok has transformed to the modern capital of centralized economics and managements, grey infrastructures are heavily promoted, reinforcing and protecting the metropolitan area from flood. The one-sided development of engineering solutions with defensive driven strategy lead to the unsustainable management against flood situations in this rapid climate changes era. The failures of this perception were shown in the case of mega flood situation in 2011, where the current flood management failed to cope with the unexpected incidents, resulting with severe damages to properties and life of people. The on-going developments also influence and slowly alternate lifestyle of people against water, neglecting the past indigenous socio-ecological living, resulting in, an increase of flood risks of the inhabitants.

For over decades, flood becomes increasingly severe for the city and its inhabitants. The need for alternative sustainable flood management strategies is required to enhance adaptive capacity coping with future climate change challenges and provide opportunities for people to learn how to relive with water once again. The question is raised upon the extend in which flood management could be incorporated as part of daily living condition of the inhabitants, reinforcing socio-ecological transformation of future resilience society.

**Research Objective and Questions**

The objective of this paper aims to transform existing grey infrastructures into hybrid flood adaptive and performative resilience system of Bangkok reducing flood risks and provoking socio-ecological transformation with water-based identity.

To achieve the objective, this paper will review the research conducted on these following sub-questions.

- How flood management could be considered as part of daily system to stimulate social process of living with environmental changes towards adaptive and performative landscape ?

- How green and blue infrastructures could be integrated with the existing grey infrastructures to perform as a new hybrid resilience network reducing flood risk ?

- How could the new flood management model influence the change of perception towards water, inducing adaptation efforts and coping with flood impacts in different scales ?

**Structure**

To this end, the research paper comprises of four main chapters, analysis, methodology, design, and evaluation.

- Analysis

In this part, the analytical studies are divided into two sub topics. The data mainly gathered with archival study and desk analysis illustrated with cross reference mapping to represent both physical and cultural qualities of water related to people life.

First, the paper provides overview of social and culture study in relation with water, represented in historical time-line development of Bangkok urbanization and water management strategies. As the results, critical factors of grey infrastructure and flood challenge are indicated influencing change of perception and lifestyle of people in the present day.

Then the paper explores on the overview interrelation of grey infrastructure and flood by layer approach analysis of Bangkok's transportation, water management, and green and blue network, revealing three major challenges of grey infrastructure development, comprises of, vehicle-based transportation, engineering water management, and fragmented of green and blue infrastructures, , which lead to other consequences of living against water across scale.

- Methodology

This chapter is classified into two sub topics of theoretical framework and case study. The first session begins by laying out the theoretical framework focuses on literature reviews of theories related with urban living with nature. The strategies have been arranged from broad perspective from overview of evolutionary resilience ideology to urban hybrid infrastructure and narrow down to flood adaptive measure for public space, inducing conception of problem solving in process. The second part of the chapter provides two case studies of the Copenhagen cloudburst formula and The Big U project, revealing different approaches integrating climate change incidents as part of the living condition in high density urban context.

- Design

Chapter 3 describes the process of design based on the conclusion of two previous chapters. In challenge and strategy part, inclusive water-based society is set as a goal to alternate current situation of Bangkok with the progressive evolutionary resilience strategy, reintroducing flood as part of future sustain-

Fig. 4 Bangkok Underwater, 2011 River Flood Incident of Bangkok (Qadri A., 2011)

able living condition, and inducing socio-ecological transformation of urban life. To achieve this goal, the concept of hybrid resilience infrastructure network is proposed merging functions of existing infrastructures to an interrelated flood management network.

Pathum Wan Downtown district is chosen as the experimental site due to the signification of the area which is the major commercial and transportation hub model of future urban expansion planned in 2037. The main infrastructures of transportation, water management and green and blue network, are explored and illustrated with constrains and potentials of development. Finally, 4 design principles of commercial artery, life corridor, underline park, and soaked community, are implied on the existing site categorized forming the interrelated flood management network with eco-service inducing changes of social and ecology system in daily life.

Commercial artery focuses to enhance better pedestrian and public transportation connectivity along the sky train and metro lines of future urban expansion. With the core commercial and transportation hub, the design induces the new management of transportation system to acquire additional green spaces on traffic island and both side of sidewalks, reducing flood risk from run-off and providing eco-services of pollution prevention.

Life corridor focuses to enhance the continuity of social and ecology system from the surrounding fragmented public green spaces to the green and blue connector routes. Avenues and Drainage canals are redesigned as boulevards and ecological canals with adaptive activities for pedestrian life as the new social platforms, illustrating pedestrian characteristics with social interaction amongst the inhabitants and nature.

Underline park focuses on the revitalization of linear unutilized spaces underneath highway structure, which reached to the connectivity of the flood management network of surrounding districts. The principle revives these unused spaces as multi-purpose community parks, providing adaptive rooms for storing excessive run-off while reinforcing local activities, reconnected communities back together.

Soaked community focuses to enhance the development potential of specific slow traffic zones, in this case can be classified into two categories, the institution model of Chulalongkorn university and the low-rise commercial model of Siam Square. These areas have potential to transform into car-free areas where opportunities for new public spaces are acquired through the modification of road systems to pedestrian street.

- Evaluation & Conclusion

In this chapter, the principles are examined based on two topics, socio-ecological transformation in relation with flood, and influences and potentials of future development across scales. The design proposals are explored on the additional benefits inducing adaptation efforts and improvement of urban qualities with eco-services. The proposals are also challenged in the extend of possibilities for applying across scales from emerging districts of Bangkok to the Delta cities in the central region.

**Scope and Relevance**

Climate change is considered as top global issue nowadays with the unprecedented rate through the upcoming century. “Human societies have always and everywhere had to develop coping strategies in the face of unwelcome variations in climate or weather extremes (Adger et.al, 2003).” Flood problems with grey infrastructure approach can be found in many Delta cities of the developing countries in Asia. Bangkok’s inclusive water-based society project demonstrates range of progressive analytical and design processes with evolutionary approach integrating flood with multidisciplinary issues of the city to cope with the future climate change challenges sustainably. The process has potential to be adopted for conducting changes of emerging and current Delta cities, expanding the interconnected flood resilience networks for the whole Delta region.

# CHAPTER I
# ANALYSIS

1.1 Social - Culture - Water

1.2 Flood - Grey Infrastructure

# 1.1 SOCIAL - CULTURE - WATER

a) Chao Phraya Watersheds and Bangkok Delta City
b) Urban Structure and Water Management Transformation
c) Transformation of People's Perception towards Water

# Chao Phraya Watersheds and Bangkok Delta City

**Location:** Bangkok, Central Region
Thailand, Southeast Asia

**Climate zone:** Tropical wet and dry
Influenced by monsoons

**Climate & Weather Averages**

| | |
|---|---|
| Mean High t°: | 33.3°C |
| Mean Low t°: | 24.9°C |
| Mean t°: | 28.6°C |
| Humidity: | 73% |
| Annual Rainfall: | 1648.2 mm per year |
| Annual Rainy days: | 1690 mm per year |

Bangkok, the capital, traces its roots back to the heritage settlements of water-based urbanization along the course of the Chao Phraya River where four rivers of, Ping, Wang, Yom, and Nan from the mountain in the north merge together in the central floodplain of the old and young delta.

Water and landscape played vital roles related to early urban settlement, economic and political management as Takaya stated “economy and urbanization of Thailand was historically dependent on irrigation and monsoon-based rice production. The size and power of a polity

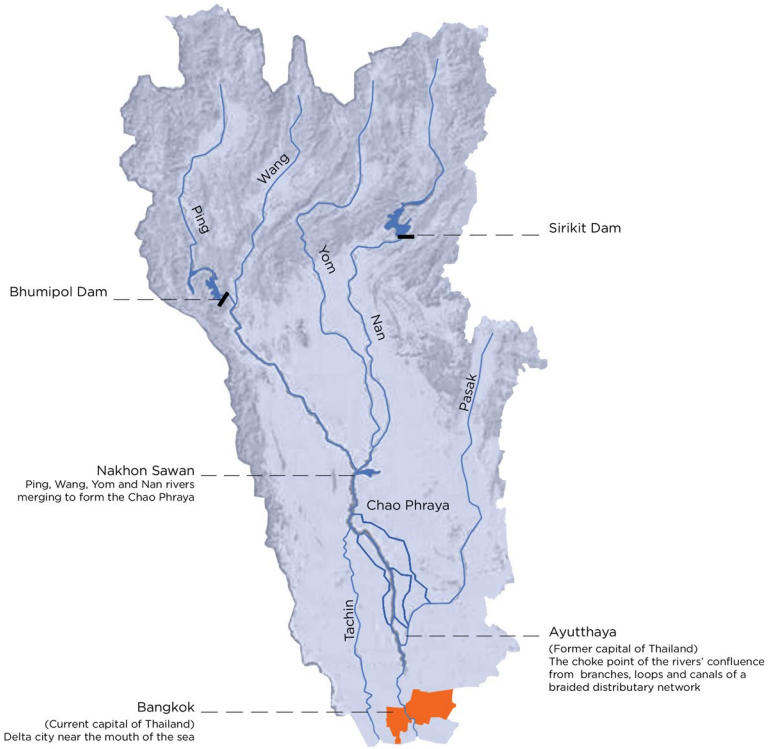




Fig. 5 (Left) Location Map drawn by author
Fig. 6 (Right) Chao Phraya River Basin & Tributaries Map drawn by author

was tied to the tributary's accumulated area of water and its distribution in successively larger catchments. Upstream settlements with smaller valleys received less water and nutrient resources than the larger intermountain valleys and successive capitols. The accumulation of water downstream is paralleled by the accumulation of power over several centuries. This tributary political system matched the hydrology of the territory, and upstream vassals delivered tribute to downstream kings, but remained politically autonomous" (1975).

Water was perceived as valuable natural resources for Thai society and culture that it is integrated in urban planning and major infrastructure of various cities along the Chao Phraya river from north to central, shown in Fig.7. Bangkok had been the site for Delta urban hydro-agricultural complex for centuries before it was influenced by European colonial powers and radically shifted to land-based urbanization.

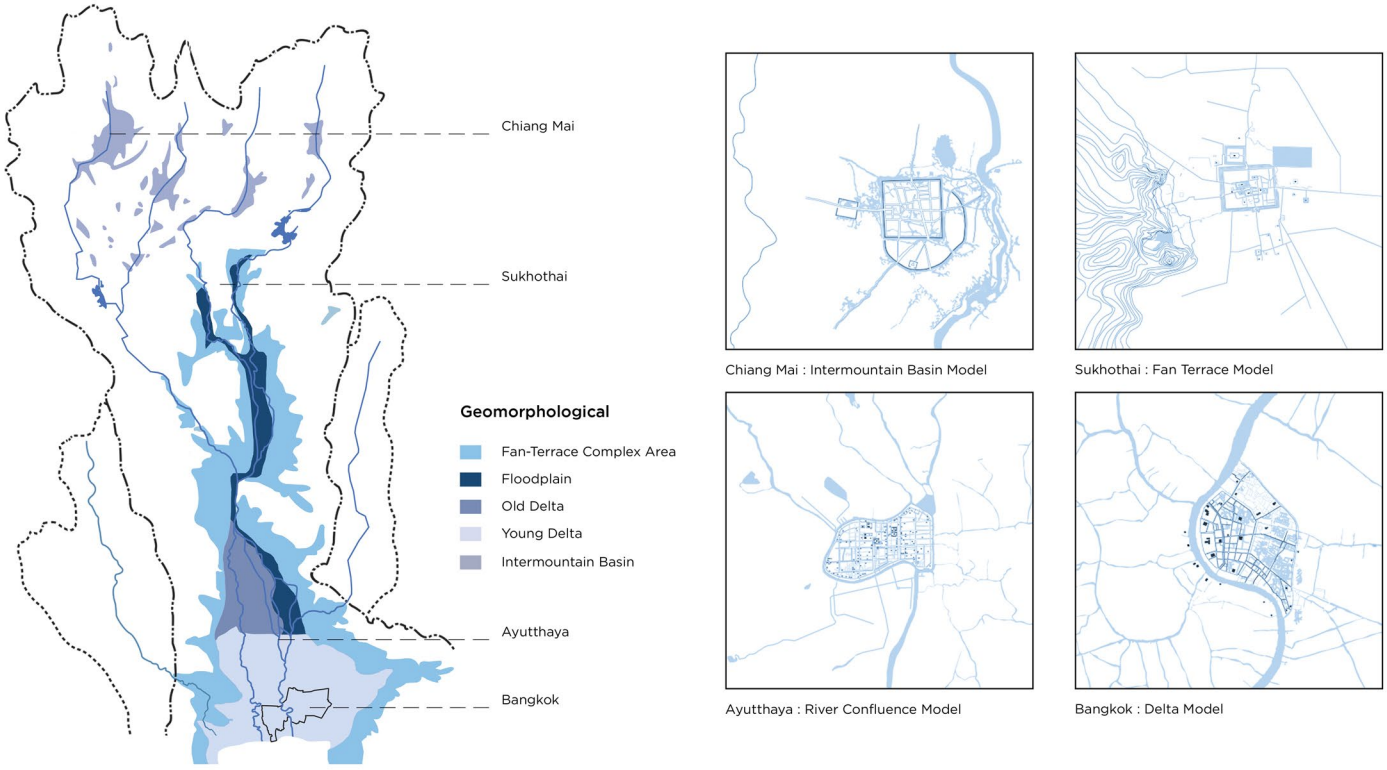



Fig. 7 Chao Phraya Watershed Tributary and Distributary System, Thailand's Water Cities (McGrath, Tachakitkachorn, & Thaitakoo, 2015)

“ When the tributary rivers reach the flat plains, both within the old and new deltas, they unbraid and meander into multiple courses, following a distributary rather than a tributary logic. Natural levees along the slow moving meanders provide settlement areas higher than the land behind, where wet rice could be cultivated in the low-lying backwaters. The levee system was enlarged to provide fruit and shade trees around settlements” (McGrath, Tachakitkachorn, & Thaitakoo, 2015).

With large fluctuations in water levels between monsoon and drought seasons, the micro hydro-agricultural matrix illustrates the independent integration system of resilience living responding to nature which embedded in traditional culture of Thai people.

By understanding climatic cycle together with landscape context, local water managements of agriculture complex could dispense water resources throughout the year, tolerating water inundation during heavy rainfall, while storing and providing water resources for irrigation during drought. To live with nature, people were adaptable and flexible with their lifestyle as seen by the vernacular elevated house design, which the semi-open space underneath has multi-purpose functions serving as living room for daily routines while occasionally allowed excessive flood to freely pass through as illustrated in Fig.10.

Linear water infrastructures of canals and rivers were carrier of social and ecology system where large rivers were routes for trading

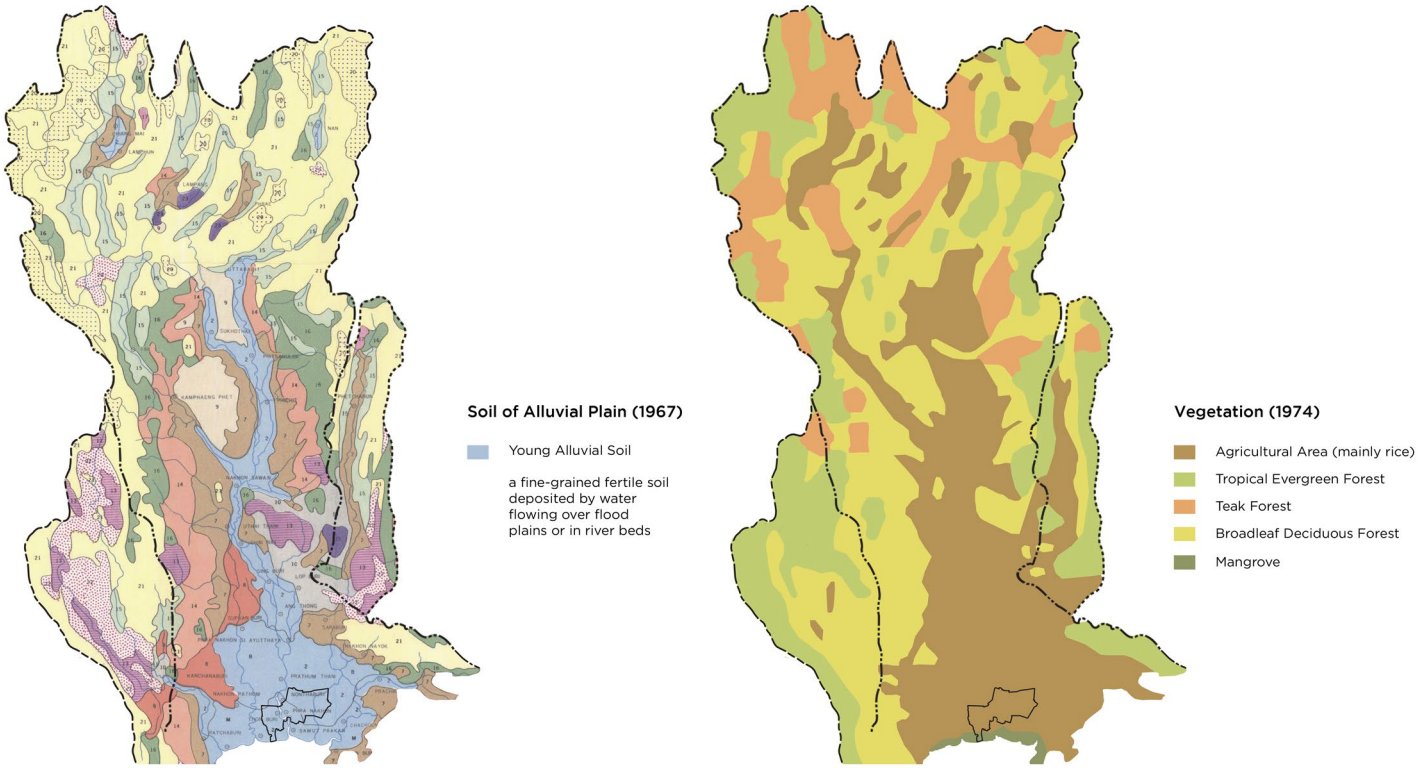



Fig. 8 (Left) Soil Map of Thailand, 1967 drawn by author
Fig. 9 (Right) Vegetation Map of Thailand, 1974 drawn by author

between cities, inducing water market communities along the lines, meanwhile, water was used as natural supply for daily routines. Waterlines were considered also as public spaces, where diverse classes of people were capable of sharing and using from private purposes of bathing or fishing to official royal ceremonial activities.

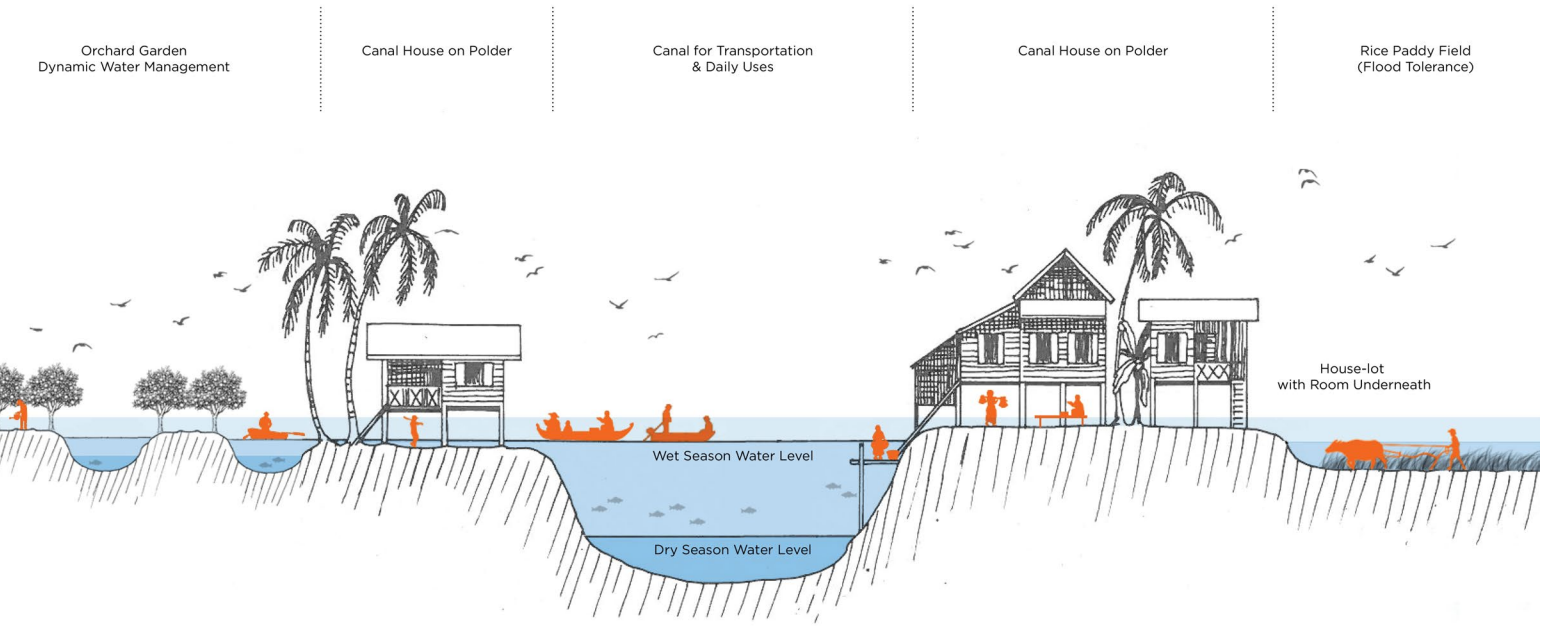



Fig. 10 Modified Conceptual Section of Typical Canal Settlement in the Chao Phraya Delta drawn by author based on (Freestone, 1974)

Fig. 11

Fig. 12

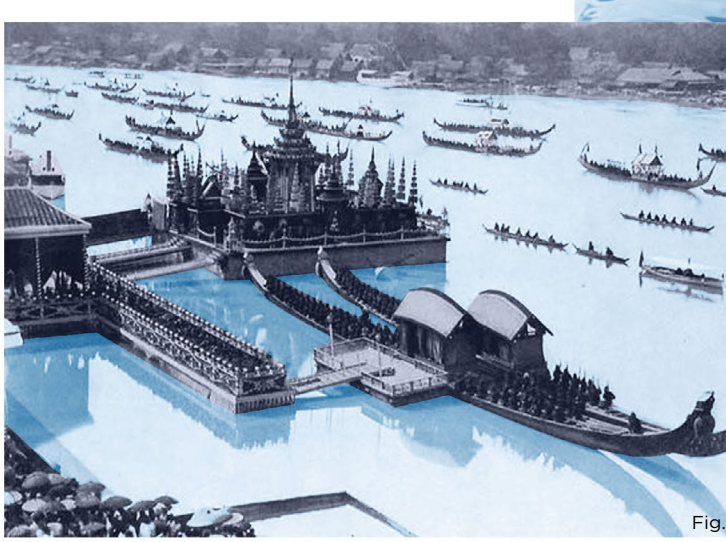


Fig.

Fig. 13

Fig. 14

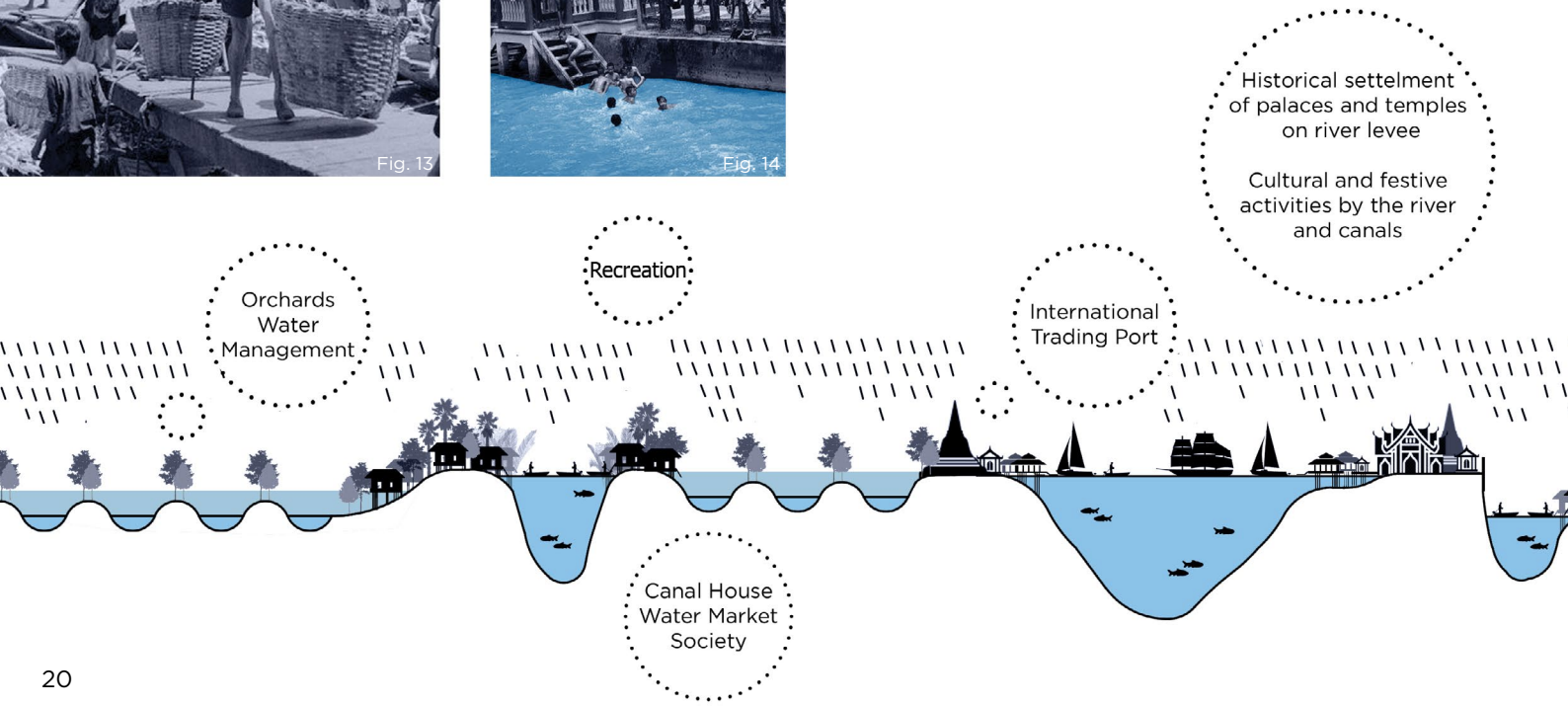


Fig. 16

Fig. 17

15

Fig. 18

# Living with Water

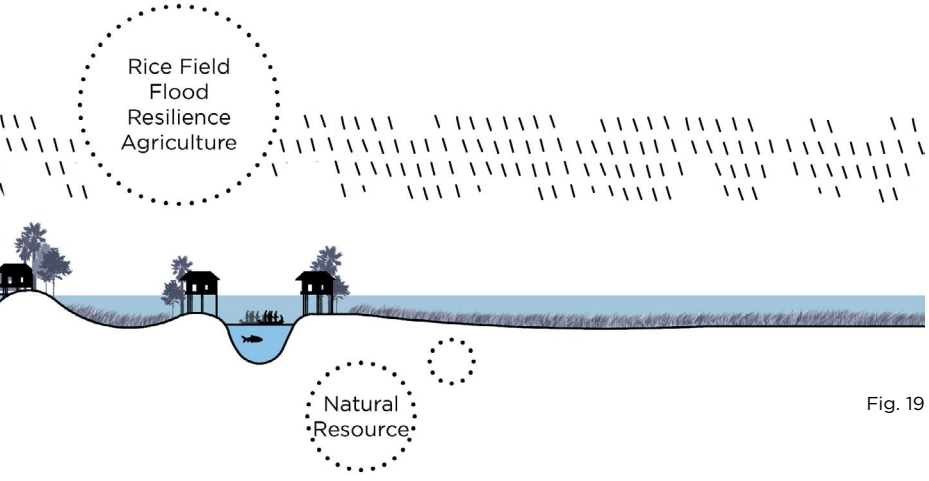



Fig. 19

Fig. 11 Agriculture Abandonment (McGrath, Tachakitkachorn, & Thaitakoo, 2015)
Fig. 12 Water Market Community (Kessel D., 1950)
Fig. 13 Tha Tien Trading Port (Bristol H., 1956)
Fig. 14 Wat Benchamabophit (Bangkok in the past, 2504)
Fig. 15 Royal Rite of Passage (From rickshaws to riches: Amazing photos of Bangkok from 100 years ago that show a metropolis in the making, 1900)
Fig. 16 Bathing by Canal (Torre L., 1956)
Fig. 17 Rice Paddy Farming (Rice Paddie Managing)
Fig. 18 Canal for Transportation (Torre L., 1956)
Fig. 19 Bangkok Indigenous Living Diagram drawn by author

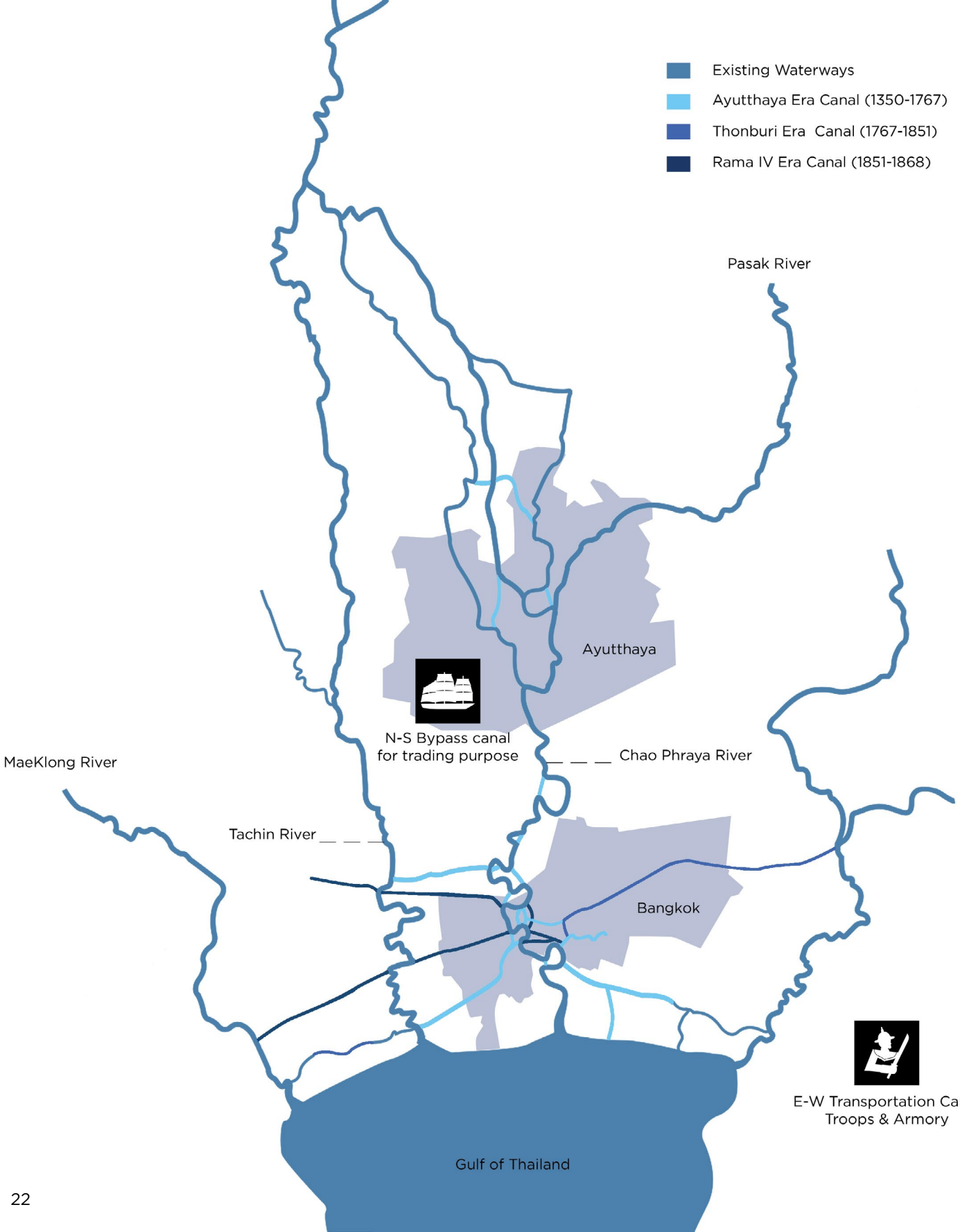

Existing Waterways
Ayutthaya Era Canal (1350-1767)
Thonburi Era Canal (1767-1851)
Rama IV Era Canal (1851-1868)
Pasak River
Ayutthaya
N-S Bypass canal
for trading purpose
Chao Phraya River
MaeKlong River
Tachin River
Bangkok
E-W Transportation Canal
Troops & Armory
Gulf of Thailand

Fig. 20

Fig. 21


Fig. 22

# Urban Structure and Water Management Transformation

**Ayutthaya - Early Bangkok (1350-1868)**
**Transportation - Trading**

During Ayutthaya era, several bypass canals were developed along the north-south direction as shortcuts for transportation routes connecting oversea traders. Meanwhile, these modified water network also induced sedimentation processes along the artificial levees as canal-side market communities were created and integrated into a world trading system. The east-west transversal defensive canals were later developed allowing transportation of troops and armory to nearby distributary cities (McGrath, Tachakitkachorn, & Thaitakoo, 2015).

Fig. 20 Modified Ayutthaya & Early Bangkok Era Canals (McGrath, Tachakitkachorn, & Thaitakoo,2015)
Fig. 21 Ayutthaya Historical Trading Routes (Manesson-Mallet A., 1683)
Fig. 22 Ayutthaya Water Market Community (Ayutthaya Water Market)

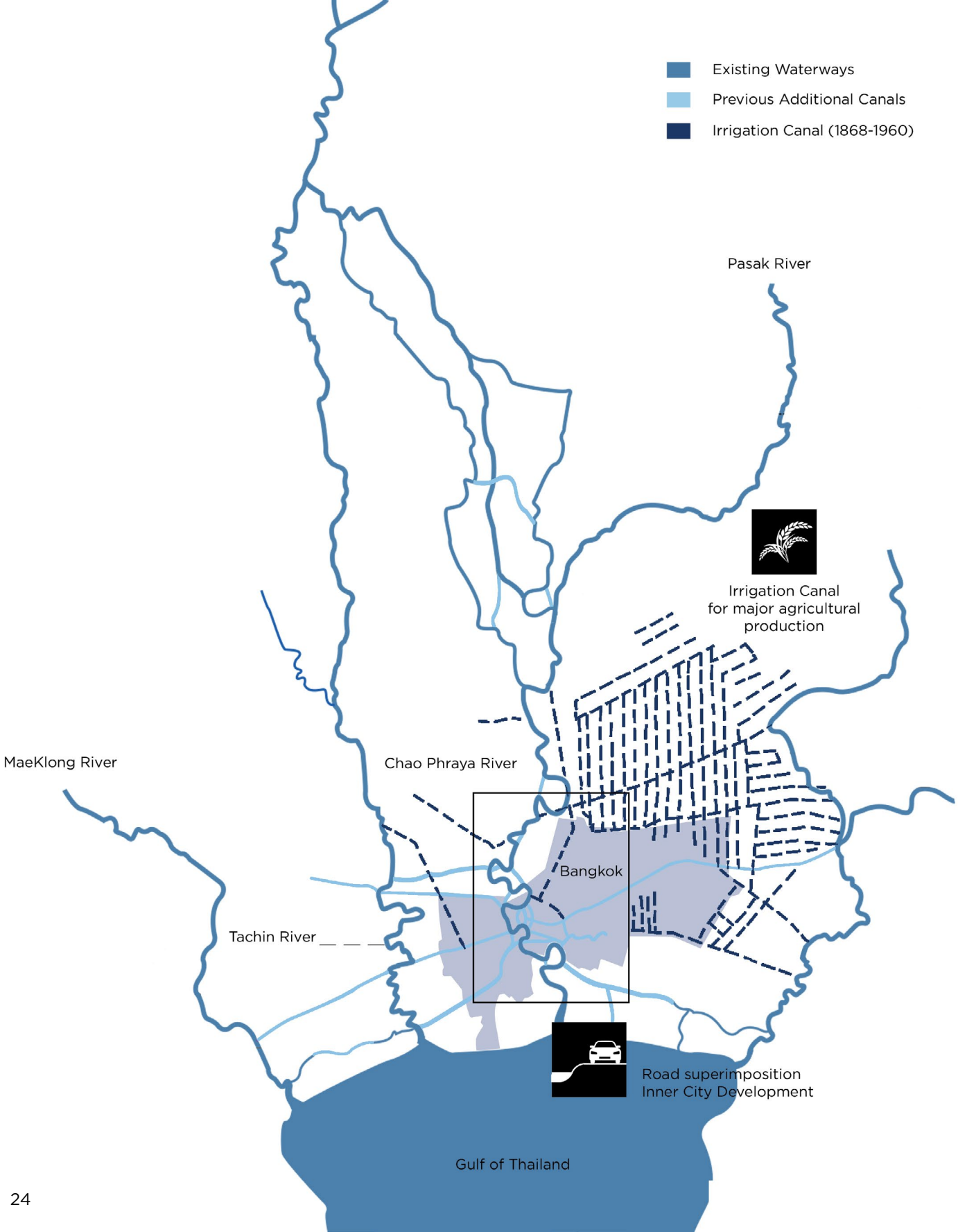

Existing Waterways
Previous Additional Canals
Irrigation Canal (1868-1960)
Pasak River
Irrigation Canal
for major agricultural
production
MaeKlong River
Chao Phraya River
Bangkok
Tachin River
Road superimposition
Inner City Development
Gulf of Thailand

Fig. 23

Fig. 24

Fig. 25

**The Reign Of Rama V (1868-1910)**
**Irrigation - Drainage**

With the influences from European colonial contract and trade in the middle of nineteenth century, the delta network was developed with massive water infrastructure additions in the north-east region. With new dependable irrigation system, the performance of micro hydro-agricultural matrix was enhanced expecting to extend rice cultivation period throughout the year. Moreover, the system also prevented villages and orchard gardens from flooding resulting in a major increase of agricultural production expansion of that period.

Meanwhile, in the urban area, the first land-based expansion with road system was developed by the influences of European colonial contract. The transforming of Bangkok's urban structure occurred at the turn of the twentieth century at Dusit and Pathumwan districts considered as the first extensive road-based expansion in Thailand. Palaces were built with the surrounding road system superimposed over canal which shifted the role of canal as parallel drainage. (McGrath, Tachakitkachorn, & Thaitakoo, 2015).

Fig. 23 Modified King Chulalongkorn Era Canals (McGrath, Tachakitkachorn, & Thaitakoo,2015)
Fig. 24 Canal for Transportation (Torre L, 1956)
Fig. 25 Rice Paddy Farming (Rice Paddy Managing)

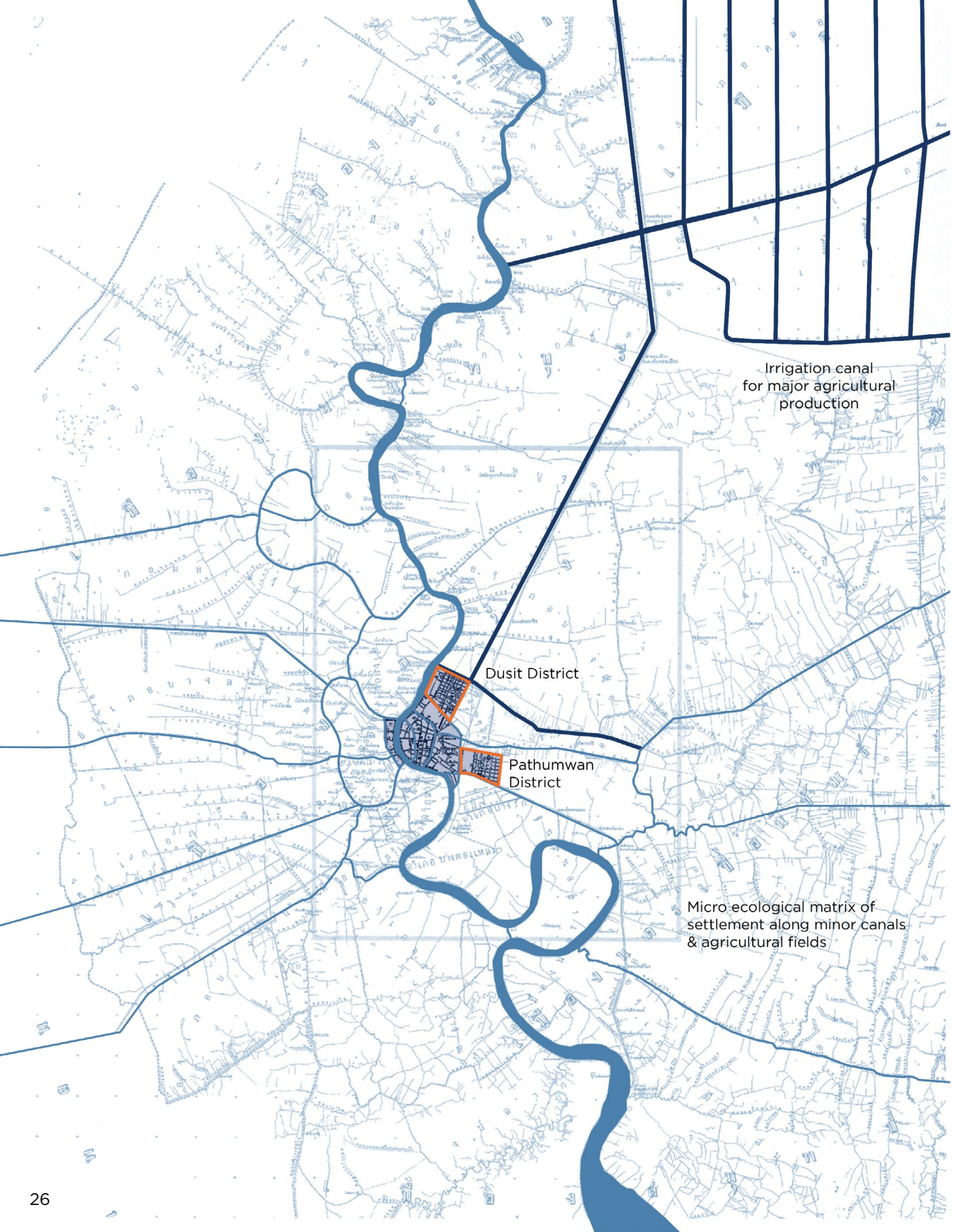

Irrigation canal
for major agricultural
production
Dusit District
Pathumwan
District
Micro ecological matrix of
settlement along minor canals
& agricultural fields

Fig. 26

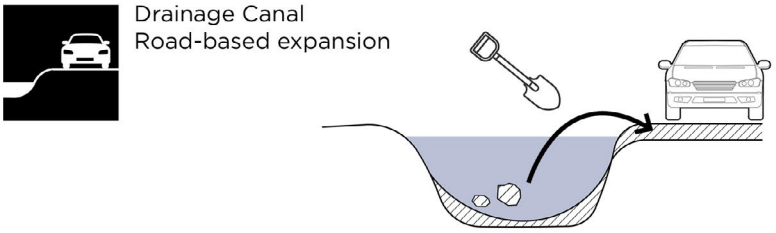



Fig. 29

Fig. 26 Map of Monthon Krungthep, 1905
(Vanno, 2012)
Fig. 27 Neighborhood of Royal Palace
(Notice the power or telephone poles , 1906)
Fig. 28 Chaloem Sawan 58 Bridge
(Chaloem Sawan 58)
Fig. 29 Shift of Transportation Infrastructure
Diagram drawn by author

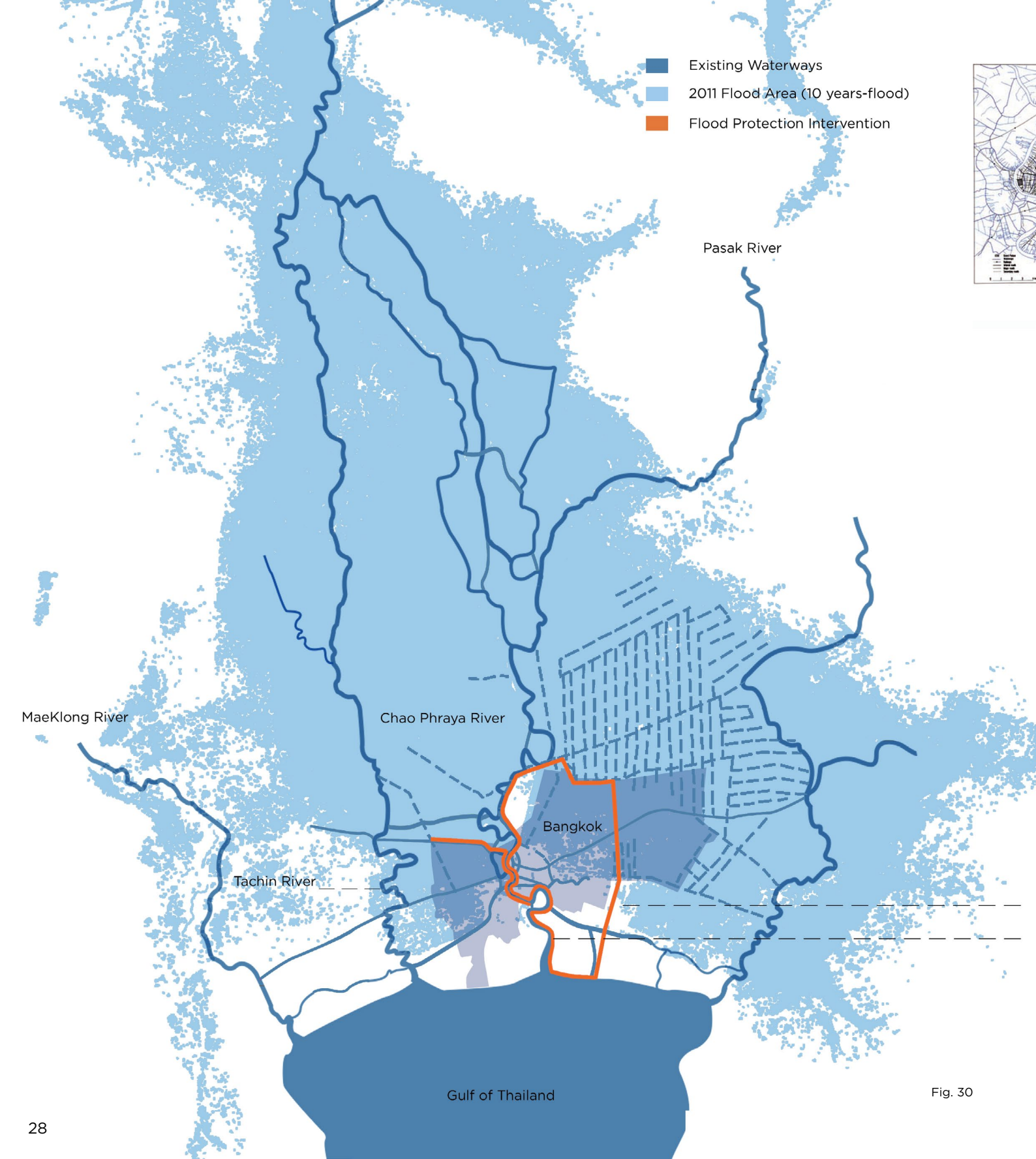

Existing Waterways
2011 Flood Area (10 years-flood)
Flood Protection Intervention
Pasak River
MaeKlong River
Chao Phraya River
Bangkok
Tachin River
Gulf of Thailand

Fig. 30

1935 1955 1975

Fig. 31

Centralized water management system to extend agricultural production period

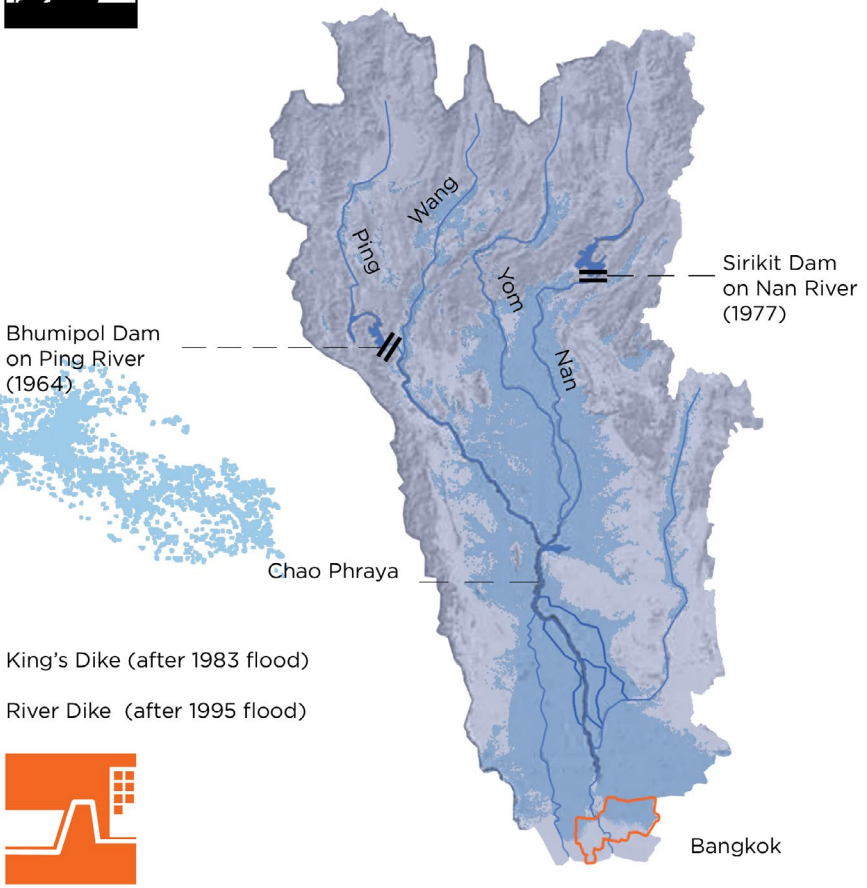





Fig. 32

**Modern Development (1977-present)**
**Flood Defensive Driven Strategy**
**& Grey Infrastructures**

Massive irrigation and retention project of Bhumipol and Sirikit dam completely transformed local water management into centralized system. The projects were executed to gained full control of water supply for agricultural productions during dry season enhancing the economic growth of the country. With the result of the development, the new urbanization of the city was developed neglecting the need of water management system. Land-based urbanization and grey infrastructure were developed as new urban form of modern road systems with engineering drainage and sewage networks. (McGrath, Tachakitkachorn, & Thaitakoo, 2015).

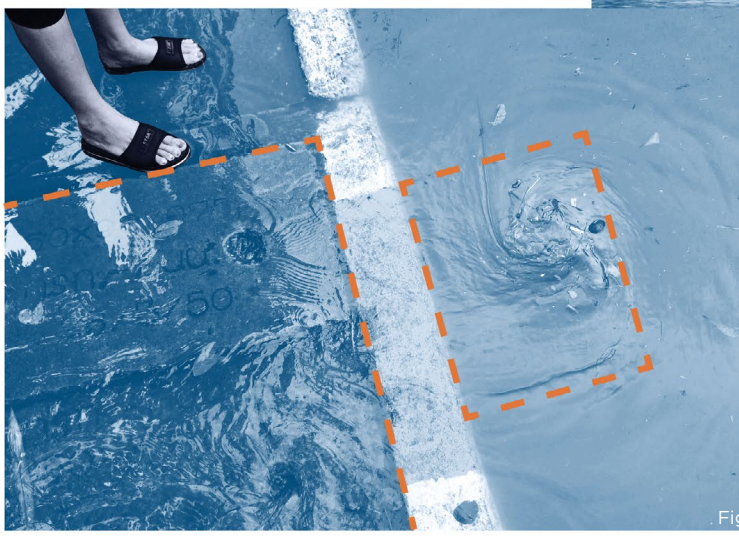
With this stage, water slowly became irrelevant for people life yet developed to be threat as Bangkok faced several floods over time. On-going land-based development inland led to the need of grey infrastructure approach for flood protection, promoting engineering management solutions. Flood dikes were built along both sides of Chao Phraya River as flood defensive system for the city.

In 2011, with the attempt to protect certain economical significant districts of Bangkok, flood was blocked and forced to alternative routes by the protection lines. Bangkok was partially safe but resulting in more severe flood effects to the surrounding provinces. The development of current flood defensive system was proved to be inefficient and unsustainable in long-term as various interventions need plentiful of maintenances and reinforcements which also create separation in relations between people and water.

Fig. 30 2011 Flood Map of Bangkok drawn by author
Fig. 31 Bangkok Urban Growth Map (McGrath, Thaitakoo, 2010)
Fig. 32 2011 Flood Map of Chao Phraya River Basin drawn by author

Fig. 33

Fig. 35



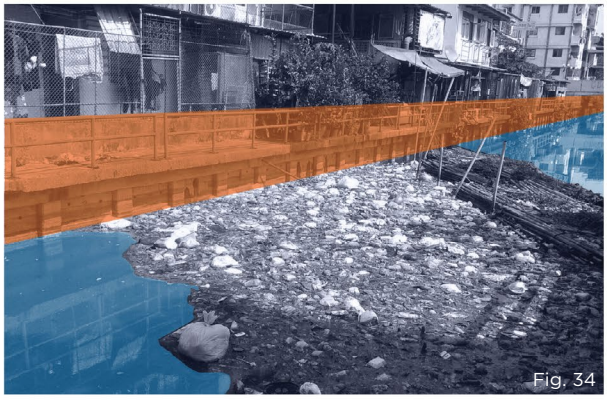
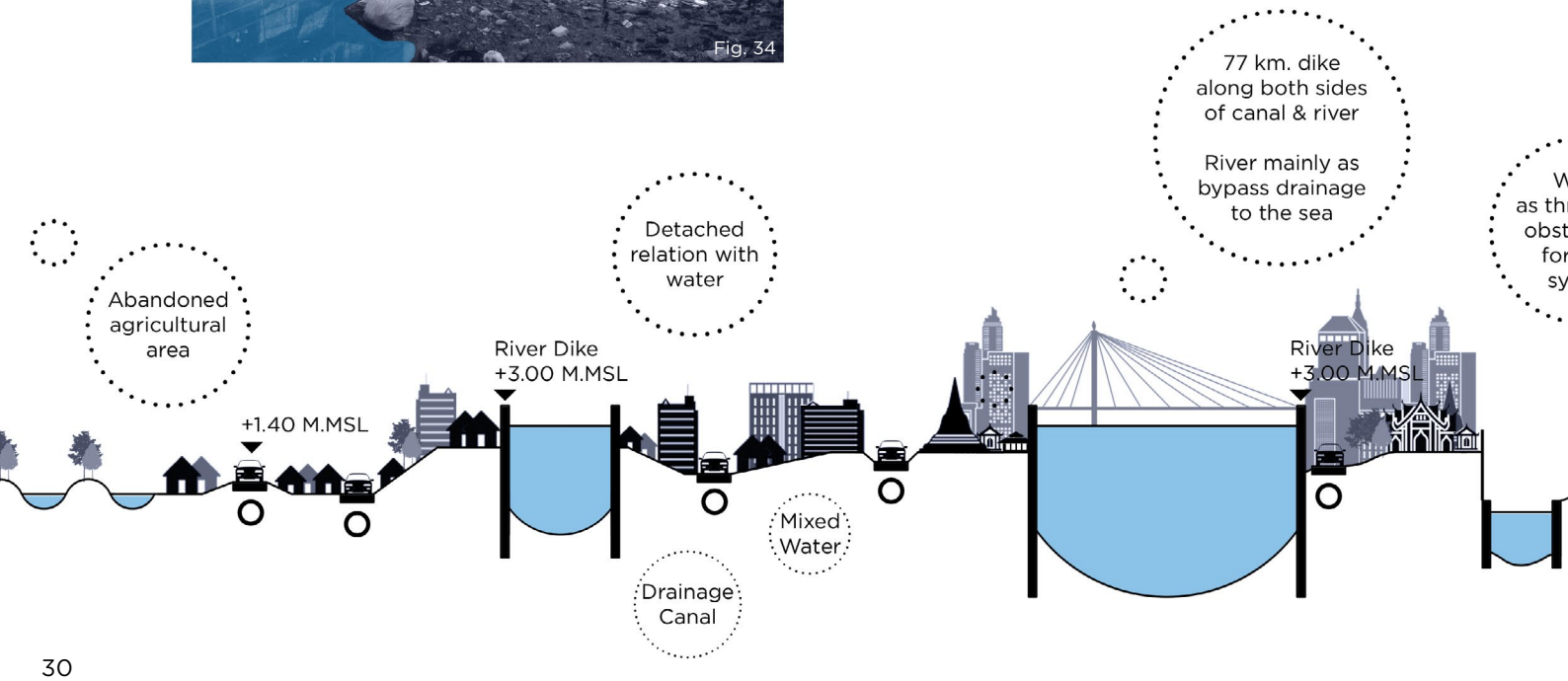


Fig. 34



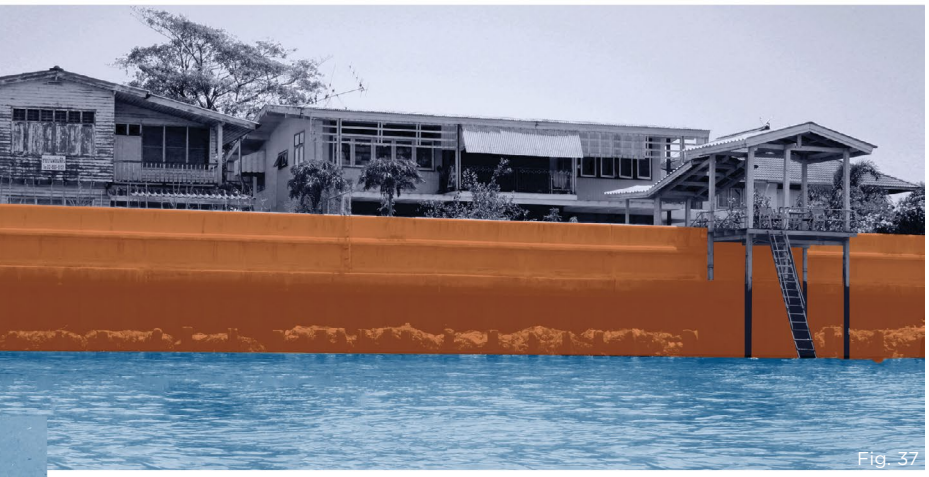


Fig. 37

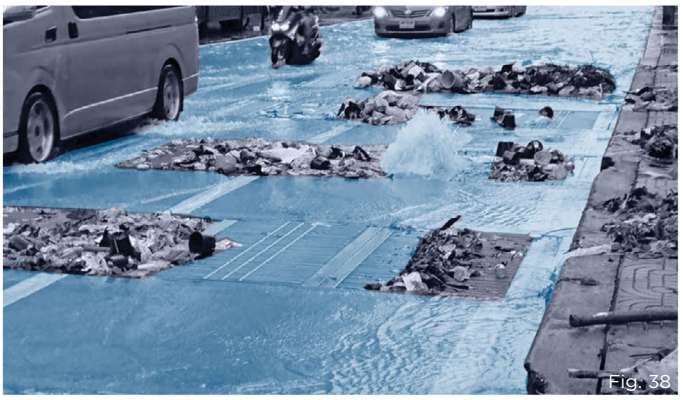


Fig. 38

## Transformation of People's Perception towards Water

"Grey infrastructures are not isolated systems but embedded in and affect social and ecological components of the urban system. Social and ecology systems evolve while influencing each other thus creating sharp contrast with fixed, long-lasting grey infrastructures that lack flexibility to be" (Depietri & McPhearson, 2017).

From this statement, it could be assumed that Bangkok's new urban form with major shift to grey infrastructure development influences changes of daily system and behavior of people in relation with water. The roles and perception of water has been altered from the living infrastructure of the past to drainage and sewage system apart from people life. Water infrastructures lost their social and ecological qualities as they are divided and controlled in certain areas by engineering flood interventions. The on-going promotion of grey infrastructure for flood defensive solutions led to the devaluation of this valuable resources.

Water is in the stage of decaying socially and ecologically. The question is raised upon the extend in which flood management could be incorporated as part of daily living condition of the inhabitants, reinforcing socio-ecological transformation of future resilience society.

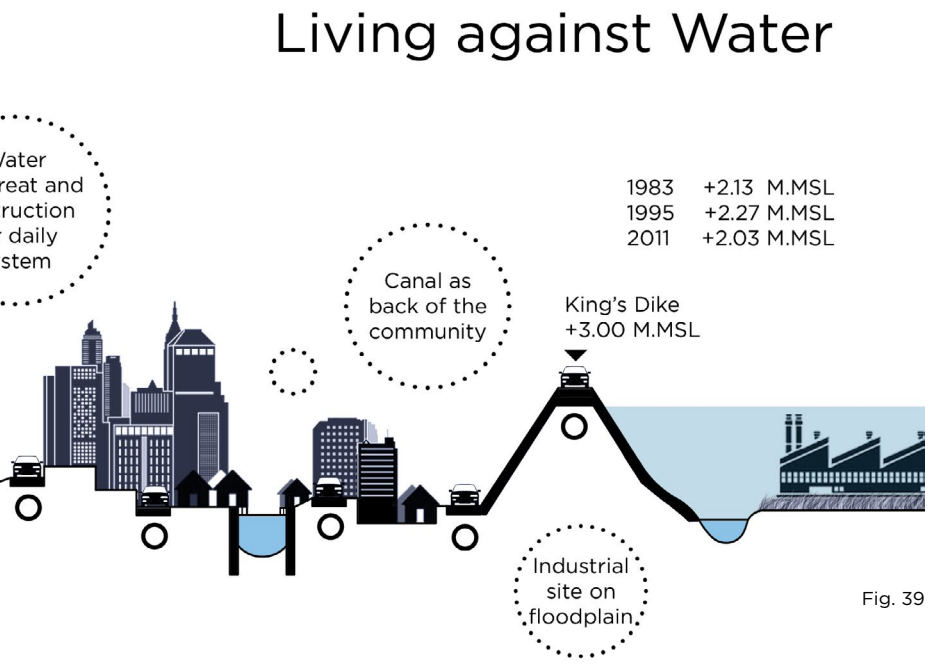



Fig. 39

Fig. 33 Sathon Canals (Day self)
Fig. 34 Trash Crisis in Canals (sunserne, 2016)
Fig. 35 Flash Flood (Vihoknews, 2017)
Fig. 36 Underground Drainage System (T-news, 2018)
Fig. 37 Royal Rite of Passage by Author
Fig. 38 Trash Crisis from Flood (Sanook, 2017)
Fig. 39 Bangkok Flood Defensive living Diagram drawn by author

# 1.2 FLOOD - GREY INFRASTRUCTURE

a) Flood and Management
b) Water Management Infrastructure
c) Transportation Infrastructure & Urban Expansion
d) Green & Blue Infrastructure
e) Flood Risk Assessment : Grey Infrastructure Approach

# Flood and Management

Flood in Bangkok can be classified into two main situations, regular situation of flash flood and the specific situation of river flood. (Department of drainage and sewerage, 2018).

Flash flood in urban area generally caused by a combination of precipitation and high tide, generally in rain season with the influence of tropical monsoon. Excessive run-off water on surface causes temporary flood which obstruct the flows of urban and daily system of the inhabitants. Underground drainage systems of pipes and tunnels are used supporting mixed water system of both run-off and sewage, hence, the current water treatment stations could not fully support. Some sewages are drained directly to Chao Phraya river without proper treatment. (Department of drainage and sewerage, 2018).

River flood occurred within a year of heavy monsoon with large amount of water from the north and high tide combined. This flood is considered as national issue as it affects large areas of several delta cities. (Department of drainage and sewerage, 2018). Bangkok as a capital, has centralized privilege to get extra protection and gain the power to control amount of water in the city, while the surrounding cities suffer from longer period of flood. This controversial issue of rightness and fairness was discussed amongst societies after 2011 flood incident.

Fig. 40


Fig. 41

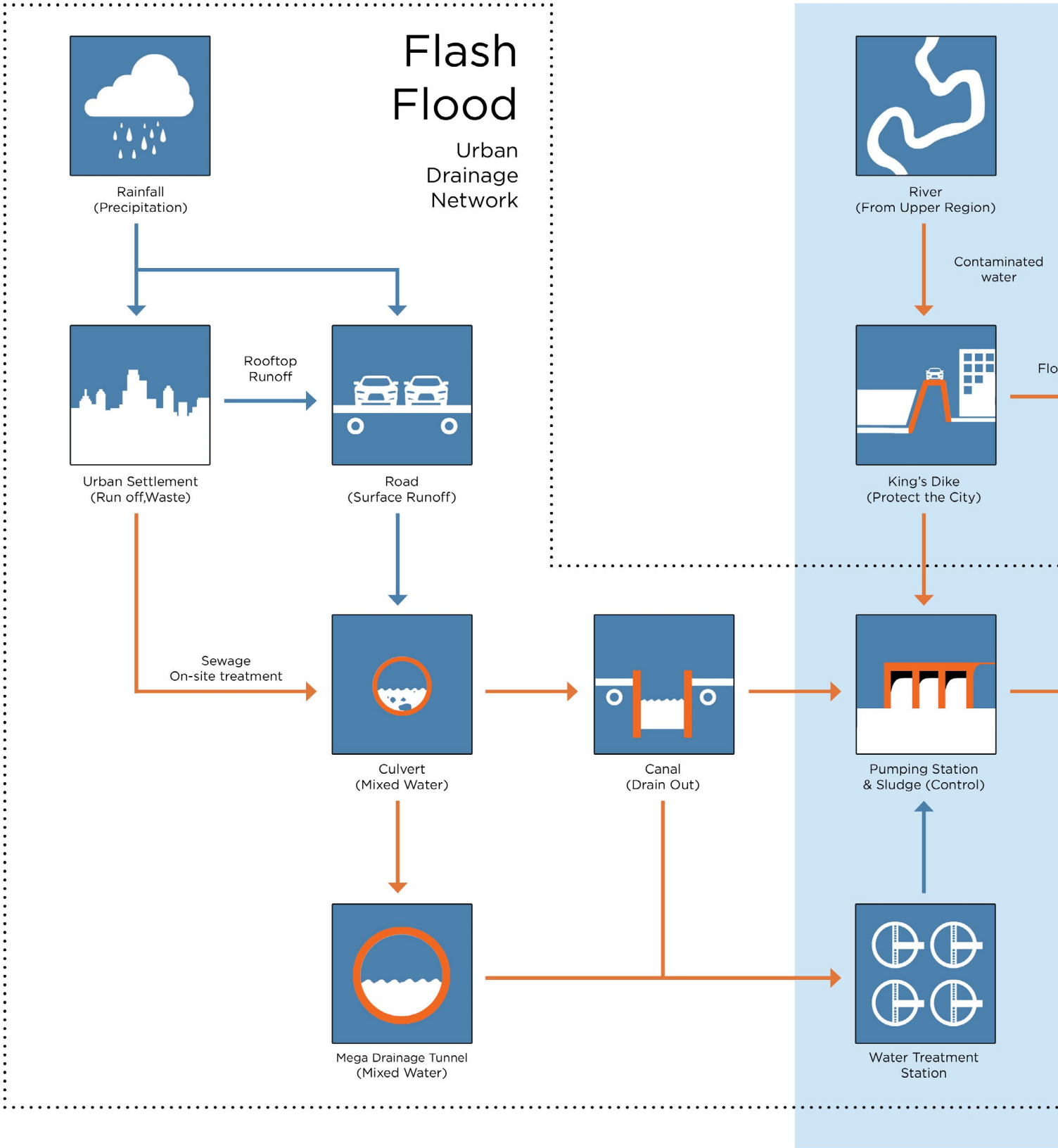
## Flash Flood

May - Oct (Seasonal)
Urban Capacity :
60 mm / hr

## River Flood

Approx. 10 years
River Capacity :
3000 $cm^3$/ sec (max)

Fig. 40 (Left) Flash Flood (Vihoknews, 2017)
Fig. 41 (Right) River Flood (Berehulak D., 2011)


Flash
Flood
Urban
Drainage
Network
Rainfall
(Precipitation)
River
(From Upper Region)
Contaminated
water
Rooftop
Runoff
Urban Settlement
(Run off,Waste)
Road
(Surface Runoff)
King's Dike
(Protect the City)
Sewage
On-site treatment
Culvert
(Mixed Water)
Canal
(Drain Out)
Pumping Station
& Sludge (Control)
Mega Drainage Tunnel
(Mixed Water)
Water Treatment
Station

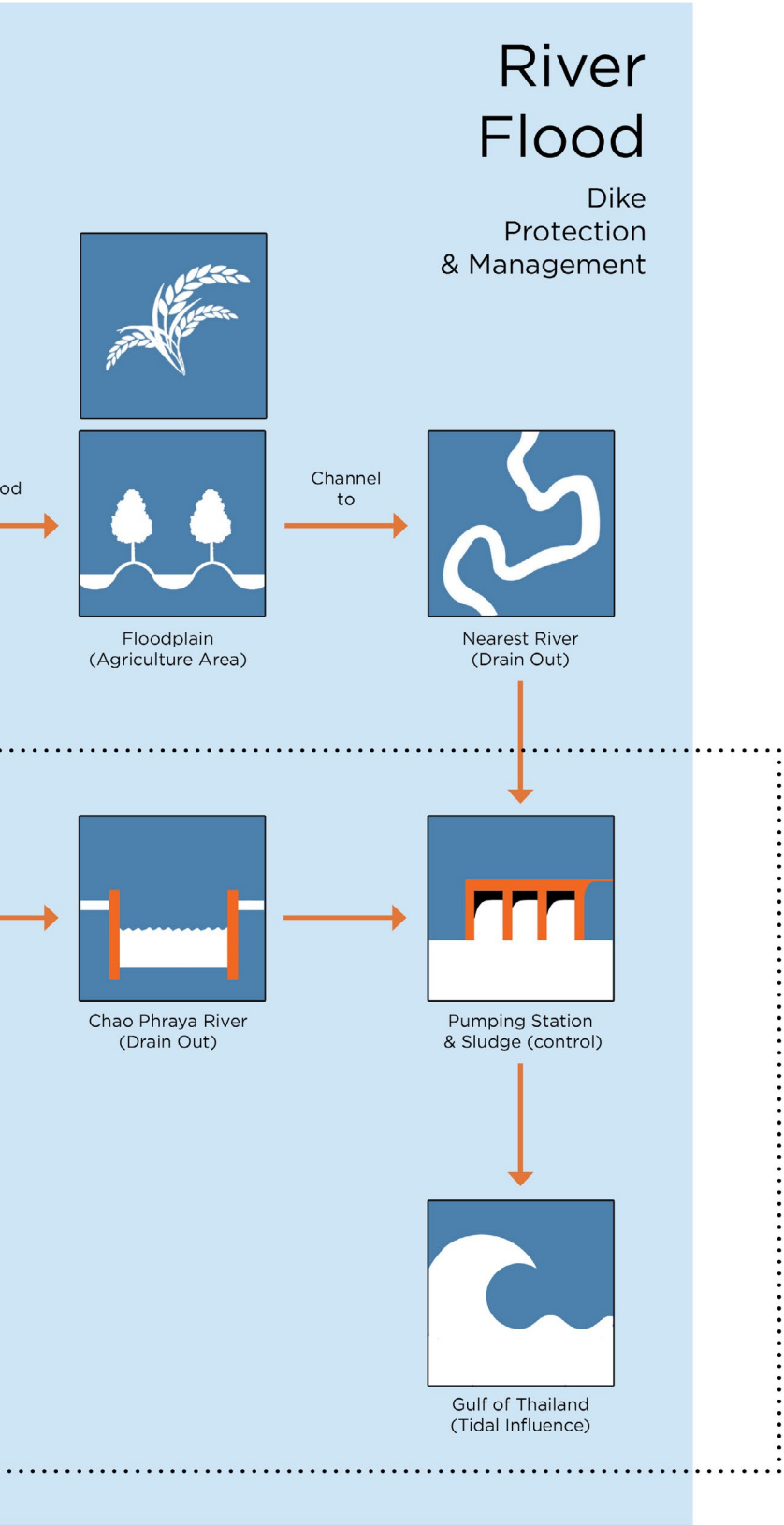
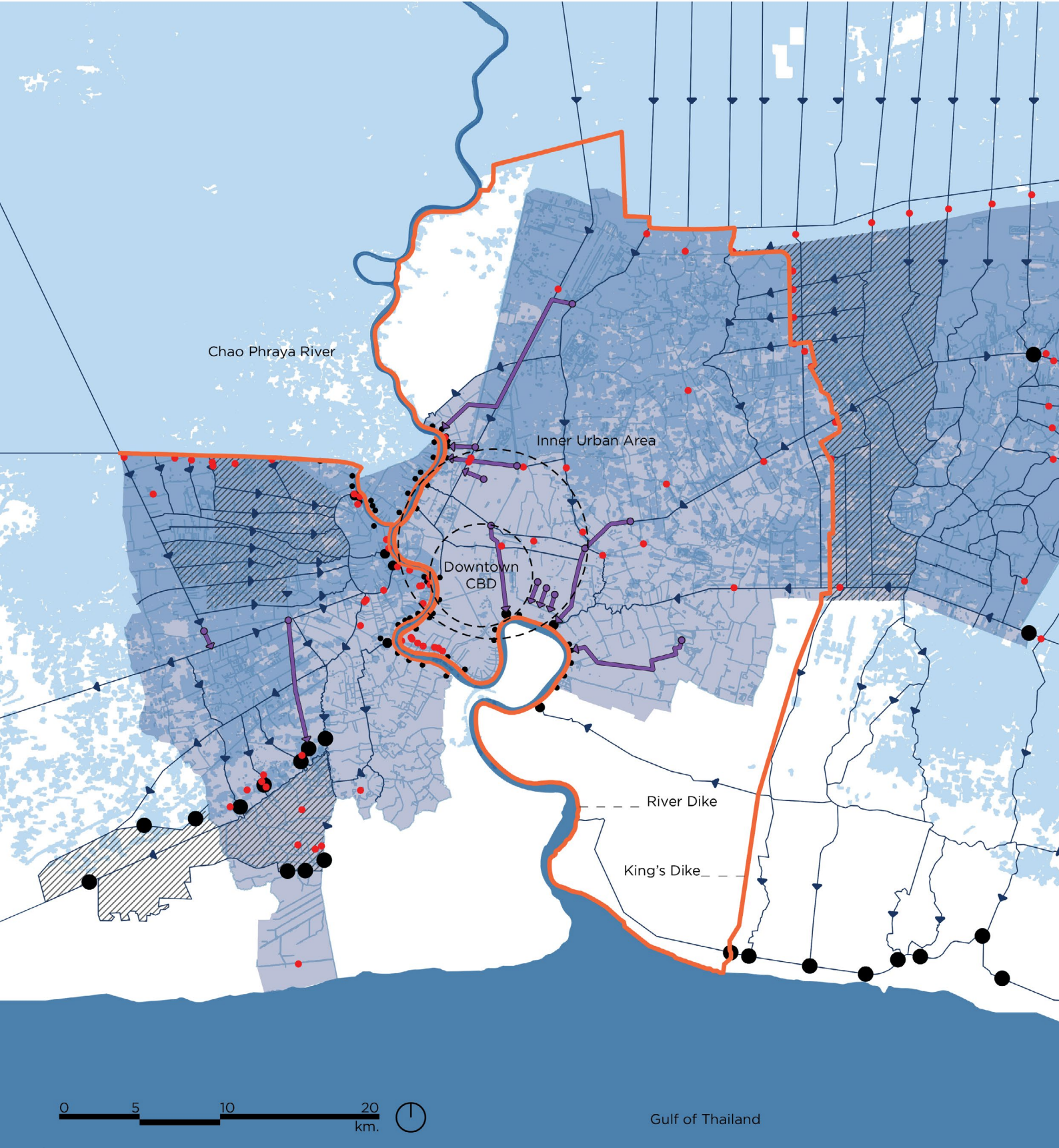
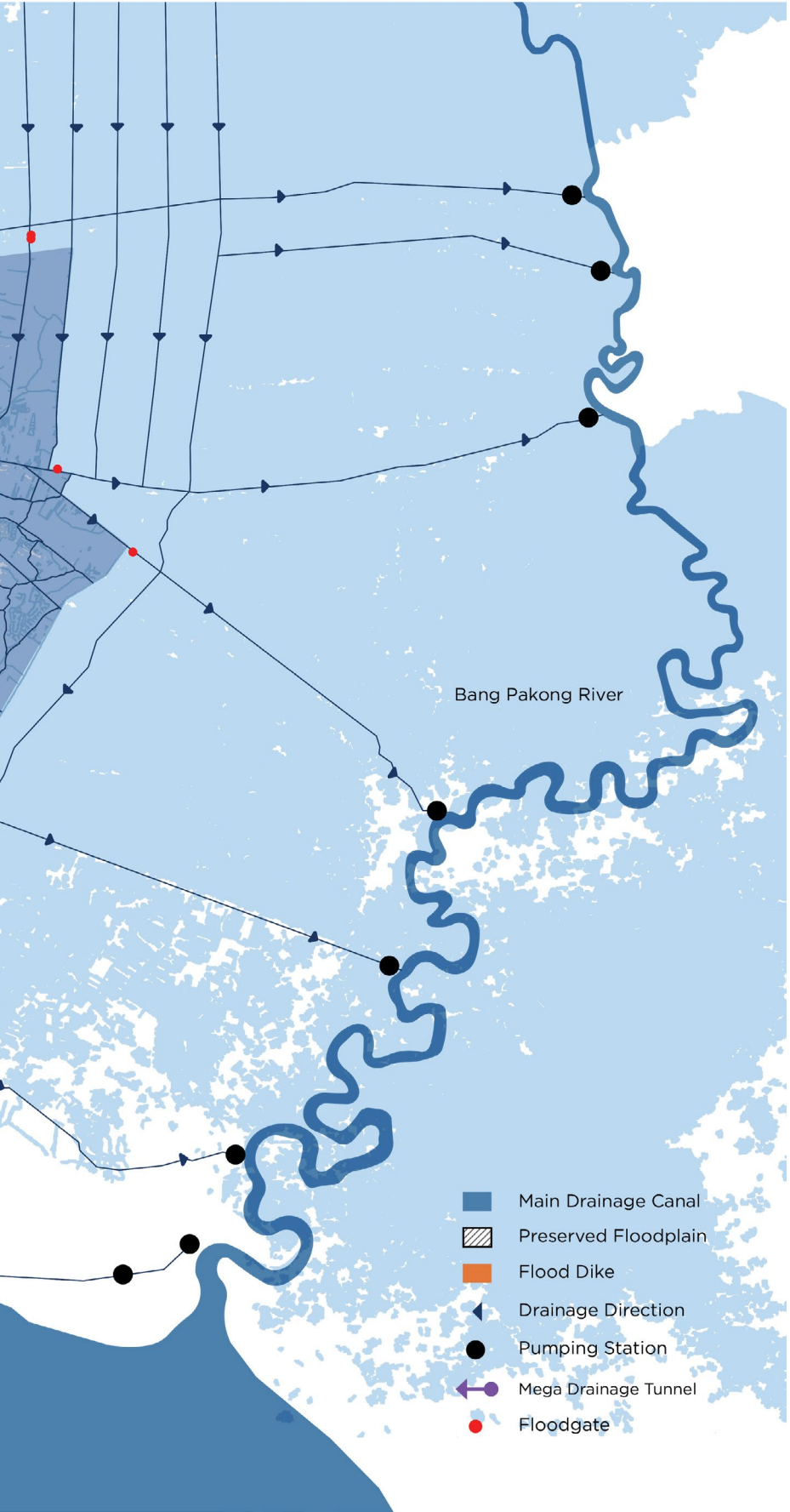



Fig. 42 Conceptual flood management of Bangkok drawn by author


Chao Phraya River
Inner Urban Area
Downtown
CBD
River Dike
King's Dike
0
5
10
20
km.
Gulf of Thailand




# Water Management Infrastructure

**(2011 Flood Condition)**

With the small margin of height different and limitation of dense urban spaces, natural gravity flow is neglected from water management system of Bangkok as stated by Department of drainage and sewerage (2018). High economical-valued commercial districts are the key areas protected by grey infrastructure approach developments. Engineering solutions are heavily promoted including, flood dike and water gate system to protect water overflow from the river and control water within the management areas, underground drainage systems of pipes and tunnels together with drainage canal system convey surface run-off and sewage preventing flood inland (Department of drainage and sewerage, 2018). With these interventions to control and get rid of water from urban area, water is currently treated and perceived as service system separated apart from daily life.

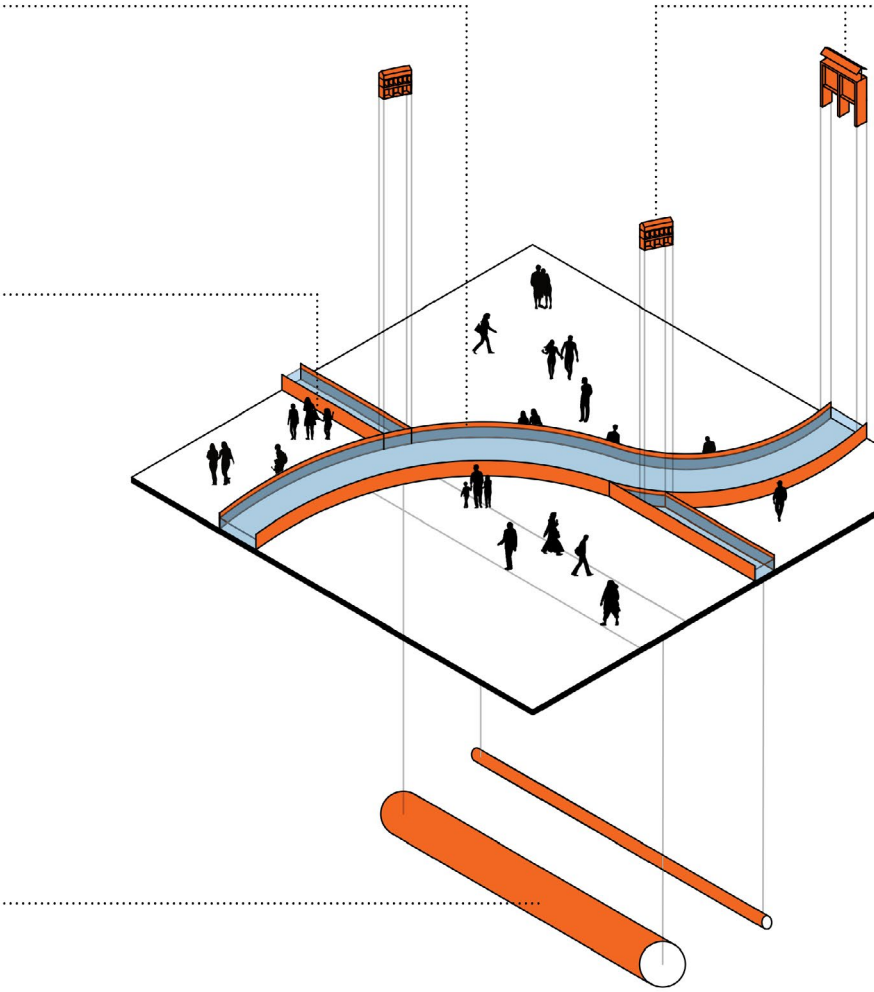
"In the aftermath of the 2011 flood, the King's Dyke and the river wall mostly protected the city, the dyke was breeched and undermined in many places. The floodgates were the site of conflict between communities inside and outside the protected urban polder" (McGrath, Tachakitkachorn, & Thaitakoo, 2015). However, engineering solutions are continuously promoted by the government as the defensive driven management against flood remains to be the ideal solutions for current land-based lifestyle. Major maintenances of heightening flood dikes and additions of flood tunnels are expected in 2018 flood management plans (Department of drainage and sewerage, 2018).

Fig. 43 Water Management Infrastructure of Bangkok drawn by author

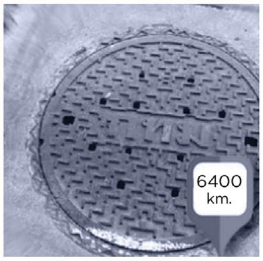
Flood Dike
Along River & Canal



+ Highten up the dike to 2.80-3.50 m. from sea level



Culvert




Water management rely mainly on network of underground drainage system

Mega Drainage Tunnel

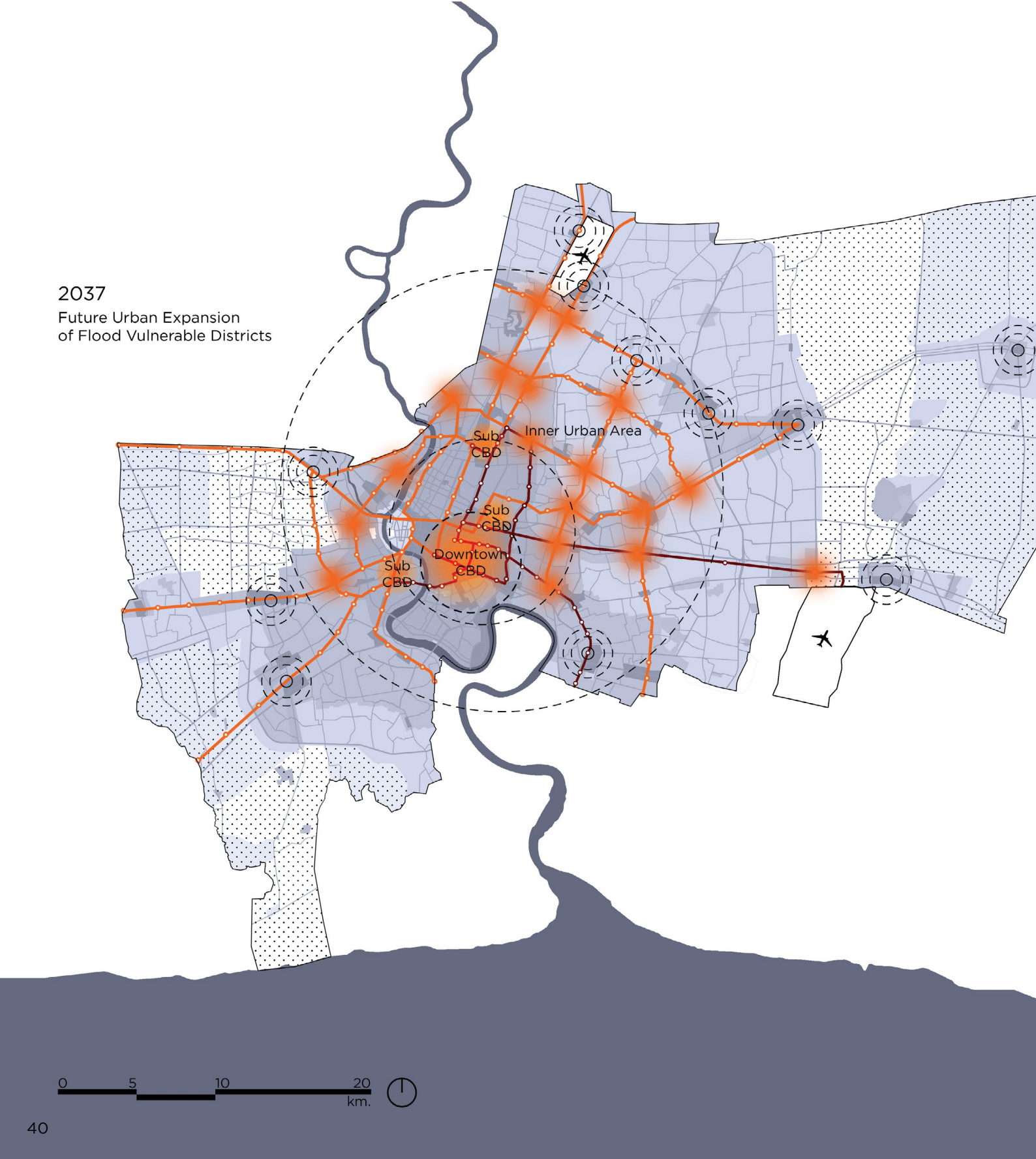

+ Construction of extra tunnels cost 22,975.865 million baht

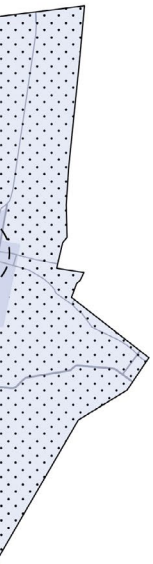
Flood Gate
& Pumping Station



n Daily System

Fig. 44 Conceptual Engineering Water Management of Bangkok drawn by author


2037
Future Urban Expansion
of Flood Vulnerable Districts
Inner Urban Area
Sub CBD
Sub CBD
Sub CBD
Downtown CBD
0
5
10
20
km.



Emerging Commercial & Transportation Hub

Sub-Urban Development

Main Road Network

Existing Railed Public Transportation Network

Extended Railed Public Transportation Network

Sub-urban / Agricultural Area

Urban Development Area

# Transportation Infrastructure & Urban Expansion

**(2037 Commercial & Transportation Hub)**

"One of the obvious urban issue of Bangkok is vehicle-based development which create the stage of conflicts for pedestrian uses. Road should be considered as public space accommodating also other type of users apart of vehicles." (Aruninta, 2011). Economic driven transportation development lead to the one-sided promotion of infrastructure for vehicle-connection inducing new estates along the transportation lines (Pomlaktong et.al, 2013). However, other aspects of social and ecology systems are heavily ignored resulting in, poor pedestrian connectivity and living quality which has continuous impact to the increase amounts of vehicles, traffic congestion, traffic pollutions and unresolved problem of flash flood. With this cycle of development model, the expansion of road system could lead to the increase of flood vulnerable districts.

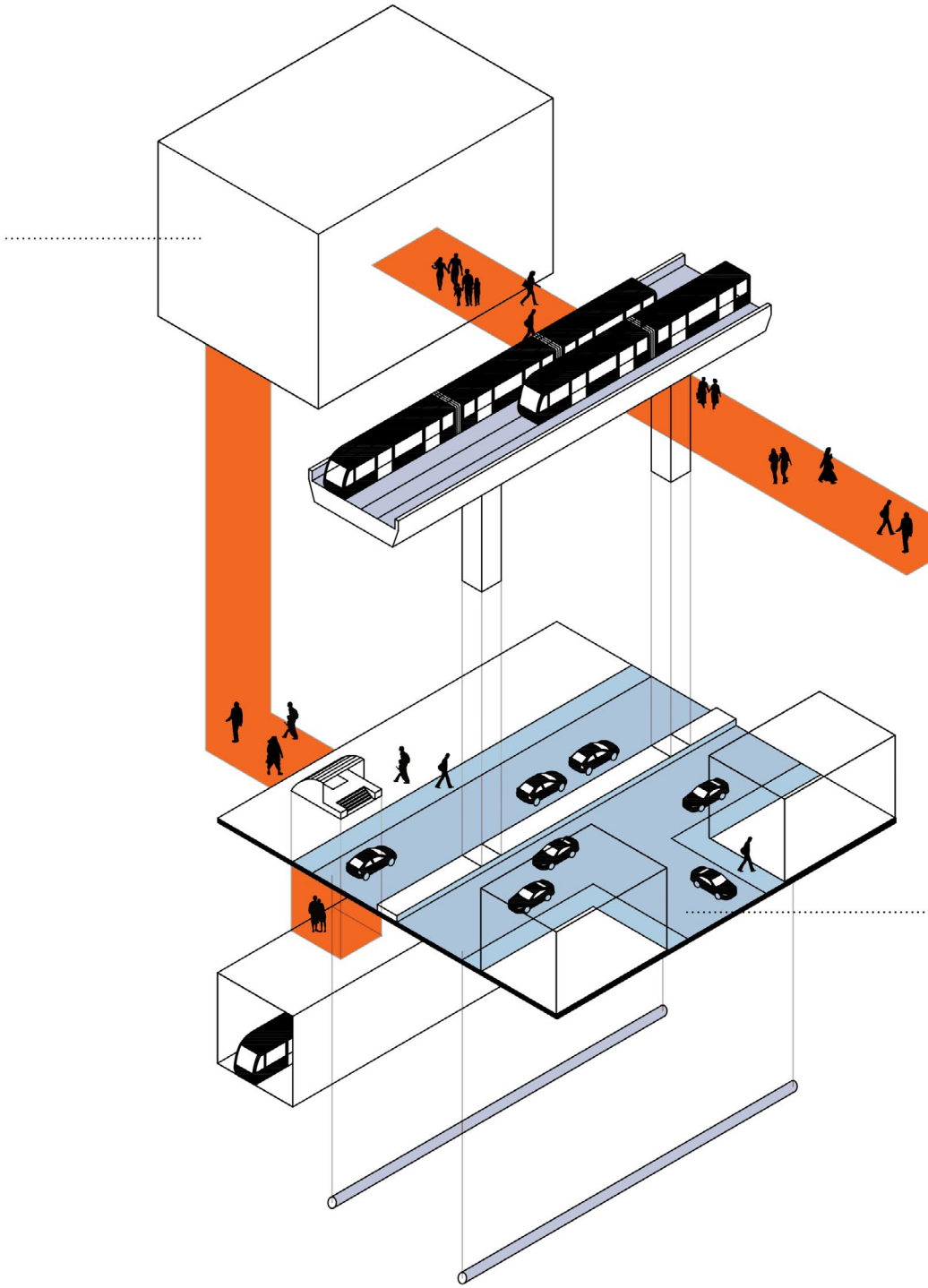
Alternative mass transit transportations were developed around the downtown areas in addition to the road systems. New pedestrian connections of multiple skywalk and underground paths, from buildings to transit stations were heavily invested by private sector adding land values for individual projects. Meanwhile, alternative pedestrian networks were introduced requiting and avoiding the inefficient connection and other problems on ground.

According to the drafts presented by The Department of City Planning on the future urban planning of Bangkok in 2037, New urban nodes of integrated commercial and transportation transits are expected along the extensions of mass transit lines (2018). The new development implies on the expansion of the unresolved grey transportation infrastructure approach of the current downtown area.

Fig. 45 Transportation Infrastructure and 2037 Urban Expansion of Bangkok drawn by author

High rise buildings are developed along the railed lines with accomodation of pedestrian connection from building to surrounding public transportation by elevated skywalk and underground connection providing social value for people and economical value to the projects

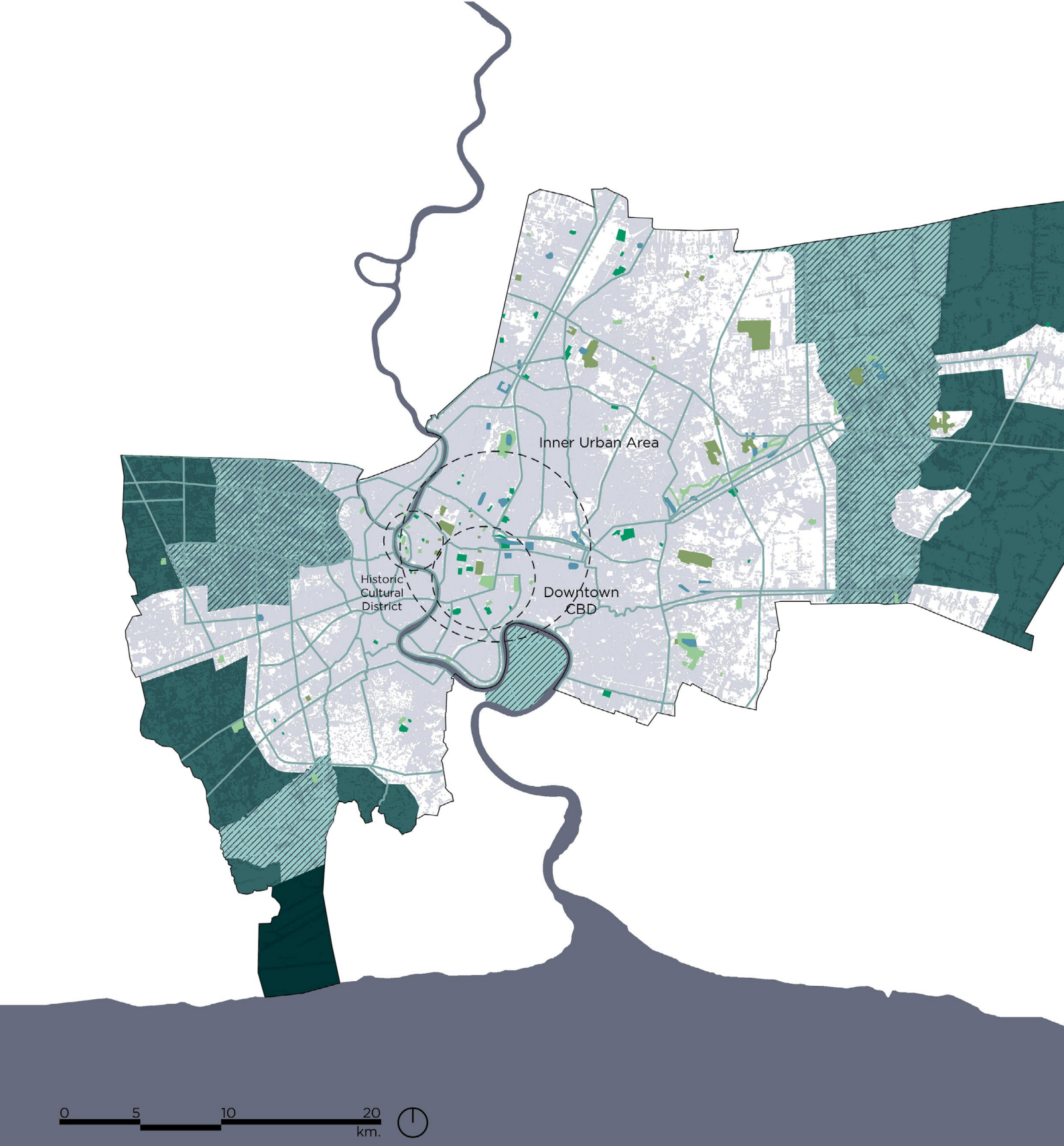




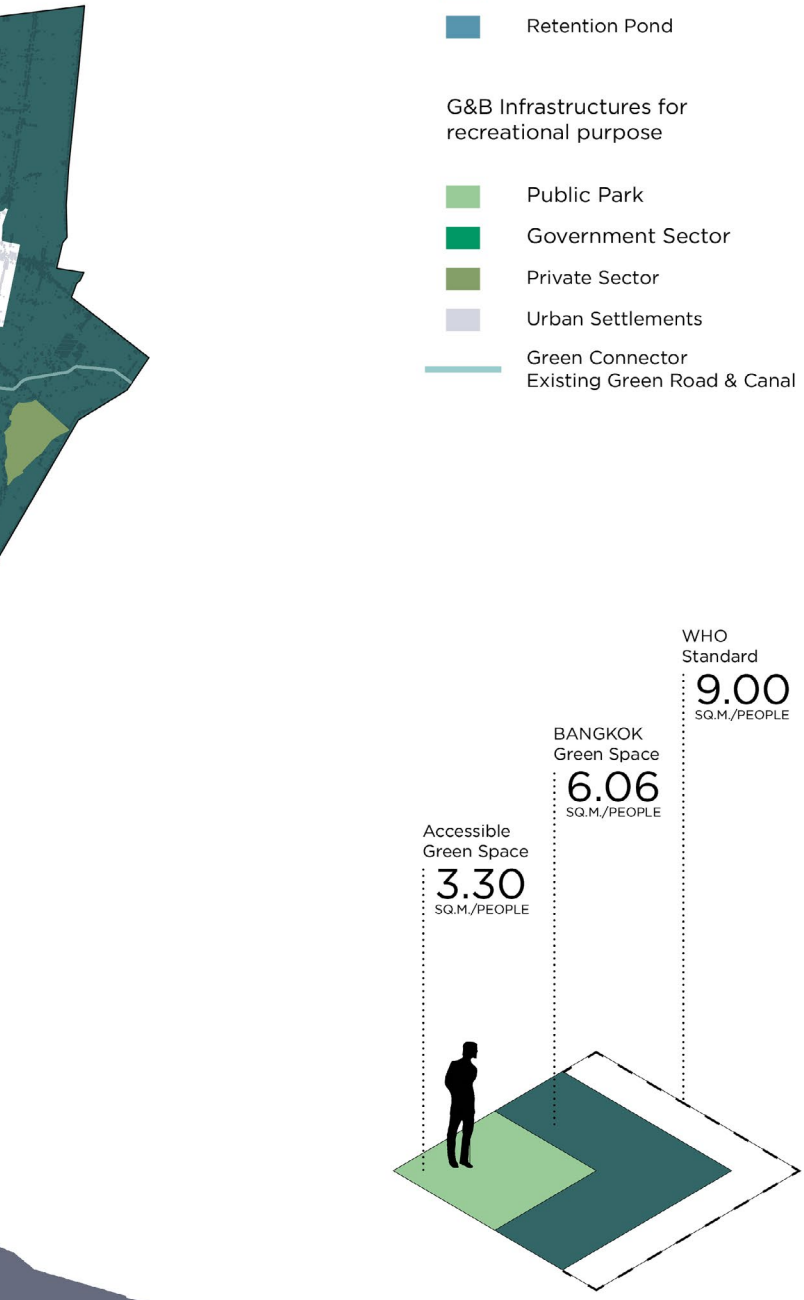
Vehicle-based Transportation Development - Expansion of Flood

Economy driven transportation lead to one side promotion of infrastructure for vehicles, extending built-up areas along the road lines, while ignoring pedestrian living qualities of social and ecology systems on ground level


Fig. 46 Conceptual Vehicle-based Transportation Infrastructure of Bangkok drawn by author


Inner Urban Area
Historic
Cultural
District
Downtown
CBD
0
5
10
20
km.

# Green & Blue Infrastructure



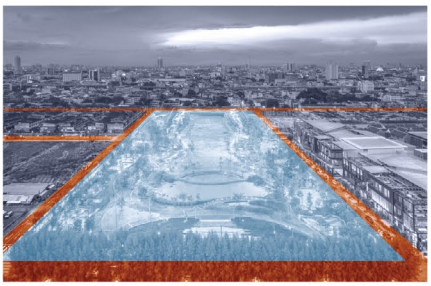




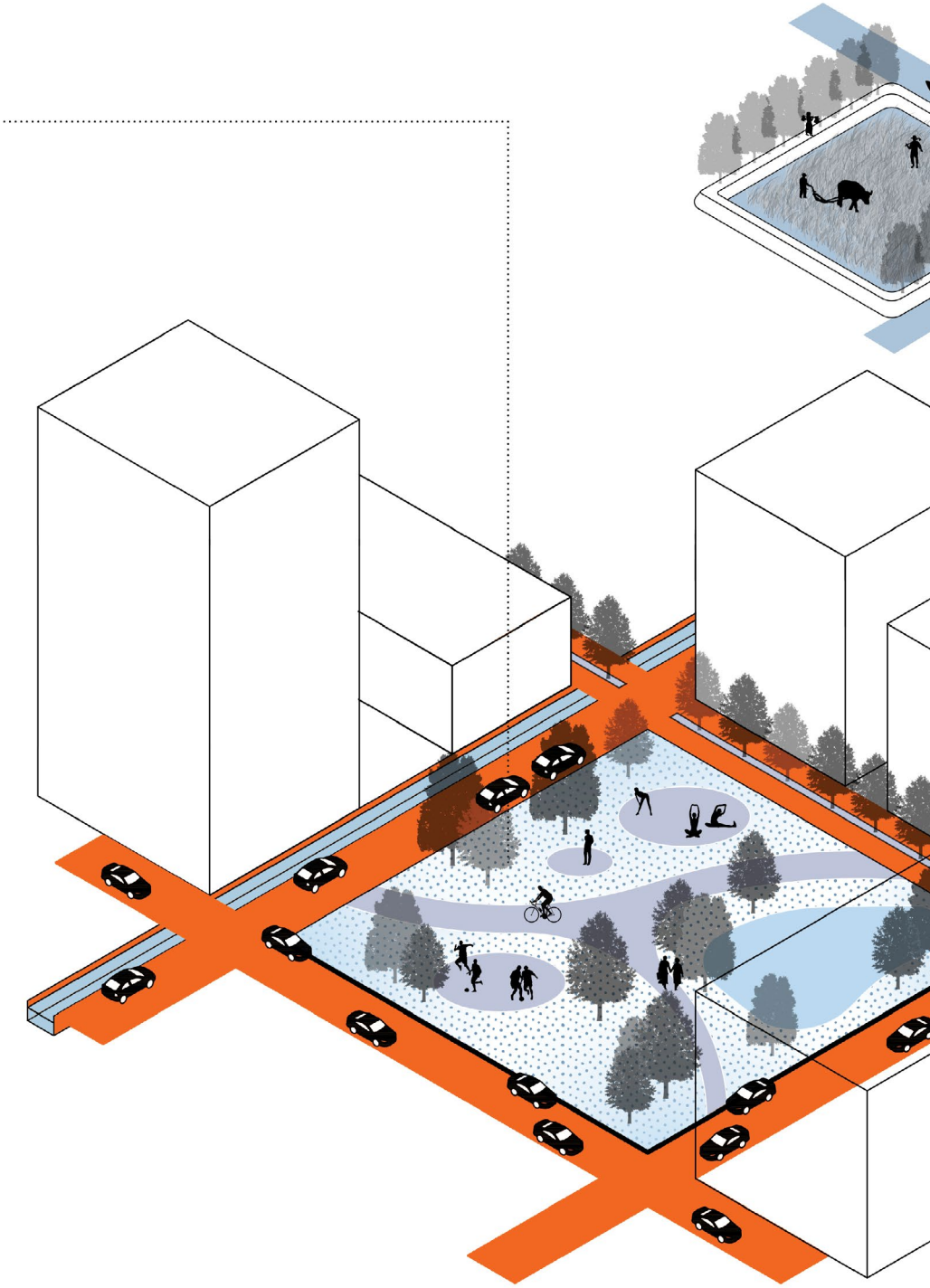
"The World Health Organization (WHO) recommends that cities provide 9 square meters of undeveloped (unpaved) open space for every inhabitant" (Sorensen et.al.,1997). Bangkok has a total green area of 6.06 square meters per people (Inchompoo & Srithanyarat, 2017) where most areas are large agricultural patches planned and preserved as flood plains outside the protective flood dike while fragments of green spaces can be found in metropolitan area mainly public parks used for only recreational services. These fragment patterns, divided by wide roads, threaten the disconnection of social activities and limitation of associated ecological functions and processes (Vanno, 2012) Water management function of the park is assumed to be separated system apart from surrounding urban drainage of the street network, unlike the integrated system of water infrastructure and agricultural matrix from the past.

"Considered from the aerial photograph of Bangkok, several green spaces could be seen all over the city. However, those green spaces are not public, thus the need to include potential green spaces of private and government sectors are required" (Inchompoo & Srithanyarat, 2017). The current green and blue infrastructure network as seen in Fig. 47 demonstrates the insufficient connector routes for the additional potential green spaces.

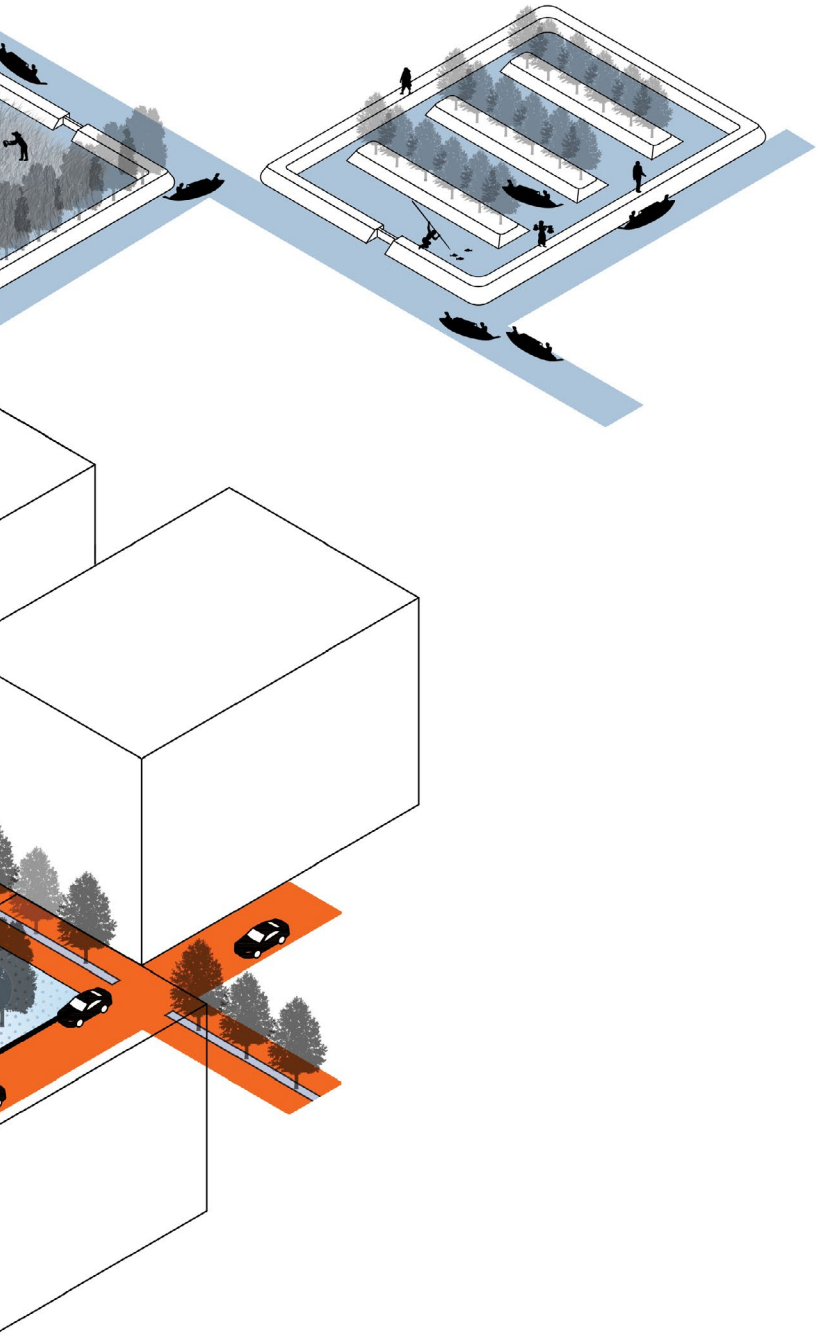
Fig. 47 Green & Blue Infrastructure of Bangkok drawn by author
Fig. 48 Green Space Ratio Diagram drawn by author



G&B infrastructure in metropolitan area are seperated in fragments by built-up areas and grey in frastructures. Social and ecological systems are limited in certain areas apart from surrounding urban systems, unlike socio-ecological network of the water infrastructures and agricultural farmland in the past.



Fragmented Green and Blue Infrastructure - Limitation of Social a

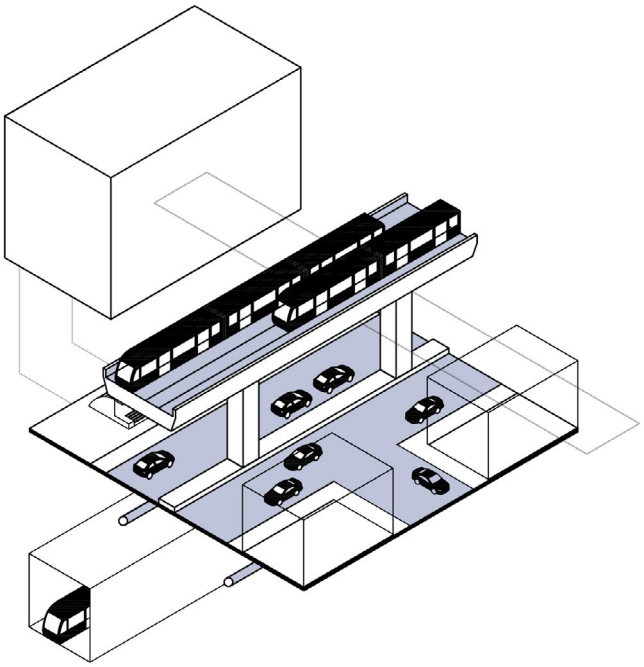


nd Ecology Systems

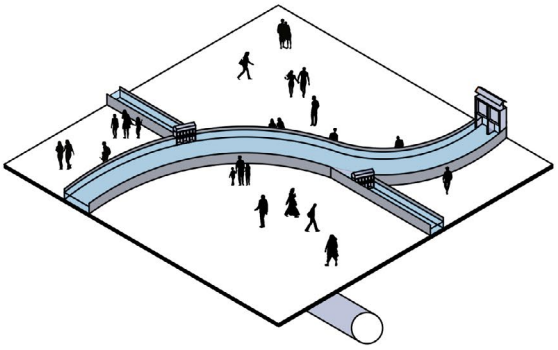
Fig. 49 Conceptual of Fragmented Green & Blue Infrastructure of Bangkok drawn by author

# Grey Infrastr

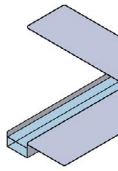
# ?



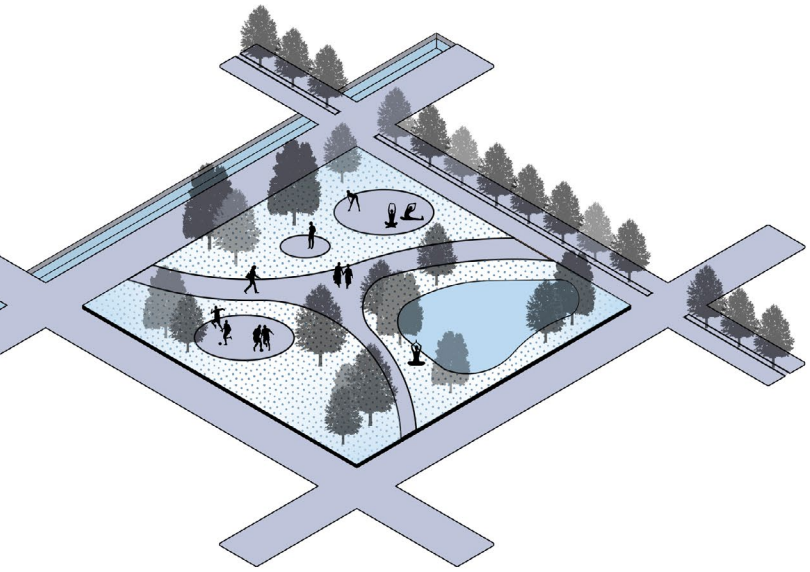
Vehicle-based Transportation Development
Expansion of Flood Vulnerable District



Engineering Water Management
Separation of Water from Daily Life



# ructure



Fragmented Green & Blue Infrastructure
Limitation of Social and Ecology Systems

Fig. 50 Conceptual Grey Infrastructure Approaches of Bangkok drawn by author

## Flood Risk

## Vulnerability

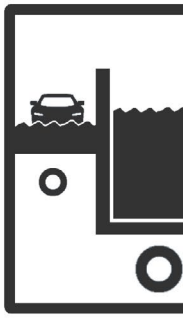
Flood Management + Economic (Regional)

Flood Defensive Driven Approach

Settlements as
in Floodpla

Grey Infrastructure (Urban)

Vehicle-based Transportation Development (Expansion of Flood Vulnerable District)



Engineering Wate
(Separation of wate

Behavior + Daily System (Local)

Dry Living Condition against Flood

Lack of Ada
to Environment

# Flood Risk Assessment : Grey Infrastructure Approach

Obstruction
in Area

Decline of Floodplain
due to Urban Expansion

r Management
r from daily life)

Fragmented Green & Blue Infrastructure
(Limitation of social & ecology system)

aptation
tal Changes

Negative Perception
towards Flood / Water

"Expanding cities increasingly rely on grey infrastructures for their protection. A false sense of security generated by these protective infrastructures can in fact lead populations to further expand in unsafe areas increasing their exposure to hazards and further aggravating risk" (Mitchell, 2003). Urban expansion of land-based industrial and housing estates in flood plains, with filling ground level and altering waterways, could be found around rural areas of Bangkok and Ayutthaya. These developments illustrate the misconception of adequacy by flood defensive management perception developed from the on-going promotion of grey infrastructures of the urbanized inland areas. With 2011 flood incident, several areas were damaged by river flood for periods of time, resulting in severe impacts on national economy.

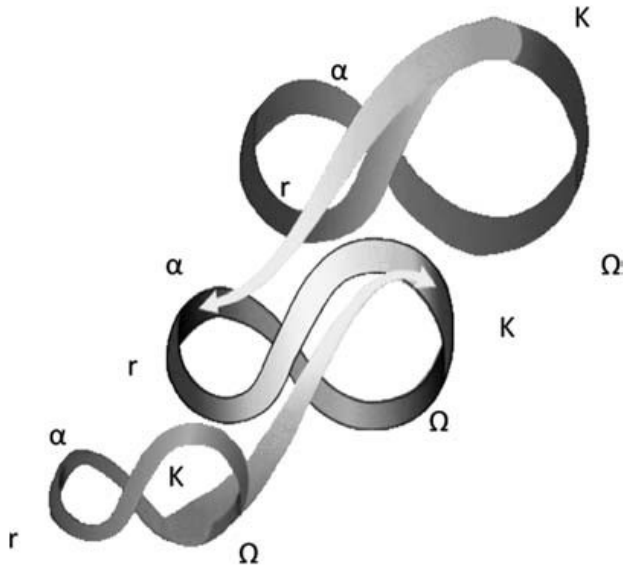
"Social and ecological systems evolve by influencing in contrast with fixed, long -lasting grey infrastructures that lack flexibility to be (Depietri & McPhearson, 2017). With grey infrastructure embedded in daily system of people, dry urban living condition is constructed regulating daily life of the inhabitants against flood and water inland. Familiarity of static behavior lead to the difficulty of adaptation to environmental changes.

Fig. 51 Flood Risk and Vulnerability Assessment of Bangkok drawn by author

# CHAPTER II
# METHODOLOGY

# 2.1 THEORETICAL FRAMEWORK

a) Evolutionary Resilience
b) Hybrid Infrastructure
c) Flood Adaptation Measure for Public Space


K
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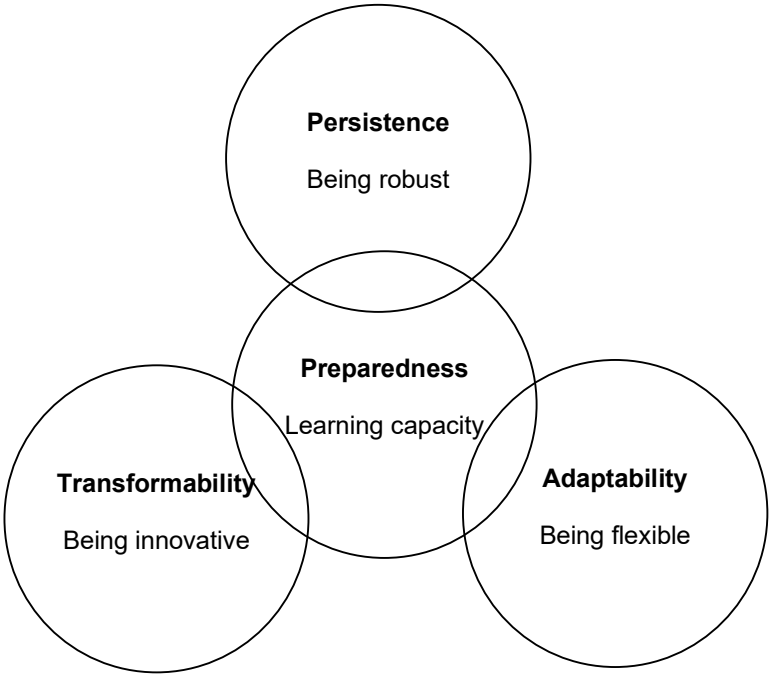

Persistence
Being robust
Preparedness
Learning capacity
Transformability
Being innovative
Adaptability
Being flexible

# Evolutionary Resilience

"The world's climate is changing and will continue to change into the coming century at rates projected to be unprecedented in recent human history. The risks associated with these changes are real but highly uncertain." (Adger et.al, 2003). Several countries across the globe are suffering with the impacts of multiple unresolved disasters and being in the stage of vulnerability where constitutions of livelihood are at risk. Societal adaptation is required to cope with the upcoming impacts, reducing risks and altering to the stage of resilience to bounce back from difficulties.

The concepts of resilience are classified into three types by Davoudi as engineering, ecological and socio-ecological resilience which the latter are also called evolutionary resilience (2012). Engineering resilience focuses on maintaining the efficiency of function to return to the normal stage (Holling, 1996). The focus on stability is similar with the engineering-based approaches.  On the other hand, ecological resilience focuses on maintaining the existence of function before the stage changes (Holling, 1996). The focuses on persistence and change are similar with nature-based approaches.

While, the previous concepts focus on single stage of equilibrium, "the socio-ecological resilience argues in favor of people and nature as interdependent systems" (Folke et al., 2010) which evolve influencing each other back and forth, adapting or transforming in respond to stress and strain (Carpenter et al., 2005). The evolutionary resilience is proved to be the most sustainable development approach for a long-term, thus the strategy suggests promotion of both social and ecology systems to grow together as interrelated system, where people understand and learn how to live with nature. This idea can also be found in the indigenous living of micro hydro-agricultural matrix of Thai people from the past.

Fig. 52 (Top) The Adaptive Cycle of Evolutionary Resilience (Davoudi, Brooks, Mehmood, 2013)
Fig. 53 (Bottom) Four-dimensional Framework for Evolutionary Resilience (Davoudi, Brooks, Mehmood, 2013)

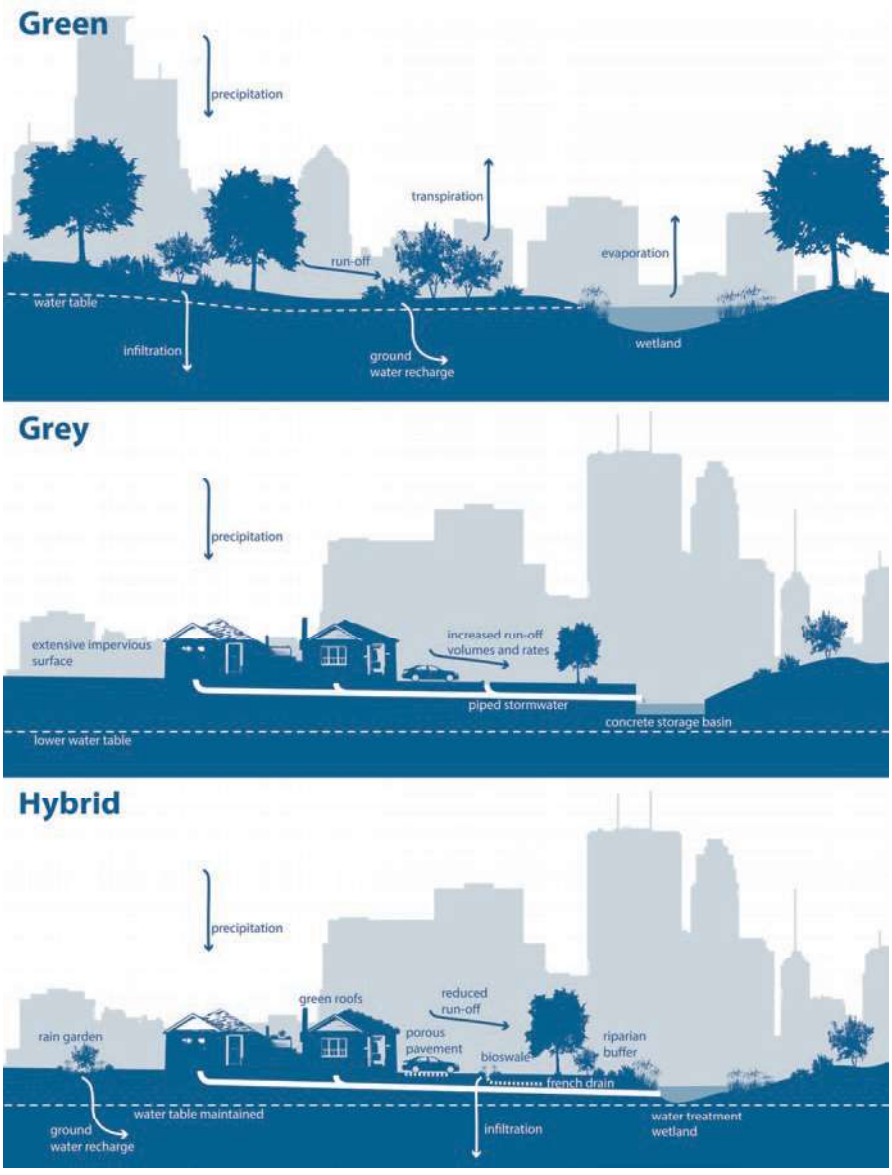



Fig. 54

| Aspect | Gre |
|---|---|
| Feasibility in the urban context | (occ |
| Reliability | The con Mix |
| No-regret strategy | Ofte |
| Long-term durability or resilience | D |
| Reversibility and flexibility | Li |
| Cost-effectiveness | Depre |
| Biodiversity conservation | |
| Other co-benefits | (bu mediu wat prov initia |

# Hybrid Infrastructure

The rapid growth of urbanization unplanned, often lead to the decrease of ecosystems in urban context without knowing that, “ecosystems and their services, though overlooked or degraded, can provide multiple hazard regulating functions” (Depietri & McPhearson, 2017). “Healthy ecosystems play a significant role in buffering communities from climatological and hydro-meteorological hazards at different scales” (McPhearson et al. fortcoming).

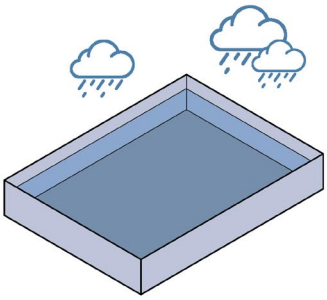
In the dense context of highly urbanized area, grey infrastructure developments are usually promoted due to the limitation of space required and obvious effective result. With the static and durable characteristic of constructed solution, the interventions could not be altered to cope with the uncertainty of future climate change effects unlike the evolving green and blue system which has more flexibility. Reconsideration of revitalizing green & blue infrastructure back in the city is required. However, in the one-sided promotion might inapplicable to meet the constrains of future flood impacts and the economic values of the urban site. Hybrid approach of integrating green and blue network to the existing grey infrastructure is suggested, “combining engineering and properly ecosystem functions” (Depietri & McPhearson, 2017).

| y infrastructures | Green infrastructures | Hybrid approaches |
|---|---|---|
| High<br><br>upies a reduced area) | Low<br><br>(But highly important and feasible in peri- and regional urban areas) | High |
| Medium<br><br>ese measures do not mpletely eliminate risk<br><br>ed success has been reported | Medium<br><br>Role has been proven but some studies lead to contradictory results due to the multiple factors that play a role in determining the magnitude of a hazard<br><br>Highly depends on the type of hazard | High |
| n high regret measure | Low regret measure | Medium |
| Durable, but can be maladaptive. | Medium<br><br>Can be affected by hazards and ecosystems in and around cities are generally highly transformed and often degraded | Medium-high |
| ttle or not reversible | Medium<br><br>Can be high or low reversibility depending on the type | Medium |
| Low.<br><br>High building costs<br><br>eciate in value over time | High<br><br>Investments in green infrastructure can be much less expensive in short and long run than those in grey infrastructure | Medium to High |
| None | High<br><br>Green infrastructures provide natural habitat for species | Medium |
| Low<br><br>ut some examples of um to high exist such as er and energy supply vided by riverine dikes ally designed for flood control) | High<br><br>Vegetation provides local communities with critical ecosystem services such as those improving livelihoods, food security and recreation and that may enhance their resilience to extreme events in the long-term<br><br>Broadly applicable | Medium<br><br>Contributes to providing other services, such as pollution control and recreation, but will depend on the green infrastructure component of the hybrid approach |

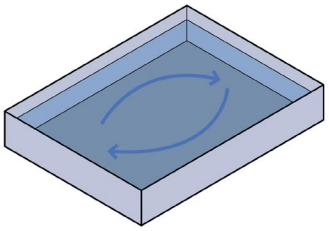
Fig. 55

Fig. 54 (Left) Three Contrasting Approaches, Green and Blue Only, Grey Only, and Hybrid for Dealing with Urban Water, in Particular Significant Precipitation Events and Other Stormwater Challenges that Cities Face (Depietri & McPhearson, 2017)

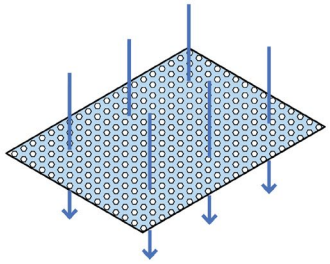
Fig. 55 (Right) Summary Table for Comparison of the Three Approaches Based on Their Suggested Low-Medium -High Performance with Respect to a List of Factors (Depietri & McPhearson, 2017)



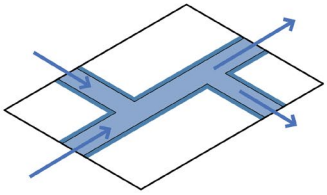
Harvest



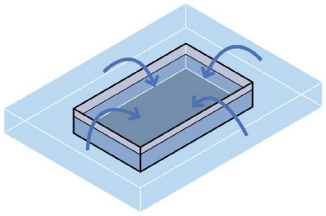
Store



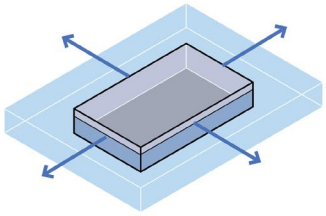
Infiltrate



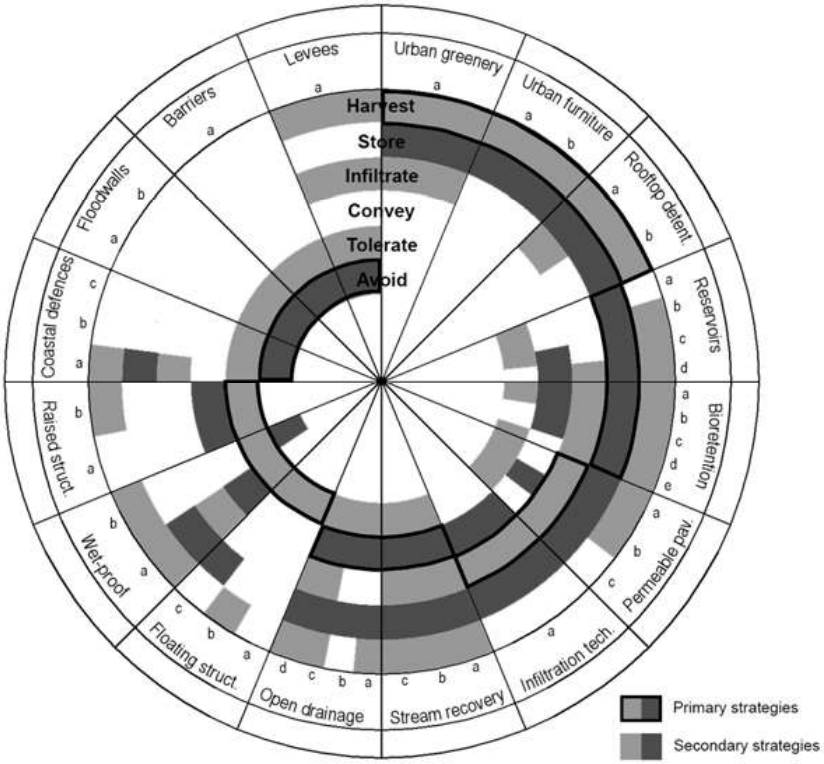
Convey



Tolerate



Avoid



# Flood Adaptation Measure for Public Space

“Urban public spaces are here considered as a common entity of shared concerns, which may accommodate civic purposes. At the same time that, they are among the most vulnerable areas to climatic hazards, and flooding events in particular, they entail specific characteristics that are particularly relevant for adaptation efforts” (Matos Silva & Costa ,2016). With the multi-functional qualification serving both people and nature, public spaces function as middle grounds where social and ecology system could meet inducing socio-ecological living in urban context.

To identify types of flood measures, six purposes of flood adaptation infrastructural strategies are classified by Matos Silva & Costa, as harvest, store, infiltrate, convey, tolerate and avoid where individual measure could associates with one or more purposes (2016). The classification helps author to assign proper flood adaptation measures according to the need of each site with suitable flood management service as shown in Fig. 28. The proposed framework of a doughnut diagram by Matos Silva & Costa in Fig. 29, matches the strategies and types of measure. “The circular diagram is radially divided into 16 equal ‘slices of pie’. Each ‘slice’ represents a category that is further divided into as many slices as its respective number of types of measures. Each ring refers to the chosen approach to classify each measure by its infrastructural strategies of ‘harvest’, ‘store’, ‘infiltrate’, ‘convey’, ‘tolerate’ and ‘avoid (Matos Silva & Costa ,2016).

Fig. 56 (Top) Flood Adaptation Diagrams modified from Proposed Range of Flood Adaptation Infrastructural Strategies (Matos Silva & Costa ,2016)

Fig. 57 (Bottom) Flexible and Comprehensive Output of the Proposed Conceptual Framework of Flood Adaptation Measures (Matos Silva & Costa ,2016)

# 2.2 CASE STUDY

a) The Copenhagen Cloudburst Formula
b) The Big U : Rebuild by Design

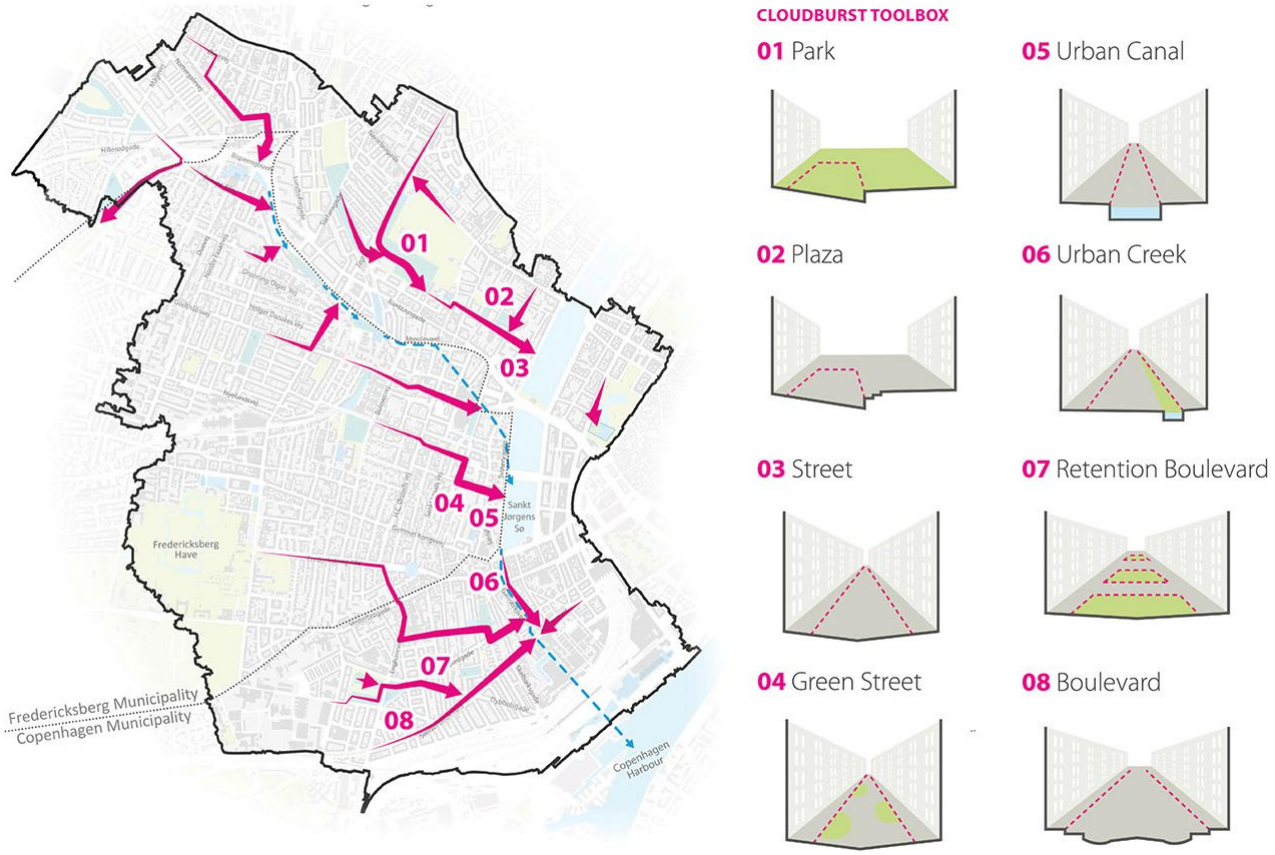


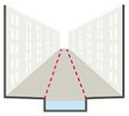

Fig. 58 Proporsal of cloudburst toolbox combining hydraulic engineering (GreySolutions) with Blue-Green Solutions to mitigate streets, parks, and plazas (Ramboll and Ramboll Studio Dreiseitl, 2016)

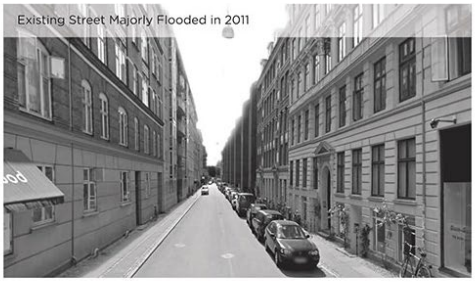
## The Copenhagen Cloudburst Formula

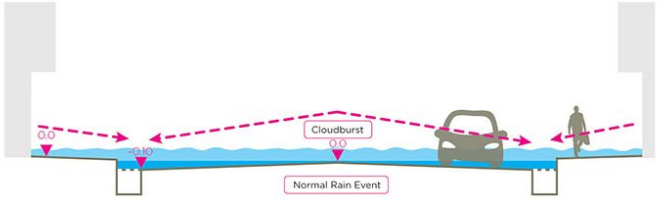
"Copenhagen has experienced four major rainfall events in the past six years. The largest, in 2011, caused damage totalling more than DKK 6bn. An economic assessment of the costs of damage to Copenhagen if nothing is done to adapt the current runoff and sewage system is estimated around DKK 16bn over 100 years" (Climate-ADAPT, 2016). With the increase of future precipitation and potential of future challenges, the traditional engineering solution of underground water management become less viable and unmanageable as the occurrence is hard to predict. Due to that reason, the cloudburst water management plan is proposed integrating green & blue solution as part of urban planning, mitigating with future flood impacts while providing extra benefits for society (American Society of Landscape Architects, 2016).

The interdisciplinary process with collaboration of experts in different field induce the 6 steps solution covering the whole process from data collection to evaluation on the outcomes of the design as seen in Fig. 30.
"In particular, the Cloudburst Management Plan consists of four surface solutions as well as pipe-based solutions, including, stormwater

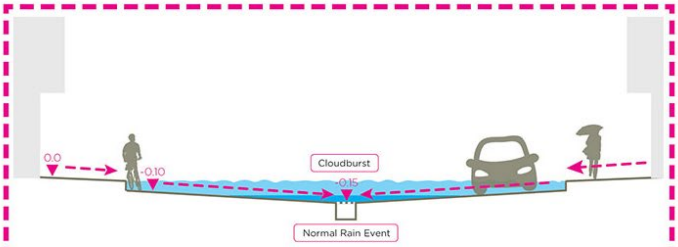
## 05 Urban Canal





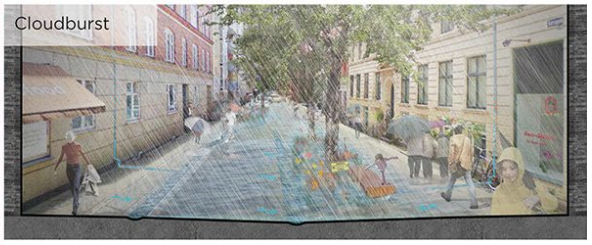



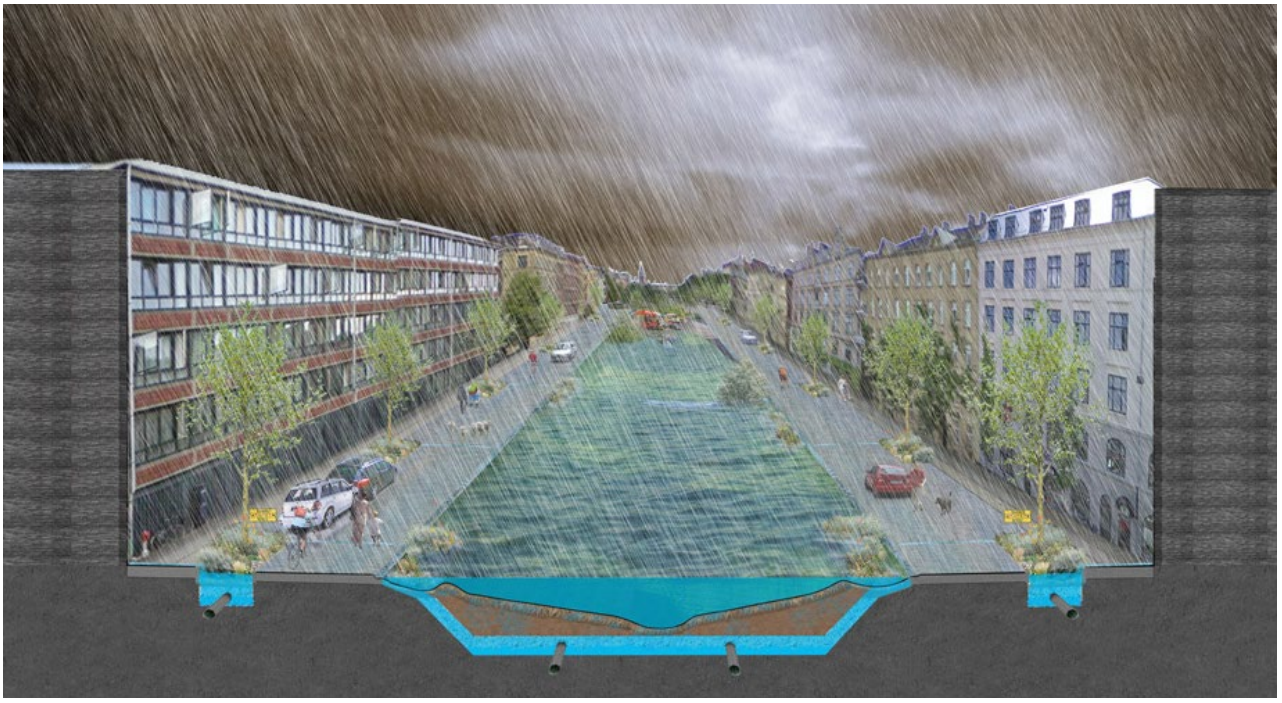

Conventional: Existing Crowned Street




Proposed V-Profile Street



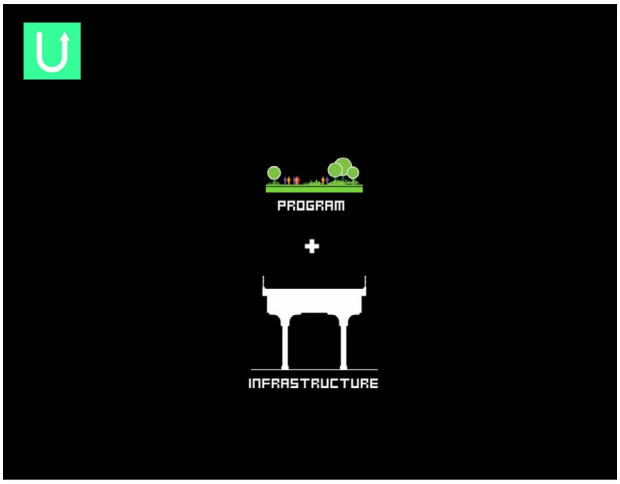


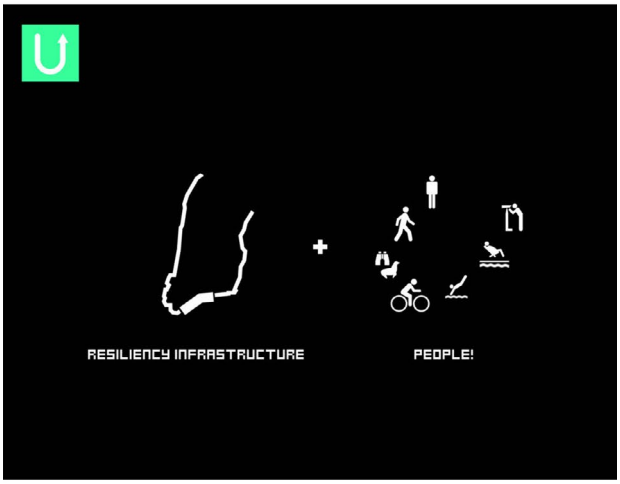



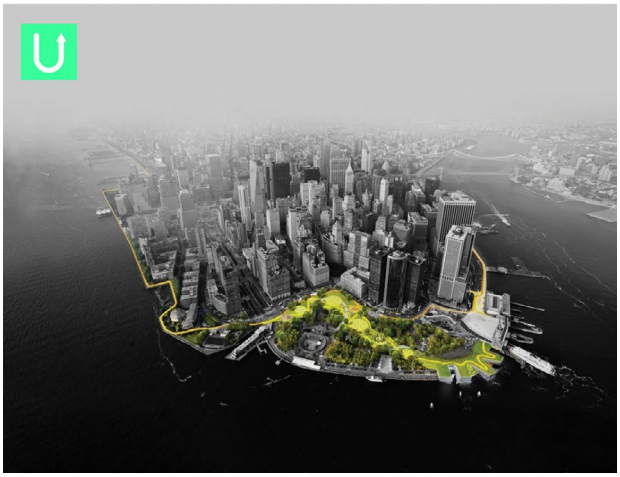
pipes that transport water towards lakes and the harbor, detention roads for storing waters, detention areas to store very large volume of waters, e.g. parks that could turn into lakes during flood events, and green roads to detain and hold back water in smaller side streets" (Climate-ADAPT, 2016).

Cloudburst toolkits illustrate the implementation of hybrid approach integrating social and ecology systems. Flood becomes part of living condition inducing adaptation efforts demonstrated with changes of different public uses in each scenario. Green and blue solutions enhance the living atmosphere of the street while also provide eco-service managing surface runoff merging with existing grey infrastructure of underground system. Existing green and blue infrastructure are modified to be storage protecting the surrounding area from flood integrating with urban flood management plan. Socio-ecological transformation could be achieve through urban public space design, reducing flood impacts while slowly influencing people behavior and daily system.

Fig.59 (Top) Urban Canal Strategy, Integration of Flood Management and Adaptive Use to the Existing Street (Ramboll and Ramboll Studio Dreiseitl, 2016)
Fig.60 (Bottom) Green Streets Utilise Lowered Street Profiles to Create a Safety Zone and a Flood Pathway Corridor. Shared Public Spaces Integrate Pedestrians, Cyclists, Motorists, and Alternative Transportation along a Common Public Realm (Ramboll and Ramboll Studio Dreiseitl, 2016)


PROGRAM
+
INFRASTRUCTURE


+
RESILIENCY INFRASTRUCTURE
PEOPLE!



# The Big U : Rebuild by Design

"The lower Manhattan is home to approximately 220,000 residents and is the core of a $500 billion business sector that influences the world's economy. Hurricane Sandy devastated not only the Financial District, but 95,000 low-income, elderly, and disabled city residents. Infrastructure within the 10-mile perimeter was damaged or destroyed, transportation and communication were cut off, and thousands sat without power or running water" (Rebuild by Design n.d.). The proposal of 10 continuous miles of flood protective system comprises with "two concepts of social infrastructure and hedonistic sustainability" (Quirk, 2014) where flood infrastructure also functioned for people daily life.

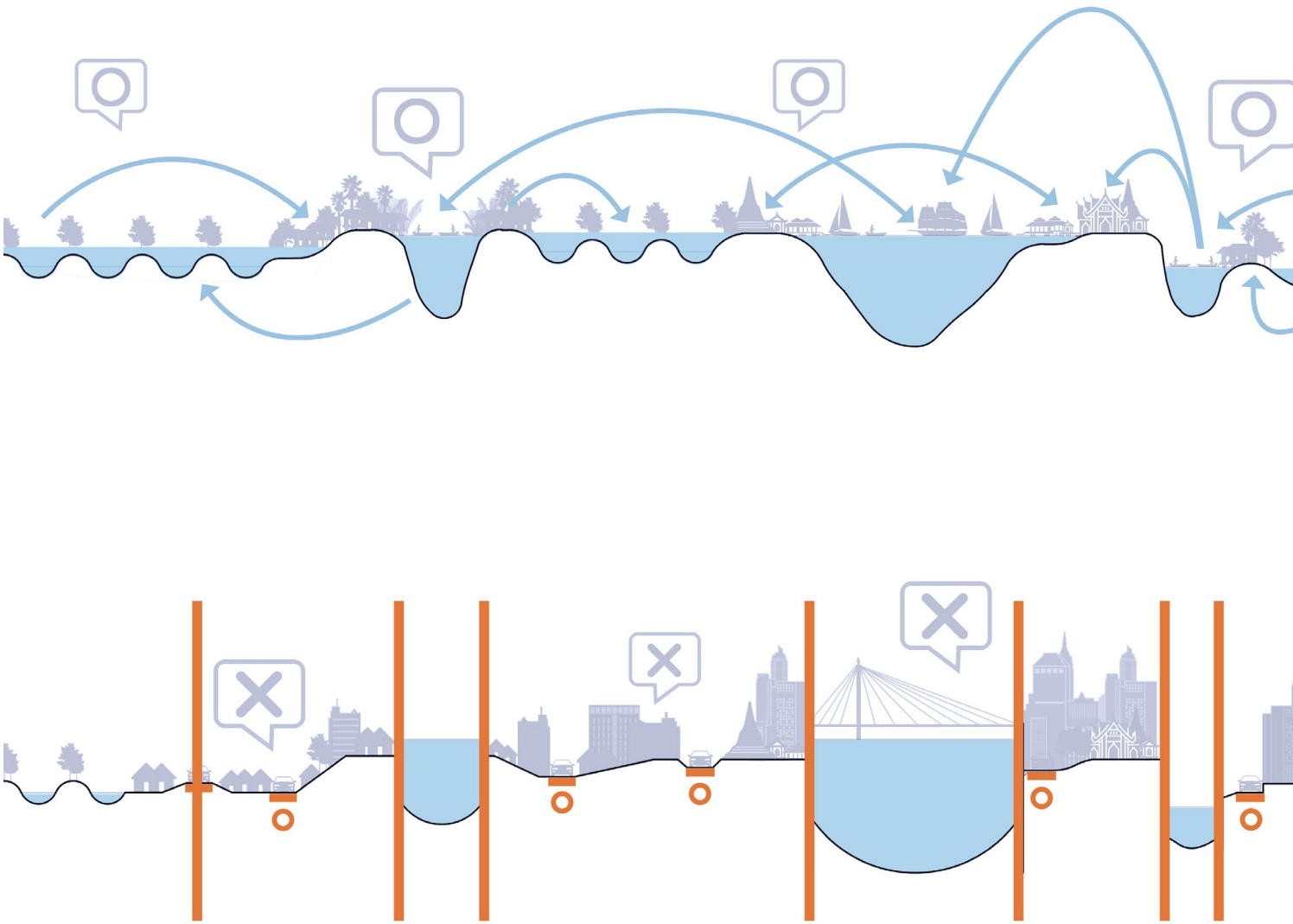
With the analysis on both technical flood measures and social aspects of urban characteristic of each area, the integrated solutions "breaks the area into compartments: East River Park; Two Bridges and Chinatown; and Brooklyn Bridge to The Battery. Like the hull of a ship, each can provide a flood-protection zone, providing separate opportunities for integrated social and community planning processes for each" (Rebuild by Design n.d.). The design implementations utilize the unutilized spaces with adaptive programs raising awareness of coastal flood while engineering solution designs are blended with nature elements and adapted by new technologies to create pleasant atmosphere instead of long continuous solid flood walls.

Fig.61 (Top) Integrating Flood Protective System as Social Infrastructure (BIG, 2014)
Fig.62 (Middle) Resilience Infrastructure for Daily system (BIG, 2014)
Fig.63 (Bottom) Overall Infrastructure Network (BIG, 2014)

# CHAPTER III
# DESIGN

# 3.1 CHALLENGE - STRATEGY

a) Inclusive Water-based Society
b) Hybrid Resilience Infrastructure Network

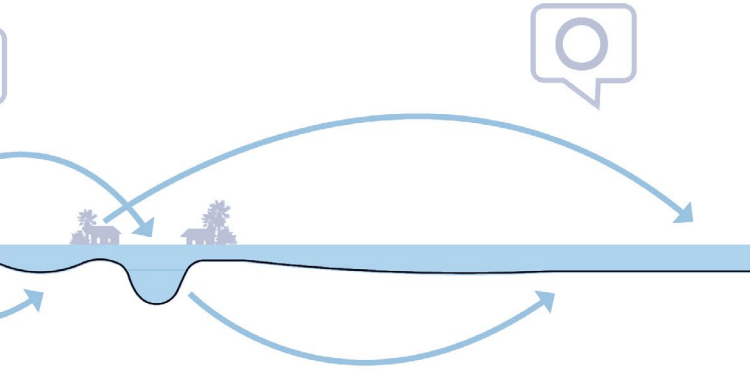


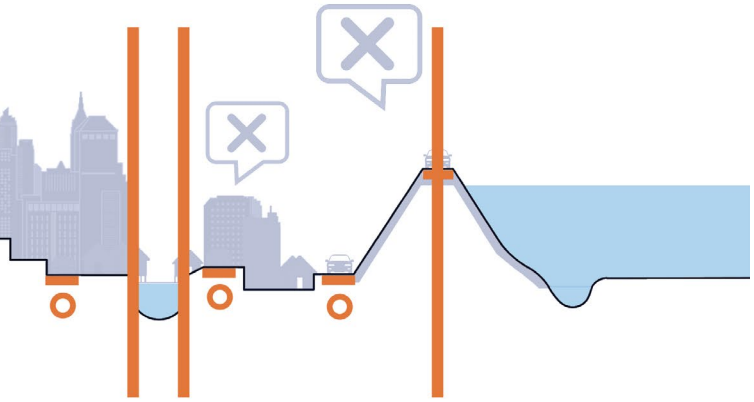
From adaptive water-based society to water defensive car-based r

## Inclusive Water-based Society

As the city had developed with major shift from water to land, from adaptive sub-urban society to modernized megapolis, the indigenous living culture and water-based identity of the past have been lost through the process. New urban form of land-based developments regulated and protected with grey infrastructure solutions represents the current identity of Bangkok as it is in the stage of engineering resilience. Engineering solutions are promoted for defensive purpose against flood maintaining the stage of stability inside the metropolitan area.

The concept of gaining control over nature has been proved unsustainable and inefficient coping with the unpredictable impact of climate change. To settle with future flood challenges, society can't any longer rely only on protective interventions but also need to relearn how to co-exist and evolve with water. The new stage of evolutionary resilience is proposed to seek for new flood management strategy which promote both social and ecology aspects as the interrelated system, forming new inclusive water-based society in the current urban form.





megapolis

Fig. 64 Conceptual Bangkok Transformation from Integration to Seperation with Water Diagram drawn by author

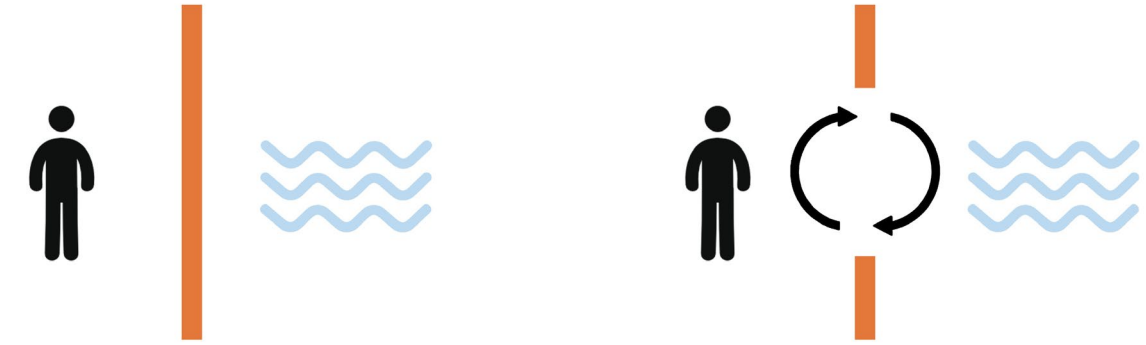



Fig.65 Transformation of Engineering Resilience to Evolutionary Resilience Proporsal drawn by author

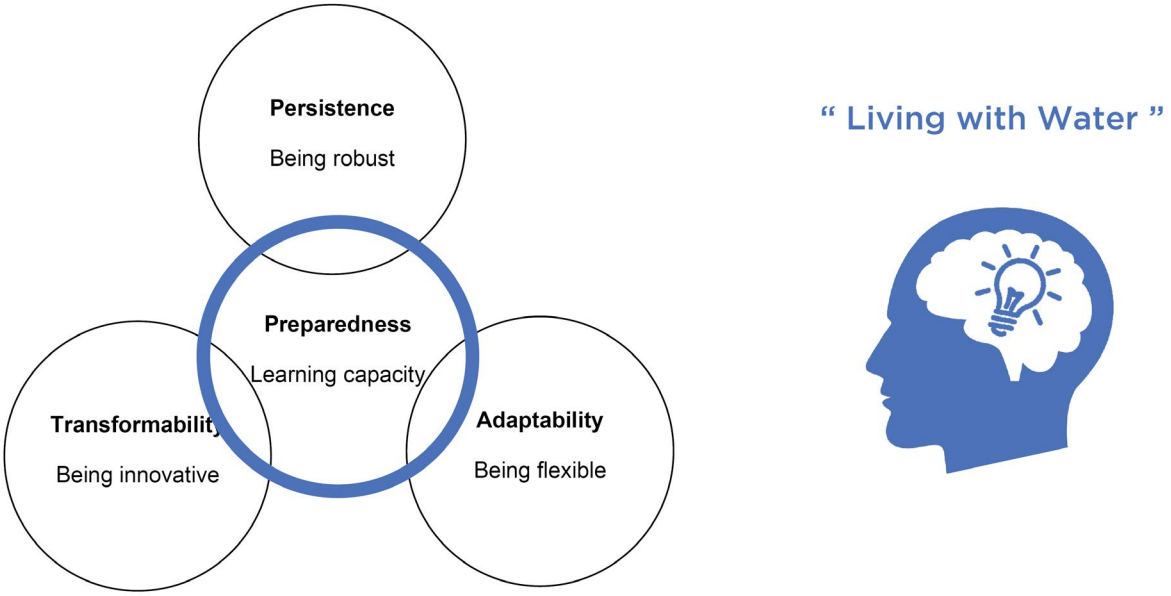



Fig.66 Learning Capacity to Change of Perception Diagram modified from Four-dimensional Framework for Evolutionary Resilience (Davoudi, Brooks, Mehmood, 2013)

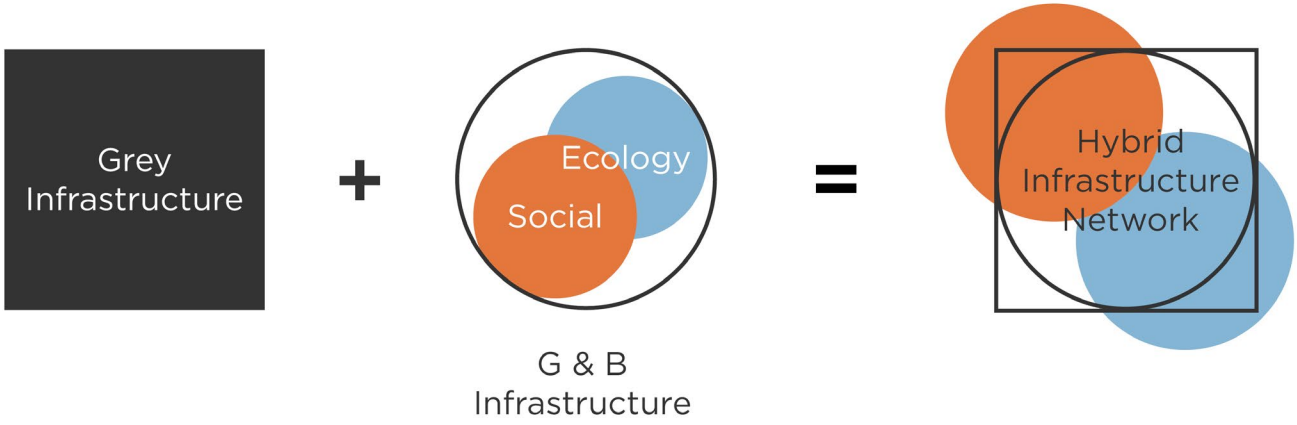
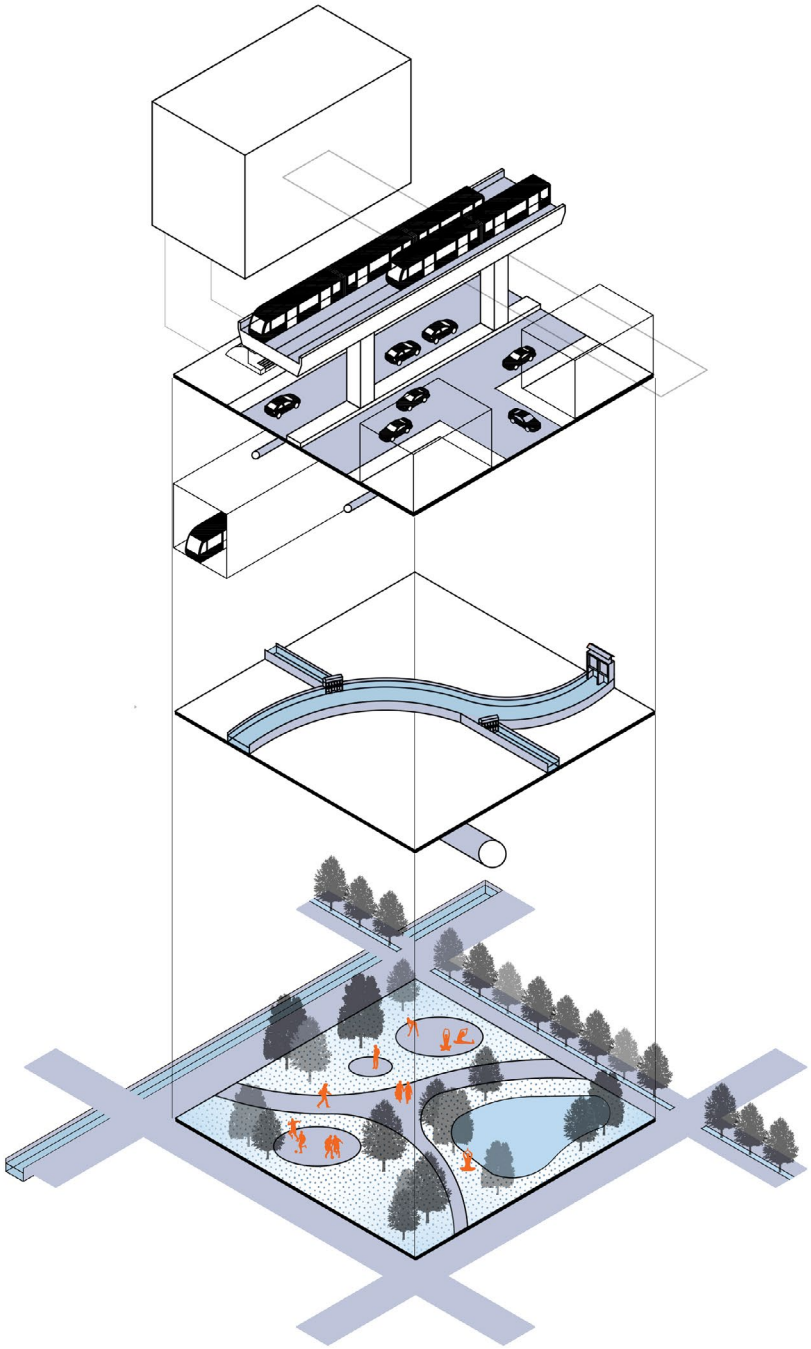
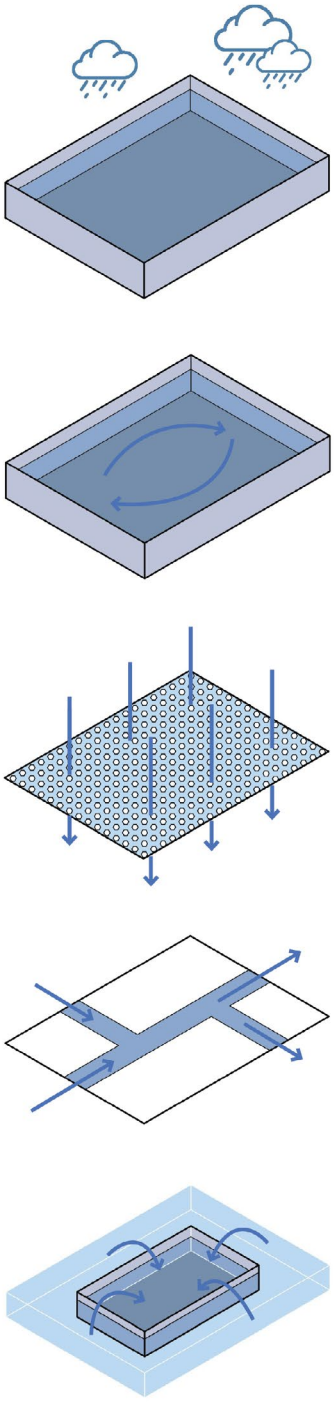



Fig. 67 Transformation of Grey to Hybrid Infrastructure Network Diagram drawn by author



Integrated Infrastructure Network
Transportation + Water Management + Green & Blue Network

+

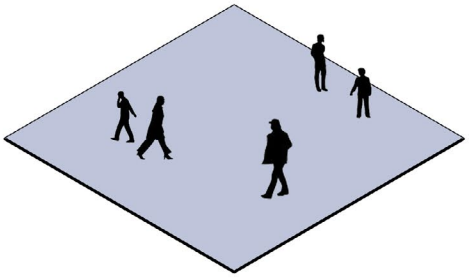



Flood Management Strategies
Reducing Flood Risks

# Hybrid Resilience Infrastructure Network

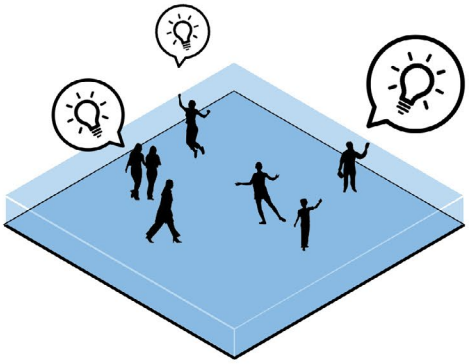
Grey infrastructures are embedded in daily system as part of urban structure and flood protective interventions while green and blue infrastructure are instead divided and separated in individual fragments apart from the urban network and people life.

Hybrid resilience infrastructure network of Bangkok is proposed integrating practicality of current grey infrastructure performances with eco-services of green and blue infrastructure together as new urban flood management system. Each individual infrastructures of existing transportation, water management, with green and blue network, functions and assists each other with interrelated roles of different flood management strategies. Meanwhile, social and ecology system are also improved along the network lines inducing adaptation of lifestyles with new perception of living with environmental changes.



Dry
(Regular)

+



Wet
(Flood)

Adaptive Programs
Living with Environmental Changes

Fig.68 Hybrid Resilience Infrastructure Network Principles drawn by author

# 3.2 SITE SELECTION

a) Pathum Wan Downtown District
b) Transportation Infrastructure
c) Water Management Infrastructure
d) Green & Blue Infrastructure

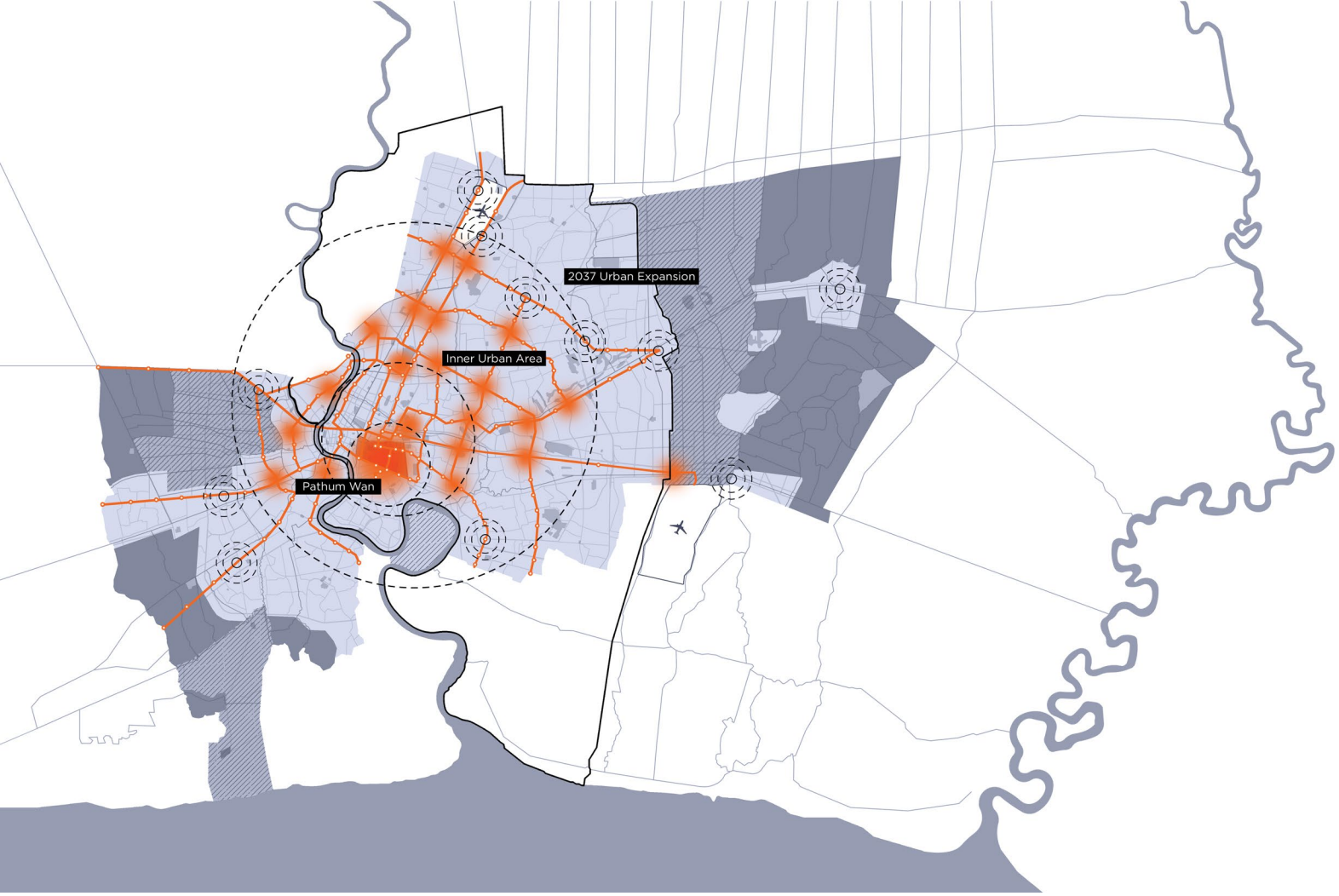
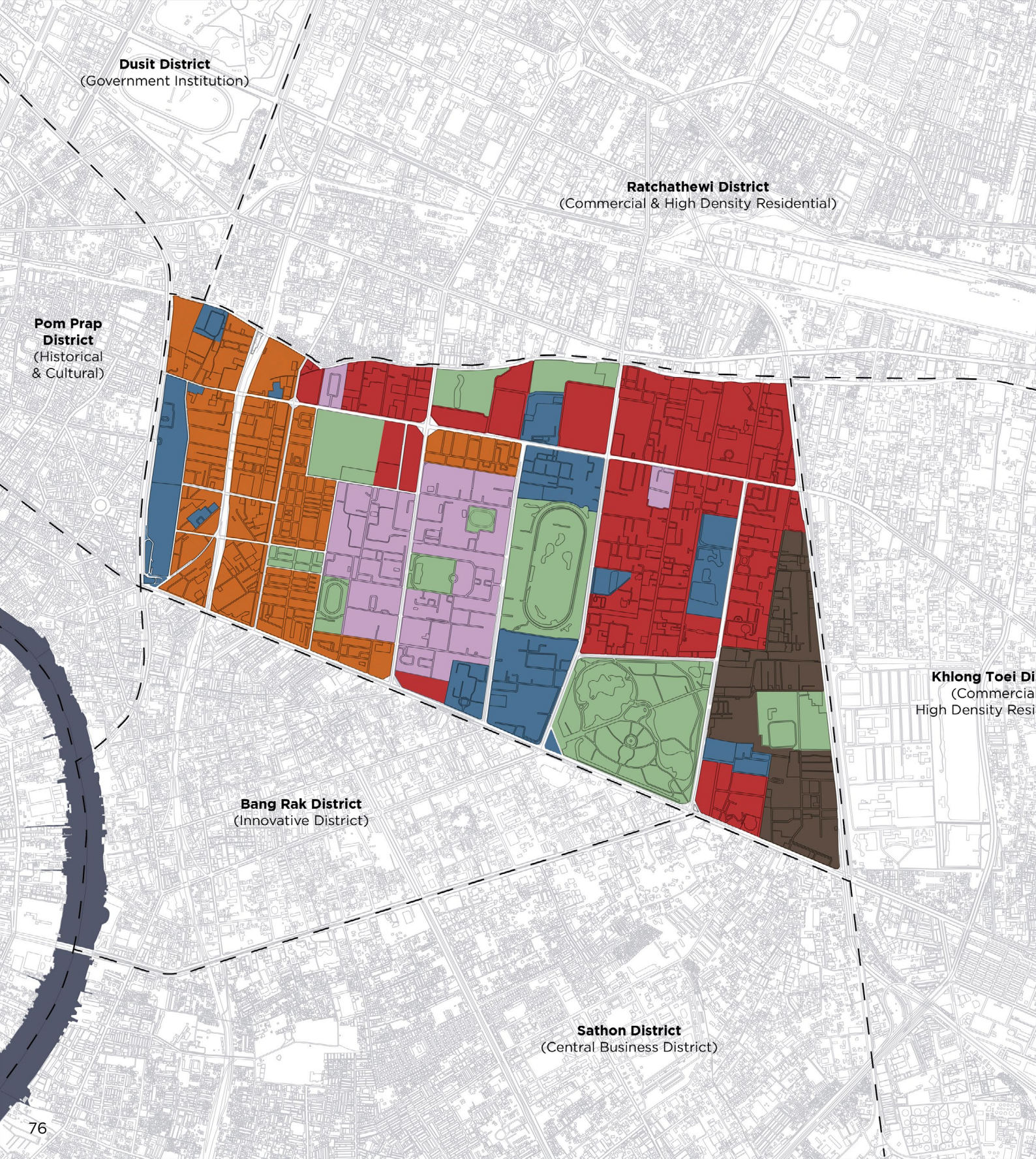


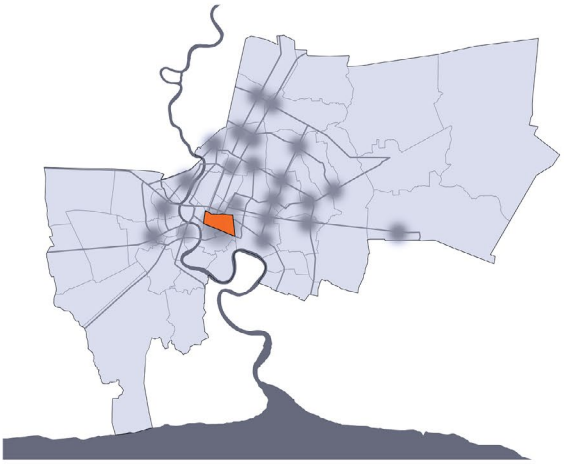

Fig.69 Site Selection of Pathum Wan Downtown Commercial District drawn by author

## Pathum Wan Downtown

To explore further on the implementation of design strategies in Bangkok metropolitan area, the critical site of Pathum Wan downtown district is selected by these following reasons :

- Pathum Wan is considered as one of the first road-based urbanization district with traditional road system patterns replacing canal networks (McGrath, Tachakitkachorn, & Thaitakoo, 2015) evidencing the unresolved problems of grey infrastructure developments in the area.
- The downtown is widely known as the center of commercial, along with various significant landuses accomodated by transportation alternatives including the existing mass transits of sky train and metro (Battaglia, 2019). The district is considered as the key model of future urban expansion of commercial and transportation transit districts.
- Most property of the districts are owned by government sectors and Crown property bureau, (Property of Management Chulalongkorn University, n.d.) which provides higher potential of development compare to other surrounding areas.


Dusit District
(Government Institution)
Ratchathewi District
(Commercial & High Density Residential)
Pom Prap
District
(Historical
& Cultural)
Khlong Toei Di
(Commercia
High Density Resi
Bang Rak District
(Innovative District)
Sathon District
(Central Business District)



1. Key Model of future urban expansion
(Downtown Commericial District)

2. High potential development area of government
and crown property with public landuses

Crown Property

Government Property

Landuse

High Rise Commercial & Office Building

Low Rise Commercial (Mixed Use)

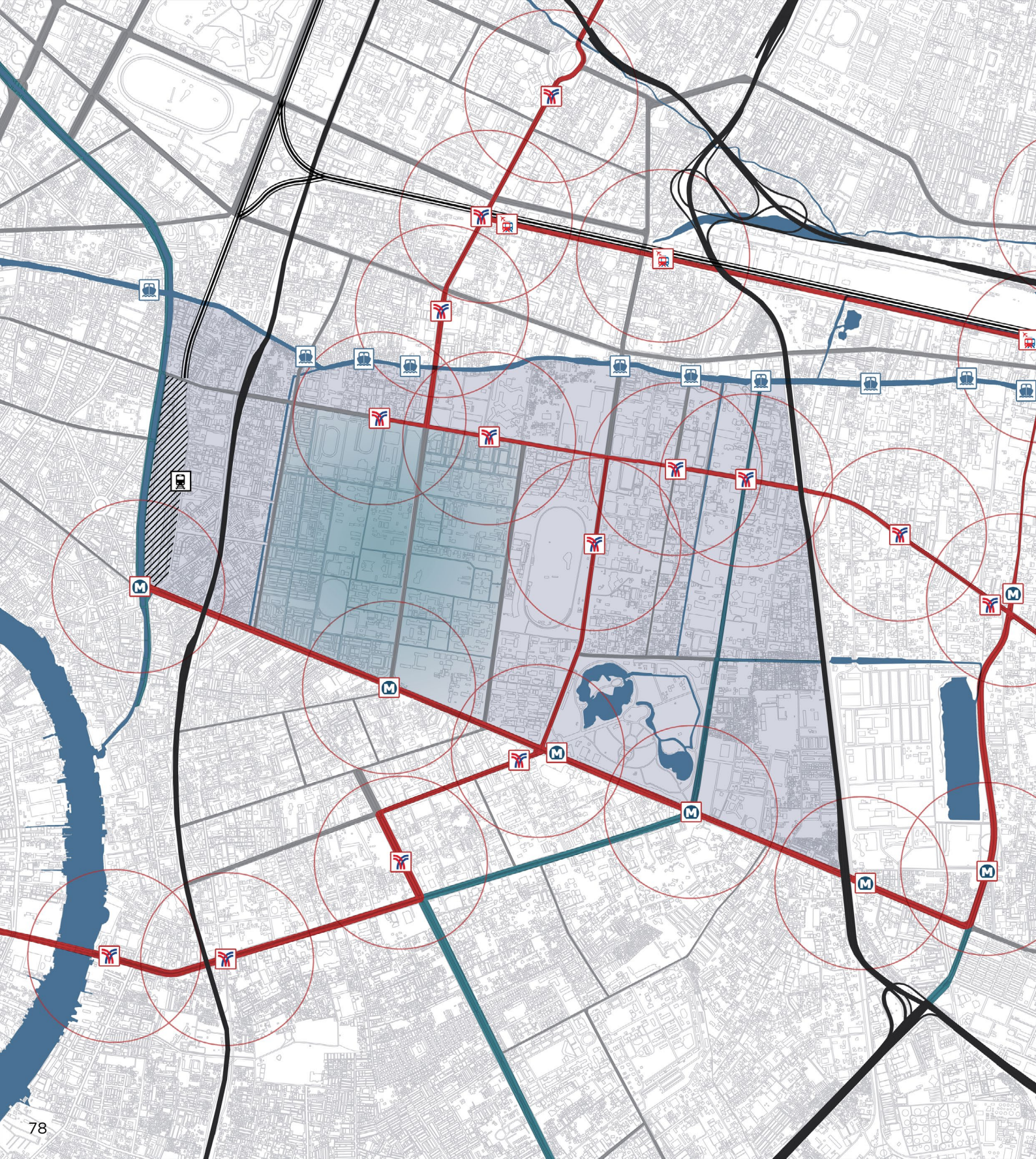
Educational Institution

Recreation & Green Space

Institution

High Density Residential

Fig.70 Site selection principles drawn by author




# Transportation Infrastructure

The networks of transportation are classified by different functional characteristics which 4 types of routes are addressed.

Mass transit route refers to economic significant sky train and metro lines which induce high rise estates, including clusters of commercial developments, hotels, and office buildings, introducing alternative pedestrian connection opportunities in different levels.

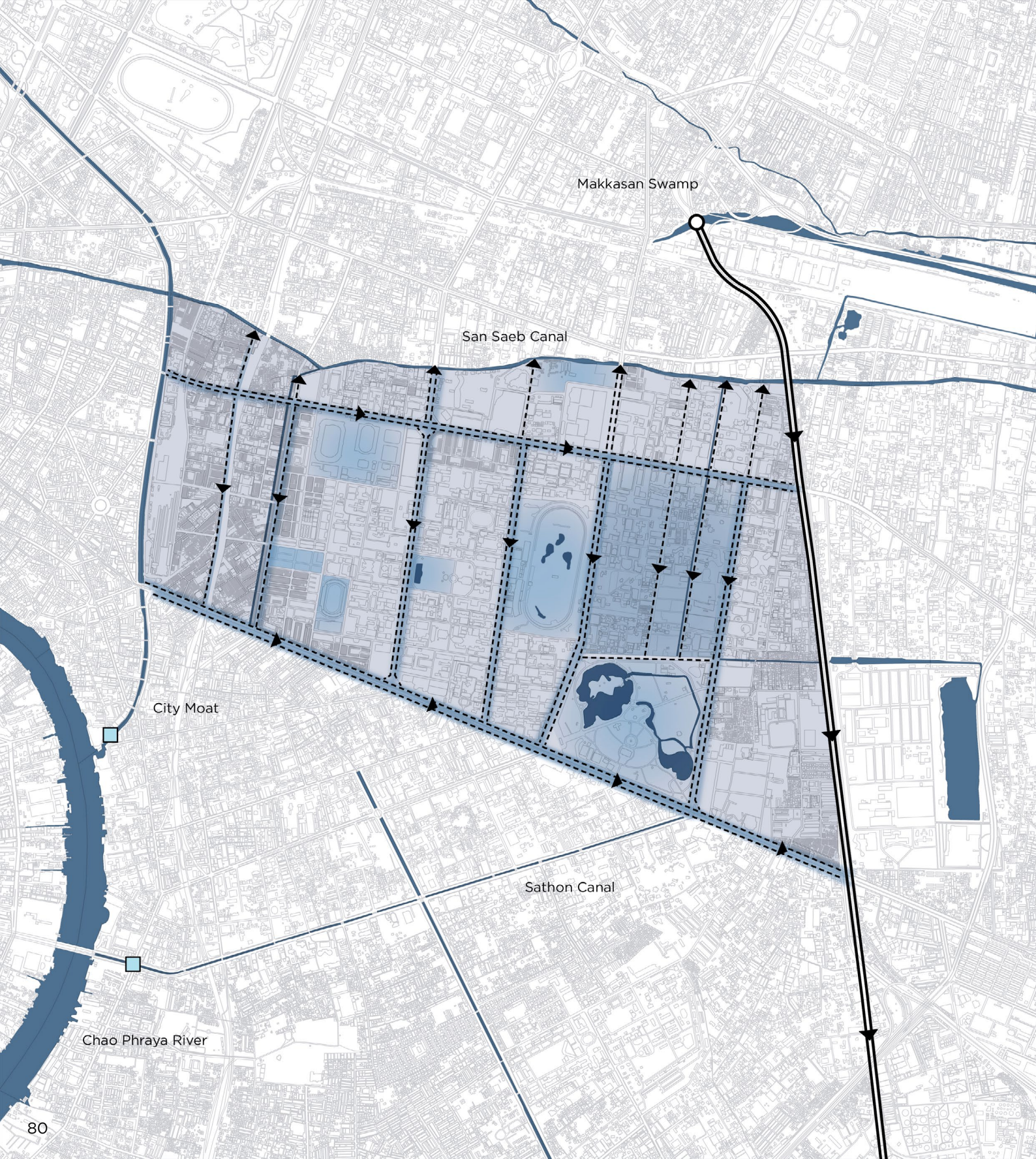
Green and blue connector route refers to the existing park connector function of road and canal system stated by Department of City Planning (2018).

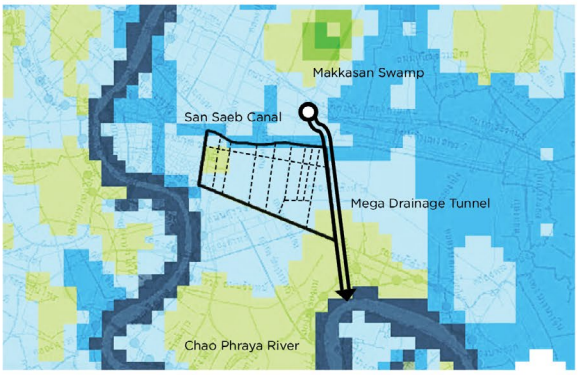
High speed traffic route refers to the busy elevated highway system. The extensive linear system reachout across districts as border separating surrounding communities with unutilized spaces underneath.

Slow traffic route refers to the secondary road system in semi-enclosed projects, covering Chulalongkorn University along with the alley system, also known as “sois, areas where people live recreating the village” (Pichard-Bertaux, 1999), of low-rise commercial development of Siam and Sam Yan which create individual traffic management within the areas.

The remains of major road system from this classification are defined as “avenues, areas for communication and commercial purposes” mentioned by Pichard-Bertaux, (1999), with characteristic of broad traffic lanes with regular tree intervals along its sides.

Fig.71 Pathum Wan Transportation Infrastructure Map drawn by author


Makkasan Swamp
San Saeb Canal
City Moat
Sathon Canal
Chao Phraya River




Urban drainage by underground pipe & tunnel system to San Saeb canal and Chao Phraya river

Levels

+0.00 - 0.50 m.

+0.50 - 1.00 m.

+1.00 - 1.50 m.

Water Management

Underground Drainage Pipe (Main Road)

Underground Drainage Tunnel

Main Drainage Flow

Run-off Catchment Area (Low Area)

Main Pumping Station

0 250 500 1000 m.

# Water Management Infrastructure

As mentioned in the previous chapter, urban water management in the district rely only on the grey infrastructural underground drainage systems of pipes and tunnels underneath road networks. As seen in Fig.72, major road systems also function as the urban catchment areas, conveying excessive water to the nearest associated drainage canal of San Saeb in the north, and mega drainage tunnel in the east. Then, water is treated and drained out to the Chao Phraya river.

However, with static characteristic of grey infrastructure design, excessive run-off from an increase number of precipitation leads to one of the major urban problem of regular flash flood obstructing daily system. Some green spaces are also stated as catchment areas by the Department of drainage and sewerage (2018). with unclear information of water management contribution to surrounding network.

Fig.72 Pathum Wan Water Management Infrastructure
Map drawn by author


Government House
Nang Leang Racecourse
Somanas Temple
Samananam Boribhan Temple
Makkasan Temple
Boromniwat Temple
Pathumwan Institute
Jim Thompson Museum
San Saeb Canal
Bangkok Art & Culture Center
Chai Mongkol Temple
Saipanya School
National Stadium
Hua Lamphong Railway Station
Chulalongkorn University
Chulalongkorn Centenary Park
City Moat
Maha Pruettharam Temple
Santiphap Park
Bangkok Youth Center (Thai-Japan)
Makkasan Swamp
Makkasan Park
Pathumwananurak Park
Makkasan Temple
Saint Joseph Convent
Pathum Wanaram Temple
Wattana Academy
Royal Sport Club
Embassy of USA
Embassy of Netherlands
Lumpini Park
RBSC Polo Club
Australian Embassy
Sathon Canal
Suan Phlu Park
Princess Mothers Commemoration Public Park
Chao Phraya River


Public Park

Future Development Public Park

Potential Green Space of Government Sector

Potential Green Space of Private Sector

Green & Blue Connector Route

Potential Connector (Avenue)

0 250 500 1000
m.

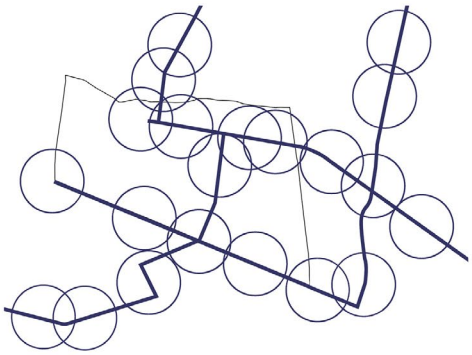
# Green & Blue Infrastructure

Phatum Wan is considered as a special district with high ratio of green space with different types from public parks to green spaces of private and government sector. The existing green and blue connector routes stated by the government are addressed in the map linking certain public parks as a network. However, missing links of the network could be clearly seen in Fig.73 as most of the potential green patches are not linked thus, separated by broad road system of avenues. On the other hand, by reconsidering these avenues as part of green and blue connector, the network could be extended conveying social and ecology systems from certain spots along the linear network, reaching the intensive areas in different parts of the district.

Fig.73 Pathum Wan Green & Blue Infrastructure Map drawn by author

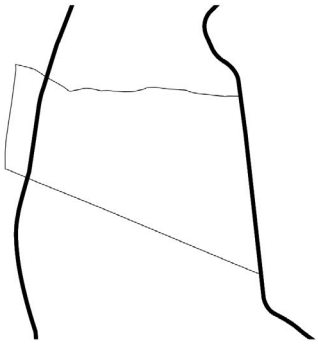
# 3.3 DESIGN IMPLEMENTATION

a) Design Principle
b) Vision and Phrasing Development
c) Mass Transit Route : Commercial Artery
d) Green & Blue Connector Route : Life Corridor
e) High Speed Traffic Route : Underline Park
f) Slow Traffic Route : Soaked Community



1 **Commercial Artery**
( Harvest + Infiltrate )
Mass Transit Route

2 **Life Corridor**
( Convey + Tolerate )
Green & Blue Connector Route

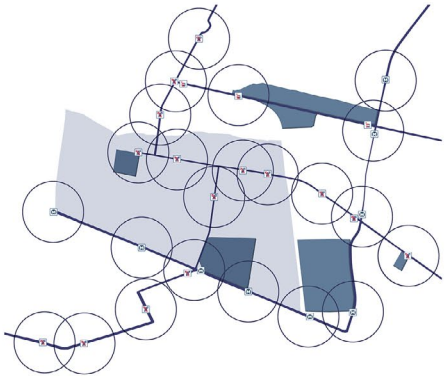


3 **Underline Park**
( Store + Tolerate )
High Speed Traffic Route

4 **Soaked Community**
( Store + Infiltrate )
Slow Traffic Route

Fig.74 Design Principles Categorized by Existing Urban Roles drawn by author

1



2

Public Park Network

Potential Green Space Network

3

0 250 500 1000 m.

# Vision and Phrasing Development

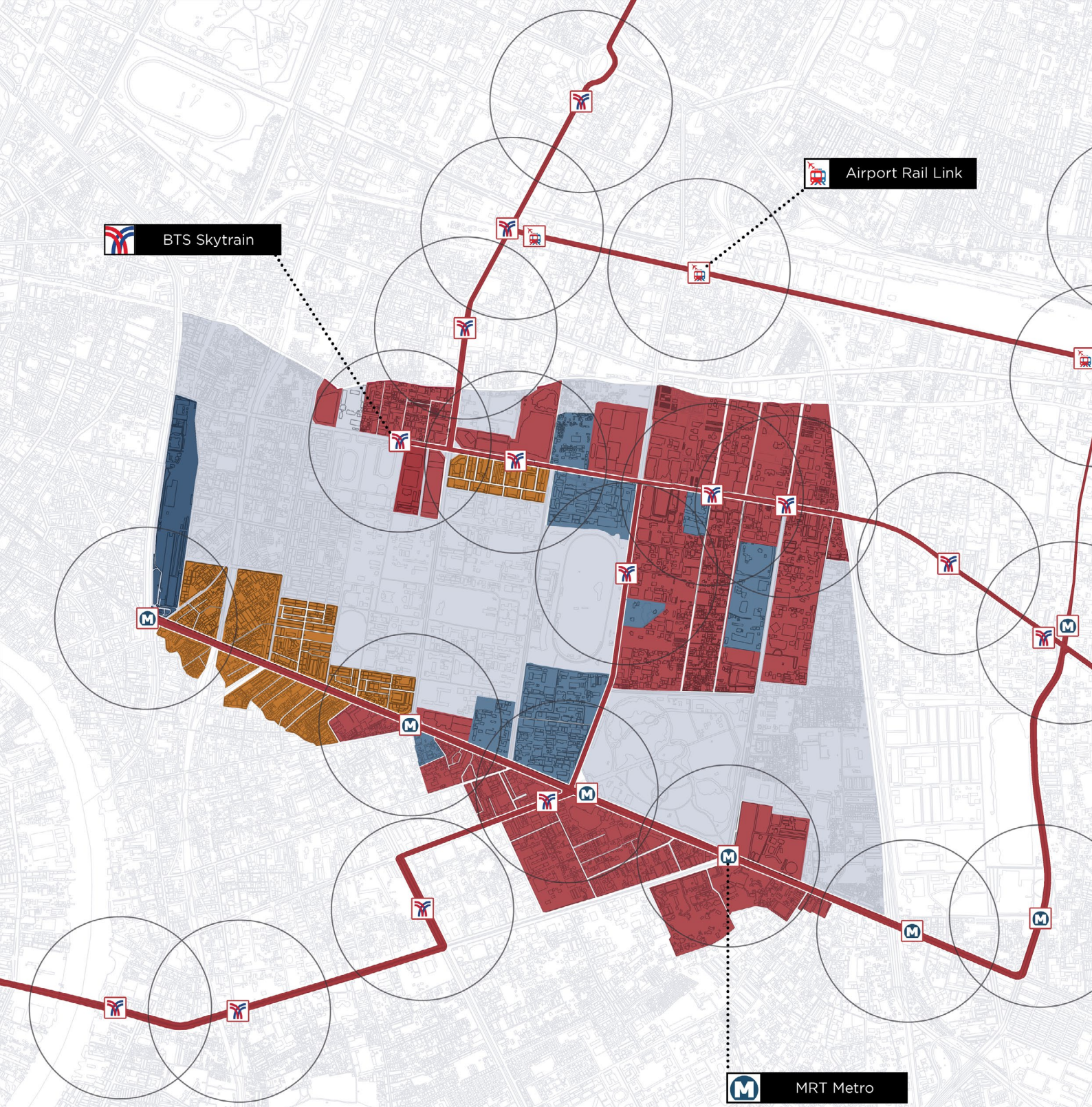
"The development of roads also led the movement of people from water to land. This also resulted in the development of loosely scattered yarns integrated by a street system" (Askew, 1996). Currently, transportation Infrastructure of road system is considered as the major grey infrastructure development which conduct people lifestyle, seperation of green & blue network along with future direction of urban expansion.

In this part, the hybrid resilience infrastructure strategy is implied to explore on the new relation of integrated eco-functions of green & blue network with the existing road and water management system, performing as flood management network and inducing socio-ecological transformation of the inhabitants.

The networks are classified into four major principles, including, Commercial Artery, life Corridor, Underline Park, and Soaked Community. The development of this network could be classified and prioritized into 3 phrases, by the contribution to urban system and the significant for future expansion, as seen in Fig.75

First, the primary commercial and transportation lines are proposed to develop as the core structure of the network, enhancing balance of social, ecology along with economic growth while the system performs together with existing public park systems for flood management. Then, the secondary routes of park connectors are proposed extending the reach of social and ecology system along the network lines to intensive areas. New potential green spaces of private and government sectors are proposed for integration in this state. For the last stage, 2 developments with different approaches is purposed. Underline park strategy seeks to intervene the borderline by development of unutilized areas improving social and ecology system amongst local communities. While, soaked community strategy focus to enhance flood management to specific controlable community scale.

Fig.75 Vision and Phrasing Development drawn by author


Airport Rail Link
BTS Skytrain
MRT Metro

High Rise Commercial & Office Building

Low Rise Commercial (Mixed Use)

Institution

1 km. Diameter Connection

Fig. 77

High Rise Commercial Development

Fig. 78

Low-rise Commercial Development

Fig. 79

Institution

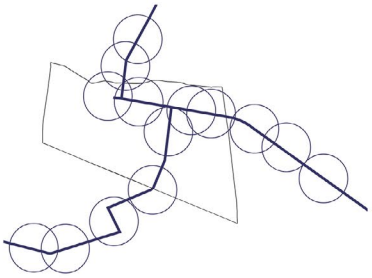
0 250 500 1000 m.

Fig. 76

# Mass Transit Route : Commercial Artey

Economic driven transportation promotion led to the conflict and opportunity of development for the commercial routes. Sky-train and metro lines are the new key transportation logistic accommodating as alternative transportation and pedestrian networks inducing new urban developments of high-rise estates along the emerging lines. While road systems are mainly design for vehicle ignoring pedestrian living qualities on street which result with consecutive consequences of pollutions and traffic congestions which create bad atmosphere along the street lines. Social and ecology systems are heavily ignored with degrading evidences such as obstructions of public utility systems and street vendors which are commonly seen on the sidewalk of Bangkok

Fig.76 Mass Transit Route and Urban flow drawn by author
Fig.77 Siam Paragon Department Store (Siam Paragon, 2013)
Fig.78 Siam Square Project ( Collins J., 2017)
Fig.79 King Chulalongkorn Memorial Hospital (DSPPA IP Network System Applied in King Chulalongkorn Memorial Hospital)

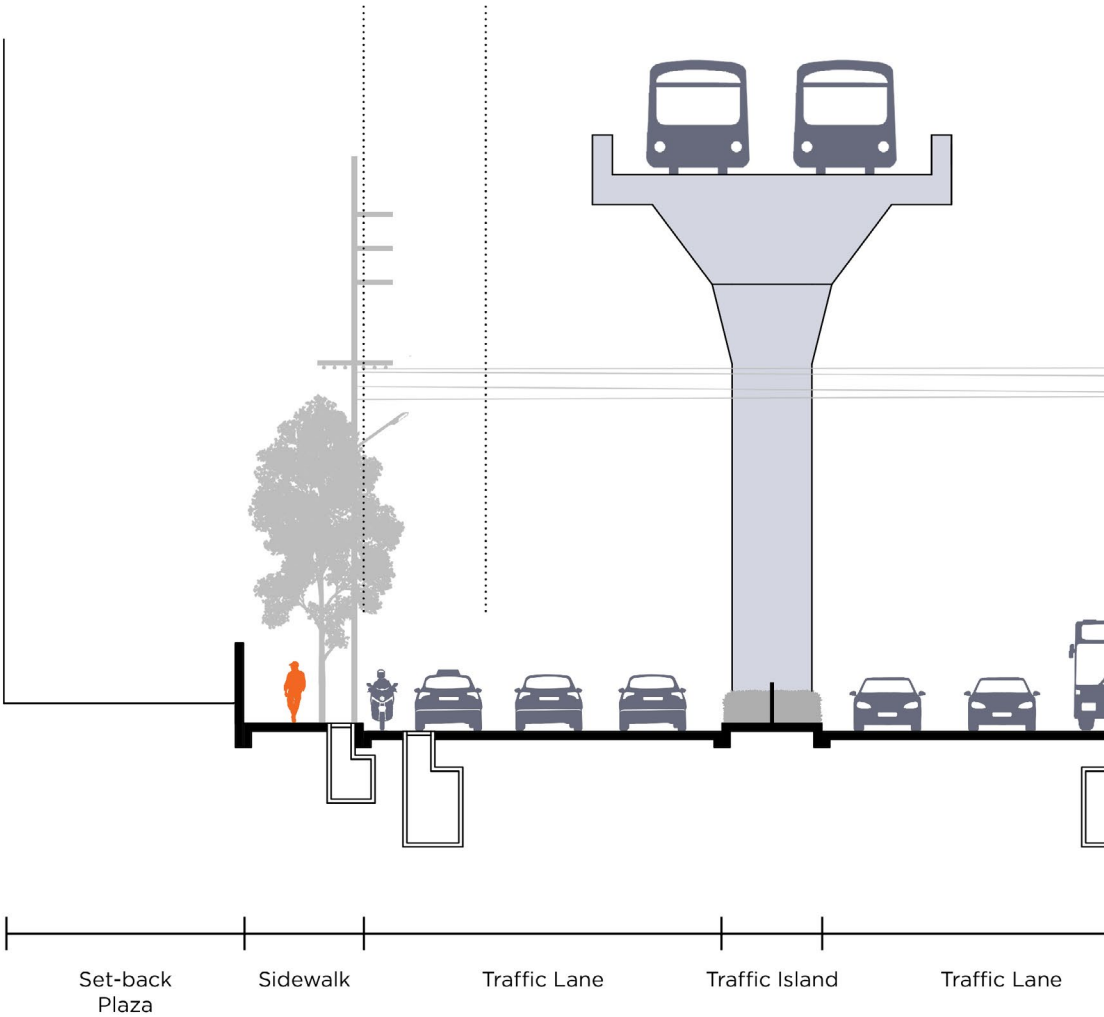


Air and noise pollution from traffic congestion

Traffic congestion of unorganised public transportation transit

Isolated & unutilized green space of traffic island

Disconnection of public sidewalk and set-back plaza



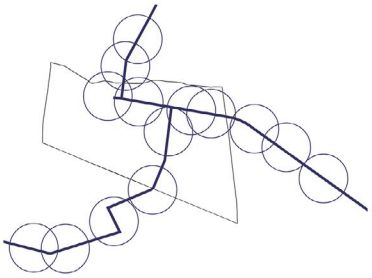
## Mass Transit Route : Sky-train

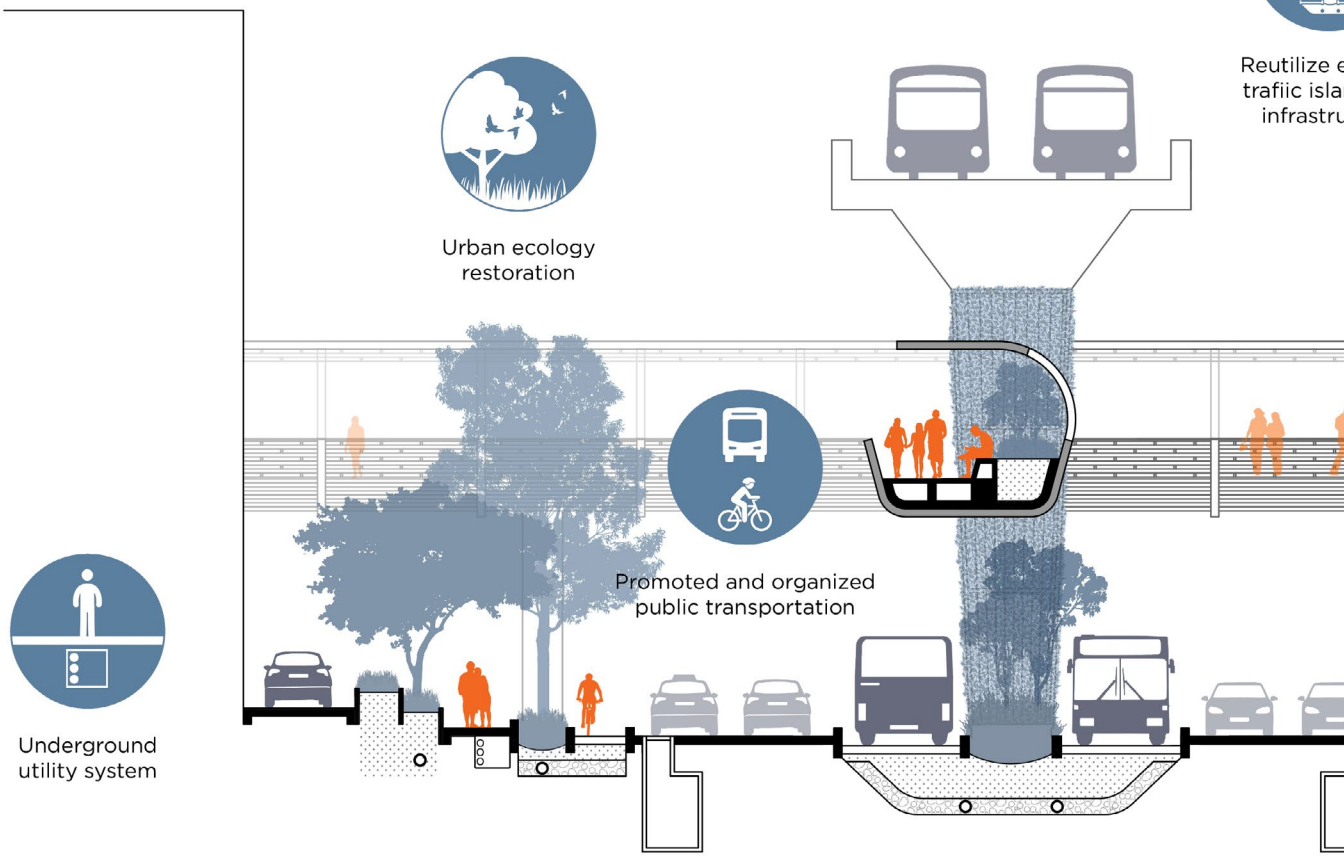
1 : 150

Underground drainage of
mixed sewage and run-off

Limitation of
urban ecology by
public utility systems


Fig.80 Existing Condition of Mass Transit Route
(Sky-train) drawn by author




Urban ecology
restoration
Promoted and organized
public transportation
Underground
utility system
Integrated Sidewalk
& Set-back Plaza
Bio-swale
Permeable
Bike lane
Traffic Lane
Permeable Bus Lane
& Bio-swale

## Commercial Artery : Sky-train
## ( Harvest + Infiltrate )

Commercial artery concept mainly focuses to improve the controversial topic of vehicle-based development by promote pedestrian connectivity and public transportation reorganization, balancing the social, ecology, and economic system. Flood management strategy of bio-swale and permeable traffic lane are integrated, supporting excessive run-off apart of sewage system. Traffic island is redesigned as the new bus stop and places for urban ecology to grow, buffering pollutions and adjusting new atmosphere. Vertical garden connecting green spaces on different levels supporting the extended skywalk network, connecting people from surrounding buildings along the route. Pedestrian connectivity on ground is also enhanced with wider sidewalks merging set-back green spaces and organized public obstructions of both utility systems and street vendors.

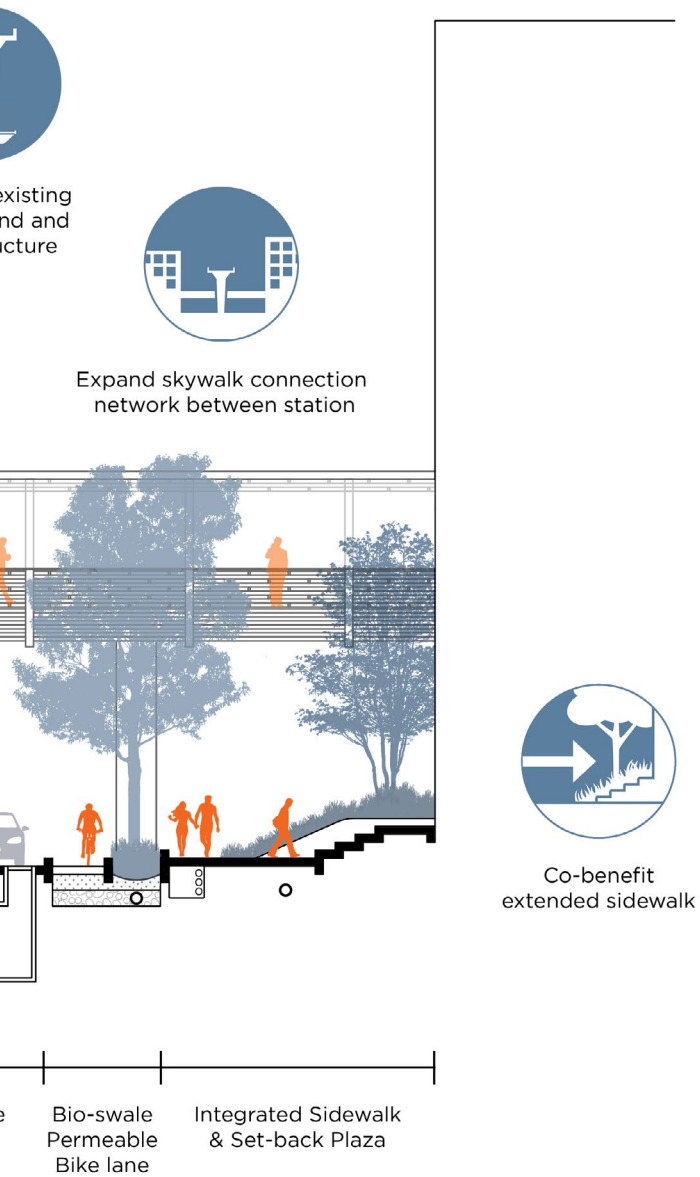



Fig.81 Commercial Artery Solution (Sky-train) drawn by author

Pollution Filtration

Shorea roxburghii

Lagerstroemia loudonii

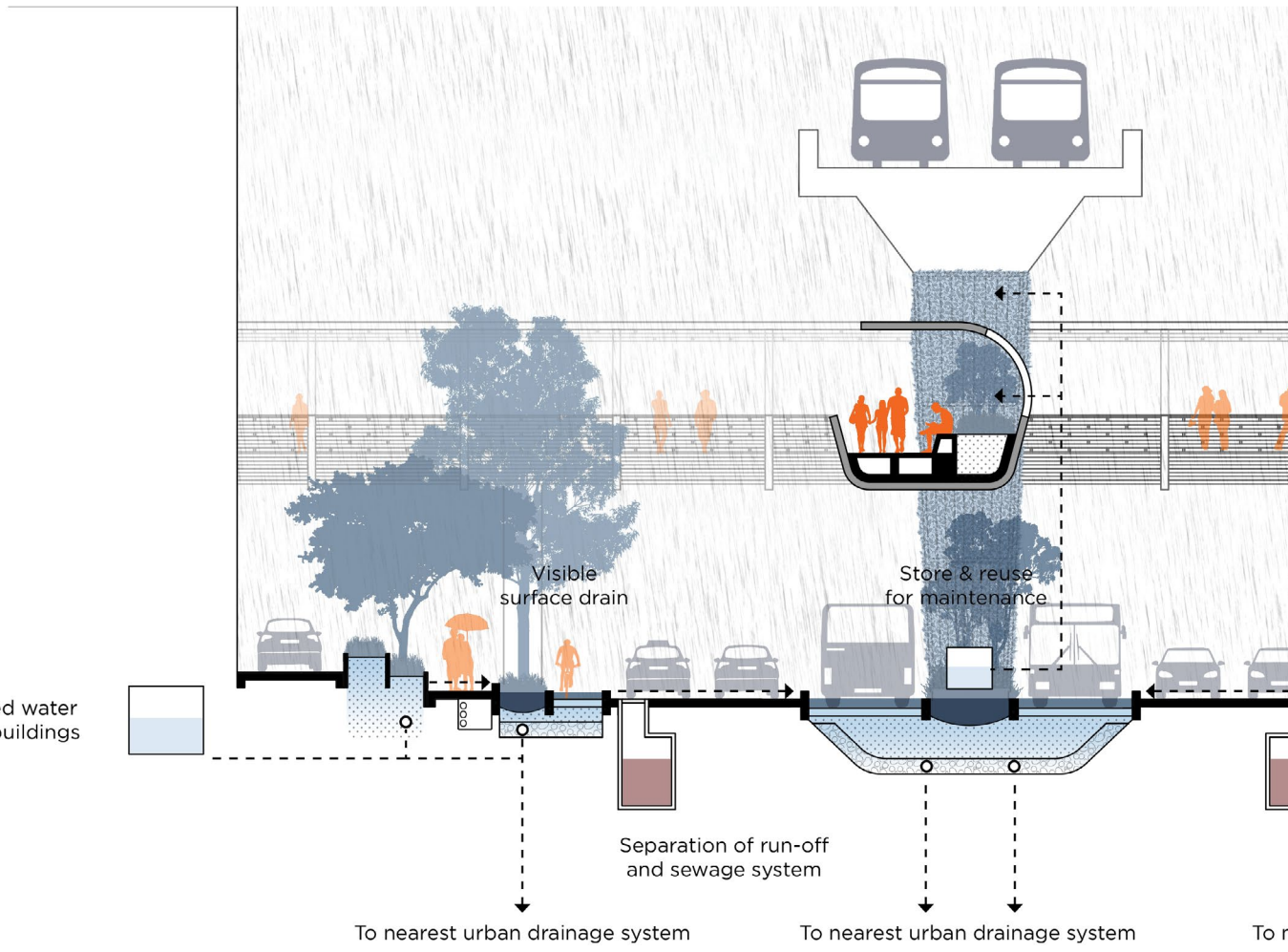
Shorea roxburghii

Bio-Swale - Infiltration

Crinum asiaticum

Gardenia jasminoides

Schefflera actinophylla



Vertical Garden

Dolichandra
unguis-cati

Scent

Ruellia tuberosa

Polianthes tuberosa

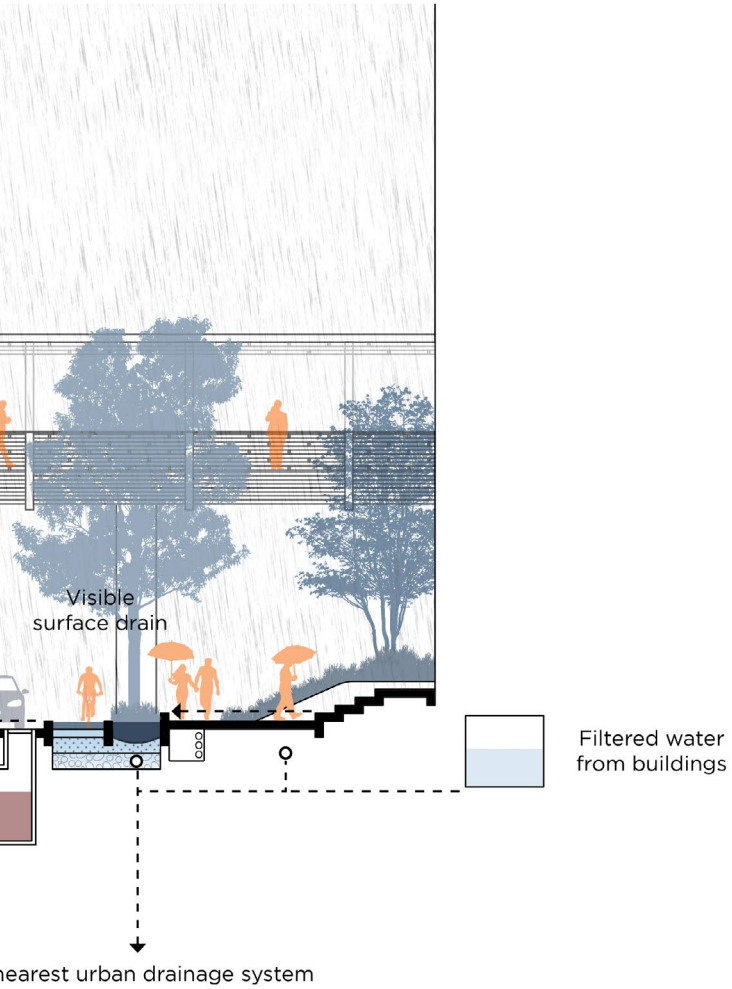
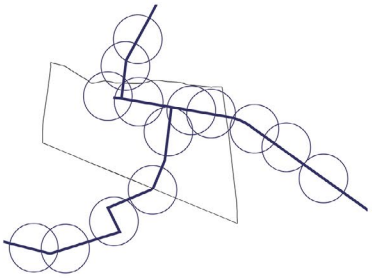


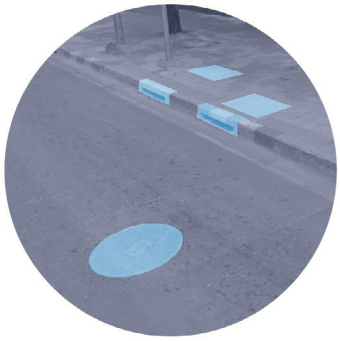

Fig.82 Commercial Artery Solution (Sky-train)
drawn by author



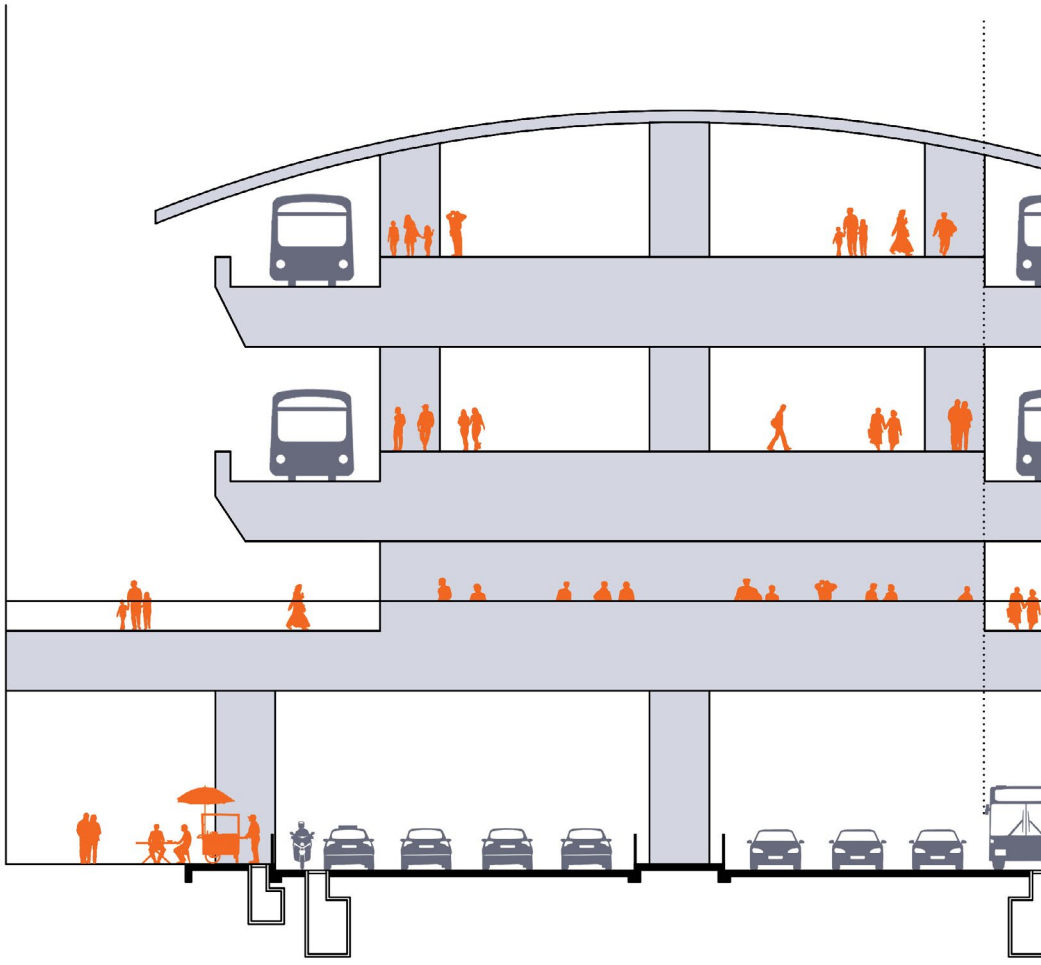
Air and noise pollution from traffic congestion

Traffic cong unorganis transportat

Lack of ecology system with unfriendly environment of sky-train structure



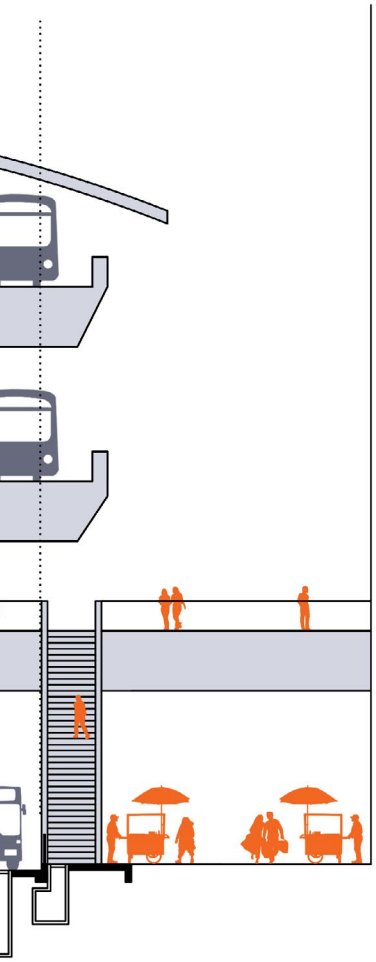
Engineering solution
Underground drainage of mixed sewage and run-off

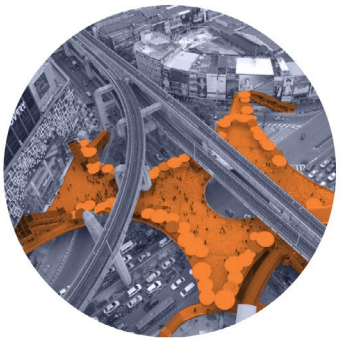


## Mass Transit Route : Sky-train

1 : 200

gestion of
ed public
ion transit





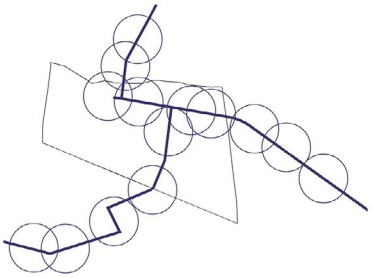
Alternative Pedestrian
Connection (Skywalk)

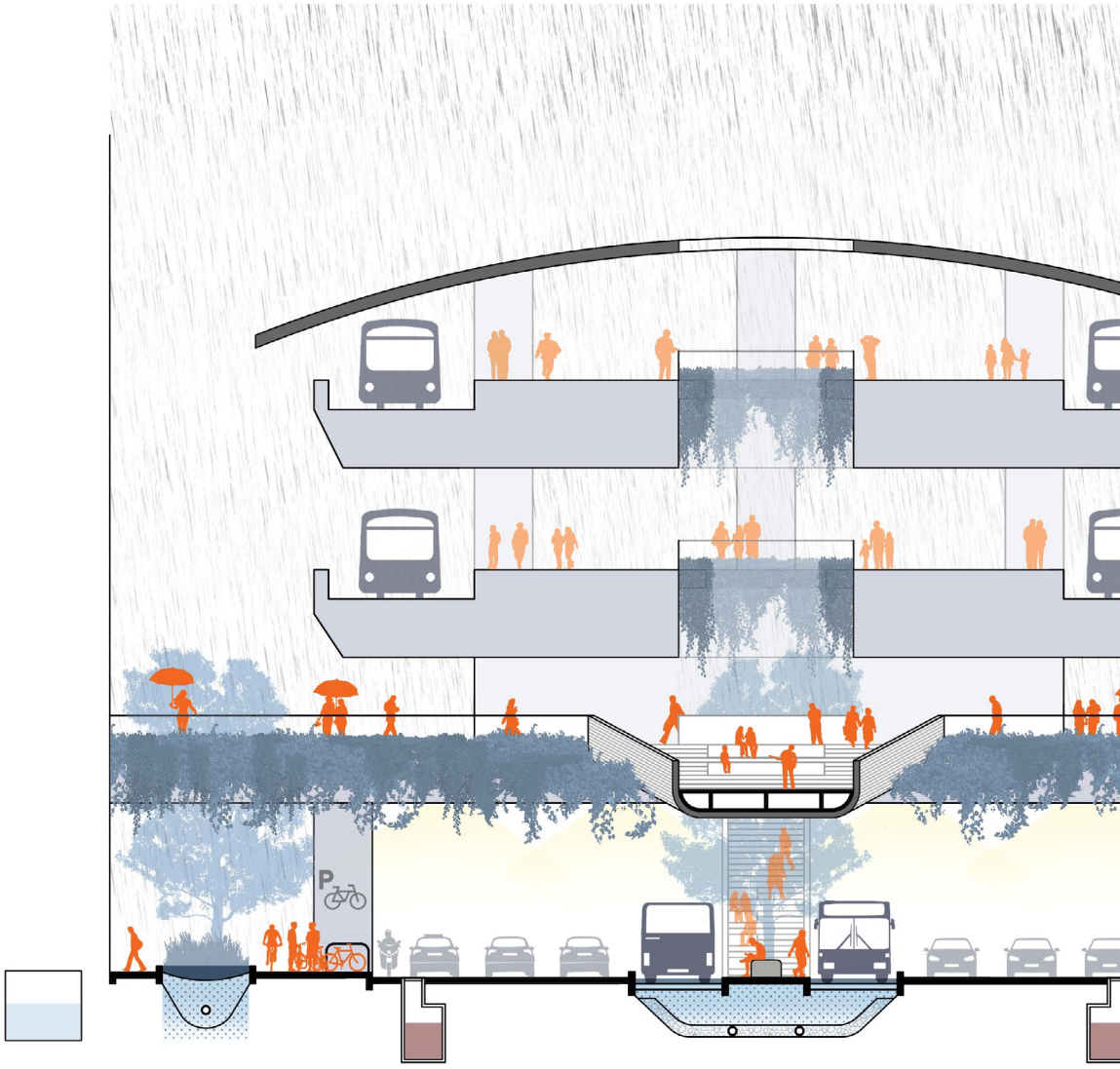
Informal street economy
on sidewalks around
commercial nodes

Sidewalk

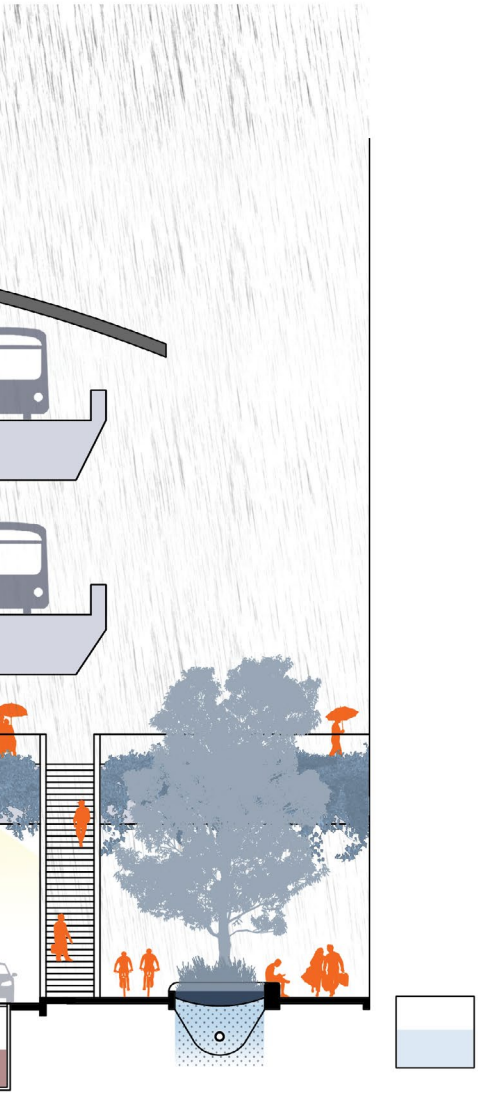
Set-back
Plaza

Fig.83 Existing Condition of Mass Transit Route
(Sky-train Node) drawn by author



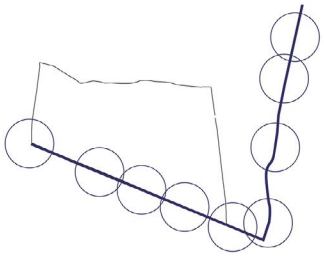

Integrated Sidewalk
& Set-back Plaza
Traffic Lane
Bus Transit / Bio-swale
Traffic Lane

Commercial Artery : Sky-train
( Harvest + Infiltrate )



Integrated Sidewalk
& Set-back Plaza

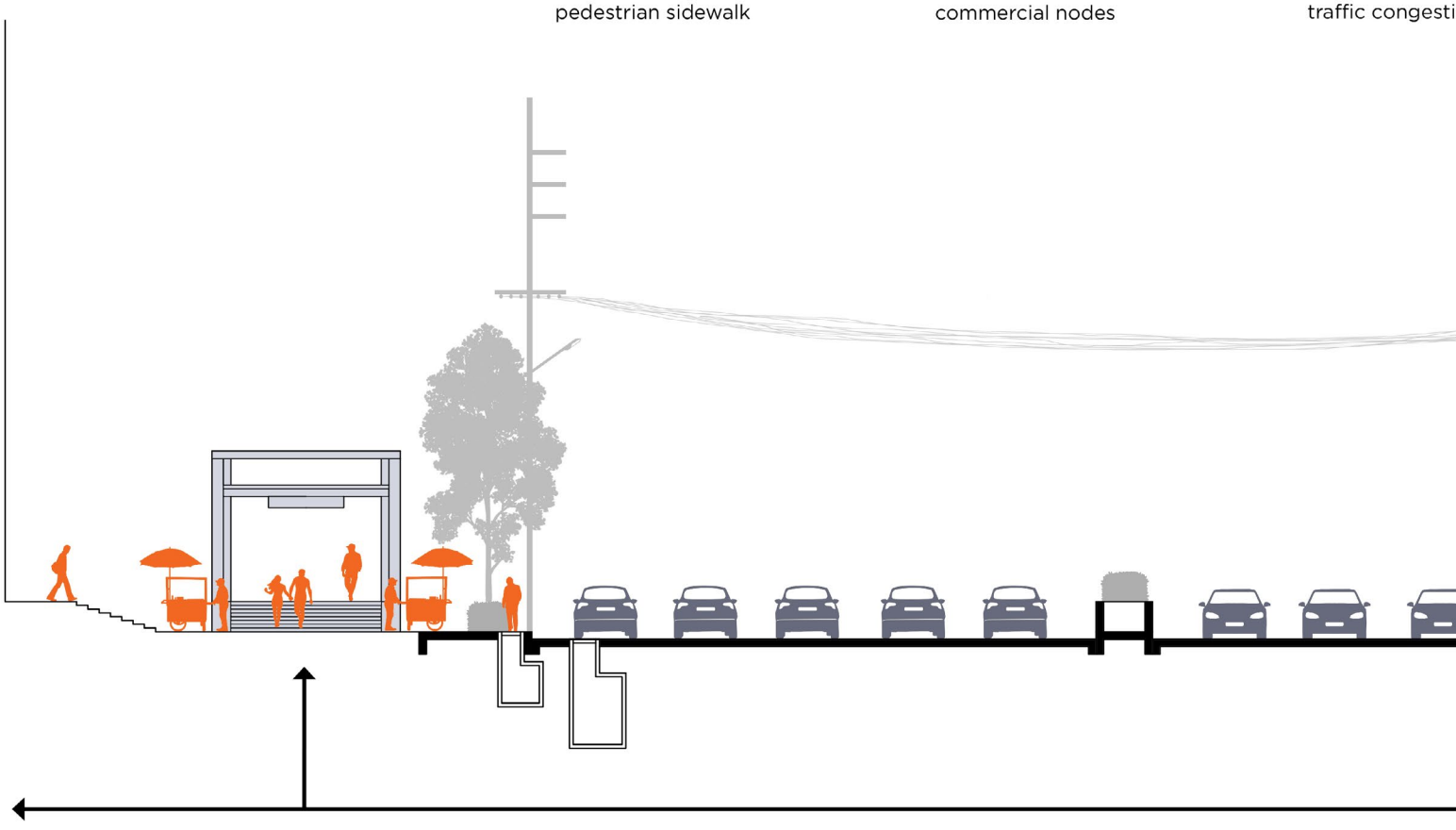
Fig.84 Commercial Artery Solution (Sky-train Node)
drawn by author



Connection between commercial area with pedestrian sidewalk

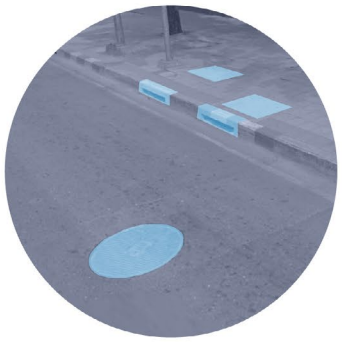
Informal street economy on sidewalks around commercial nodes

Air and noise pollution from traffic congesti



## Mass Transit Route : Metro

1 : 150



Traffic congestion of unorganised public transportation transit

Underground drainage of mixed sewage and run-off

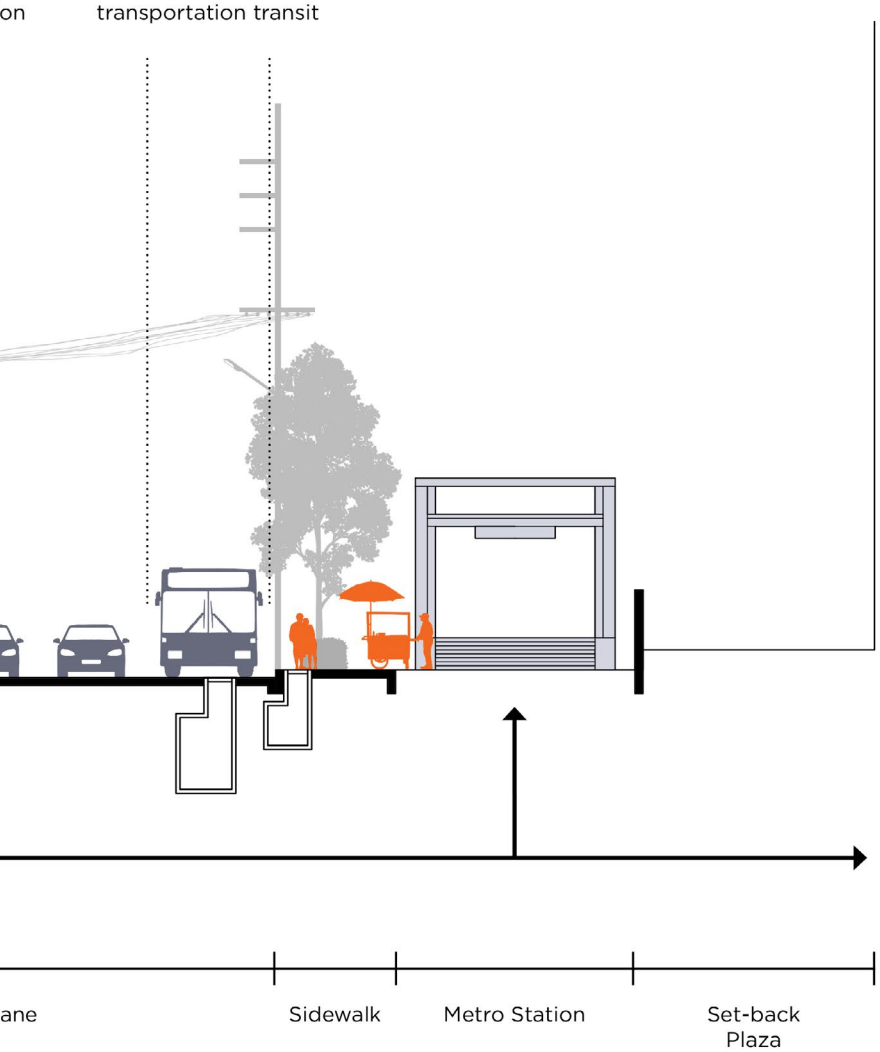
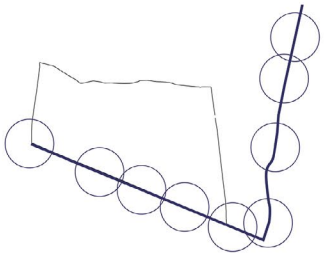
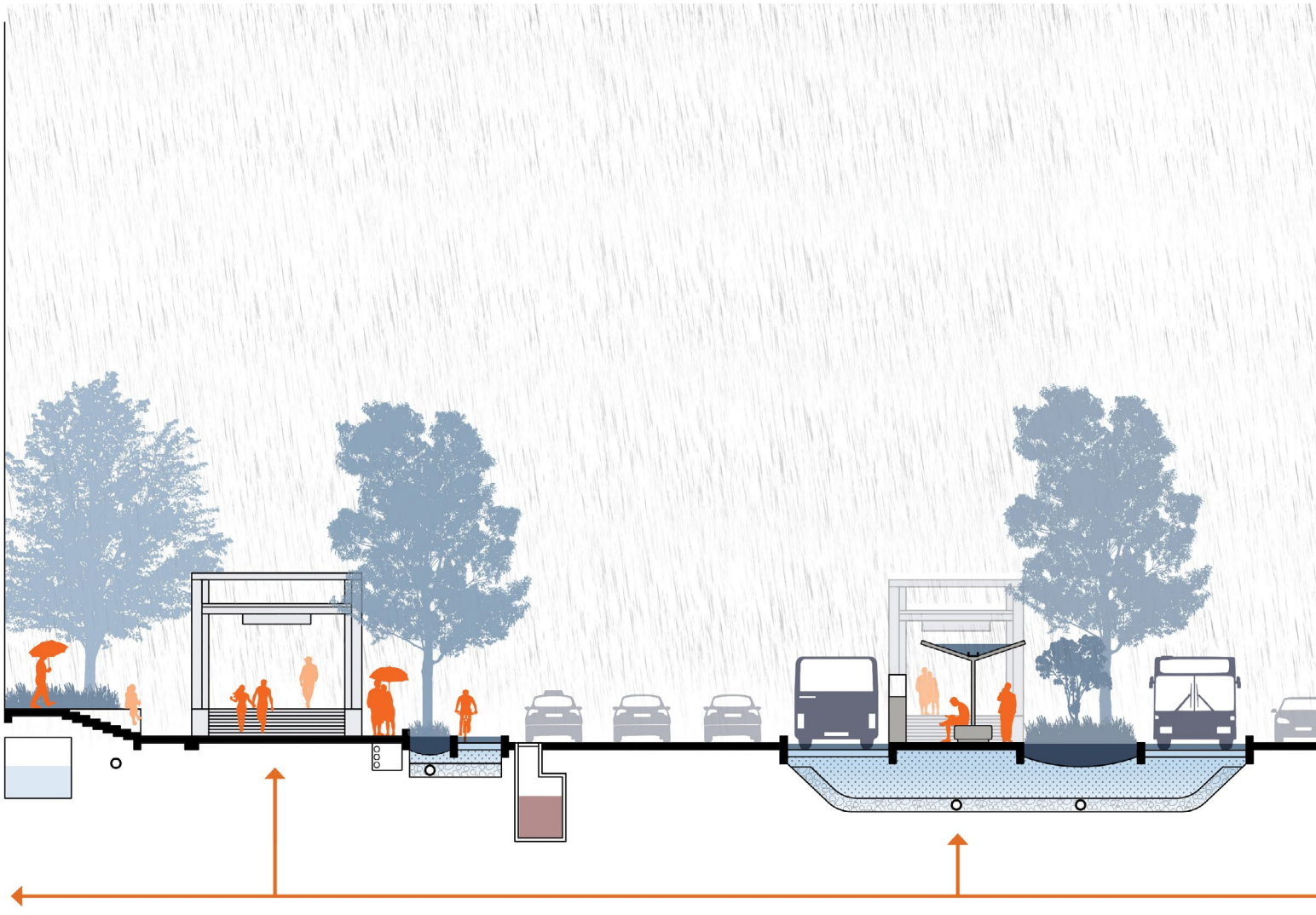



Fig.85 Existing Condition of Mass Transit Route (Metro Node)




Additional Underground Pedestrian Connection
Integrated Sidewalk & Set-back Plaza
Metro Station
Bio-swale Permeable Bike lane
Traffic Lane
Enlarged Traffiic Island Bus Transit & Bio-swale

Commercial Artery : Metro
( Harvest + Infiltrate )

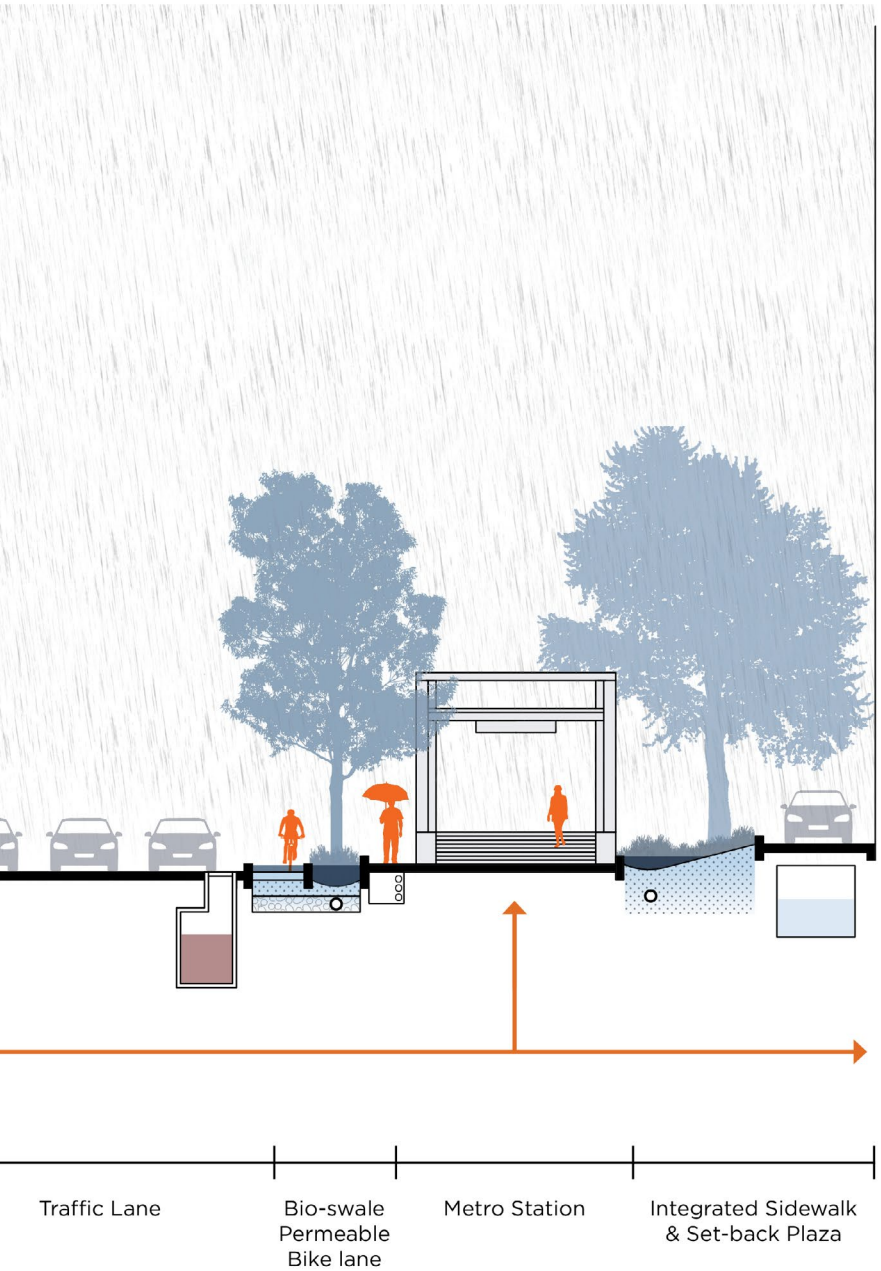
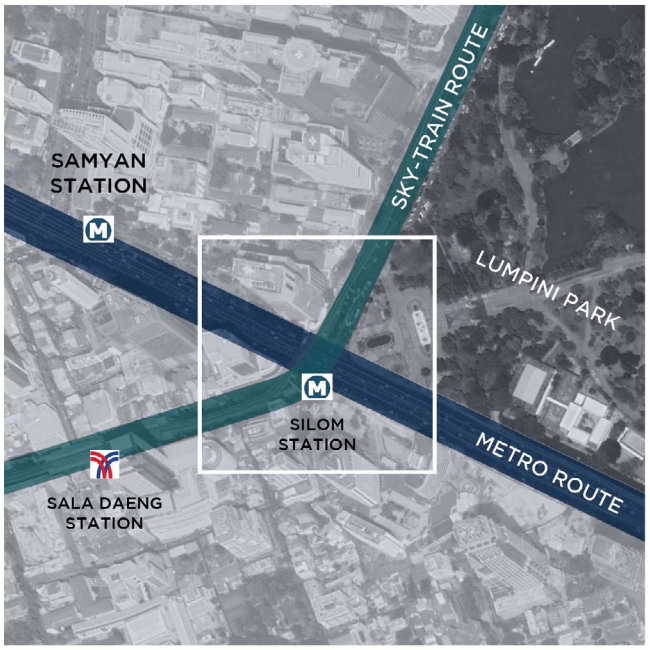
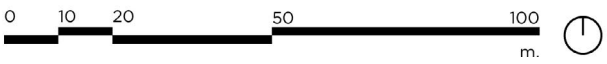
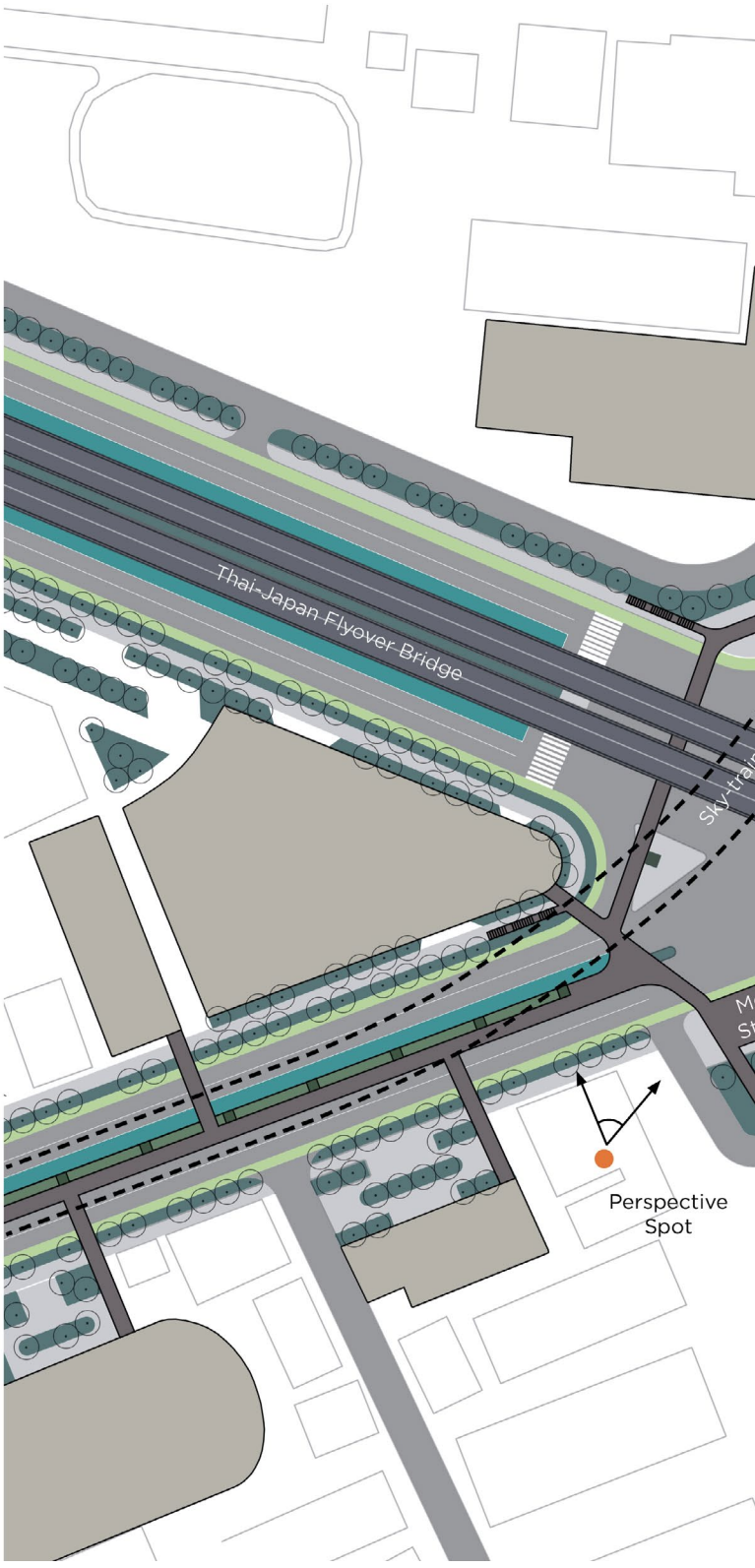



Fig.86 Commercial Artery Solution (Metro Node)
drawn by author




- Bio-swale
- Pedestrian Skywalk
- Permeable Bus Lane
- Permeable Bicycle Lane
- Urban Creek
- Vertical Green Pole



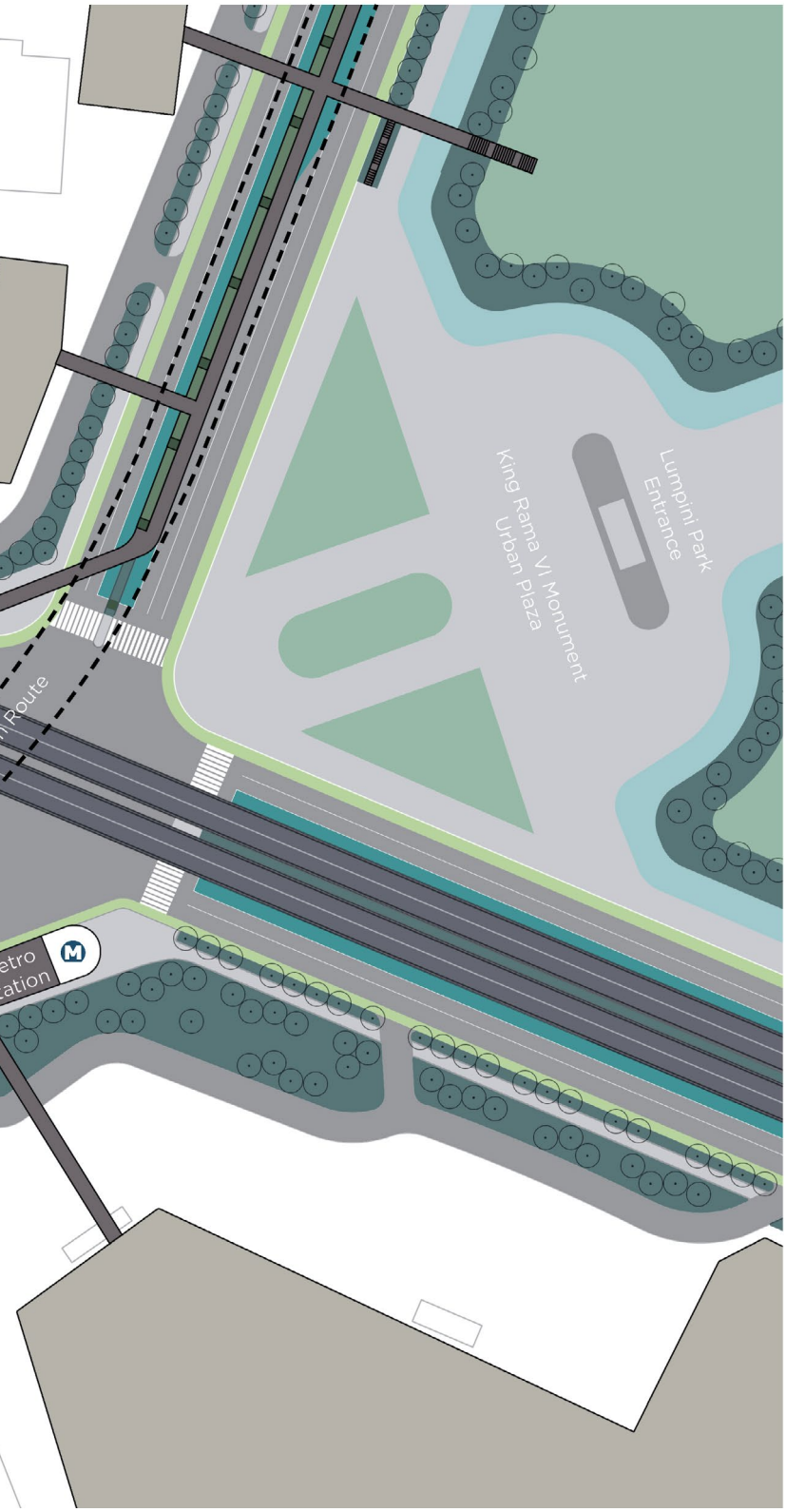
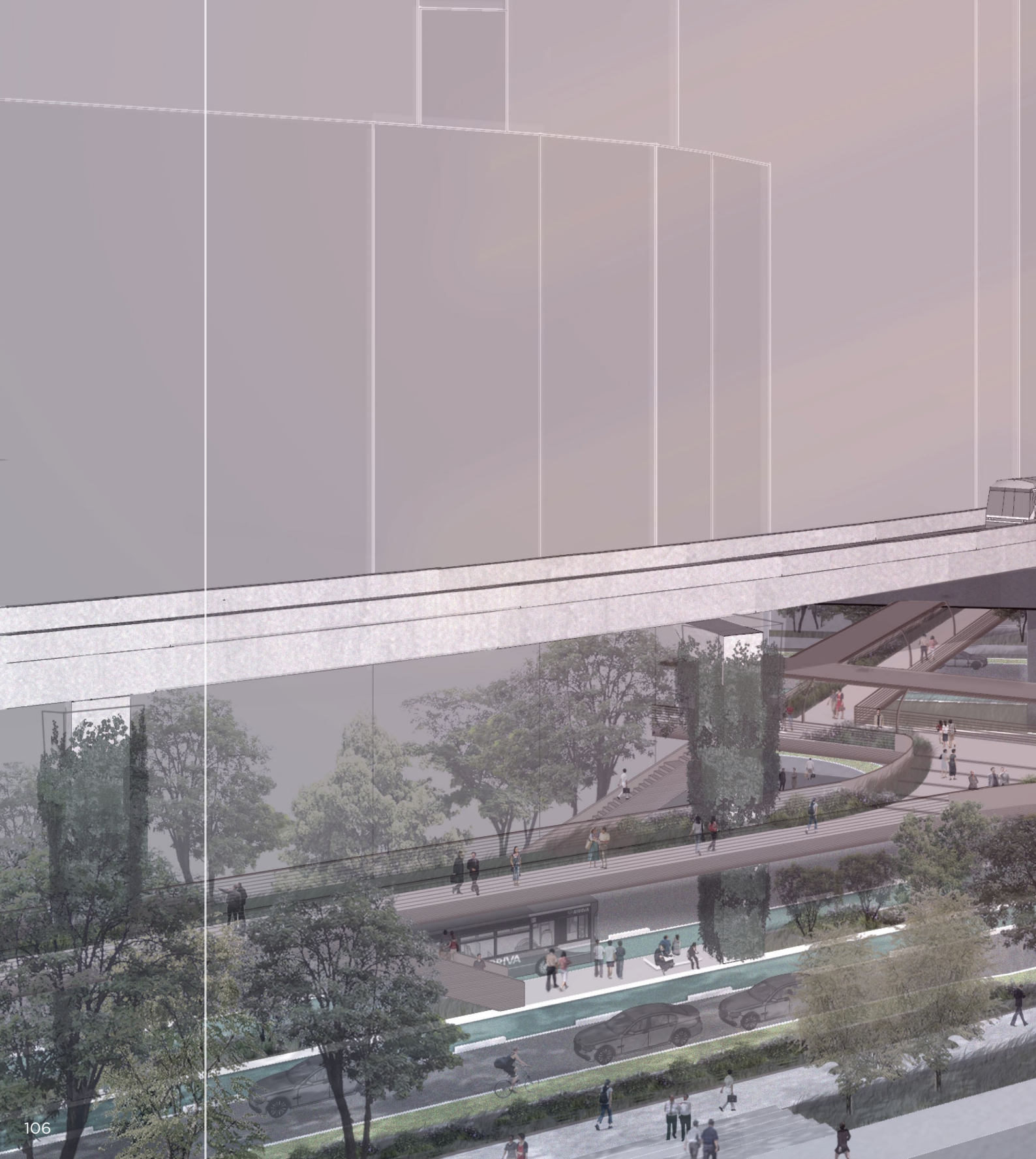



Fig.87 Silom Intersection Site drawn by author



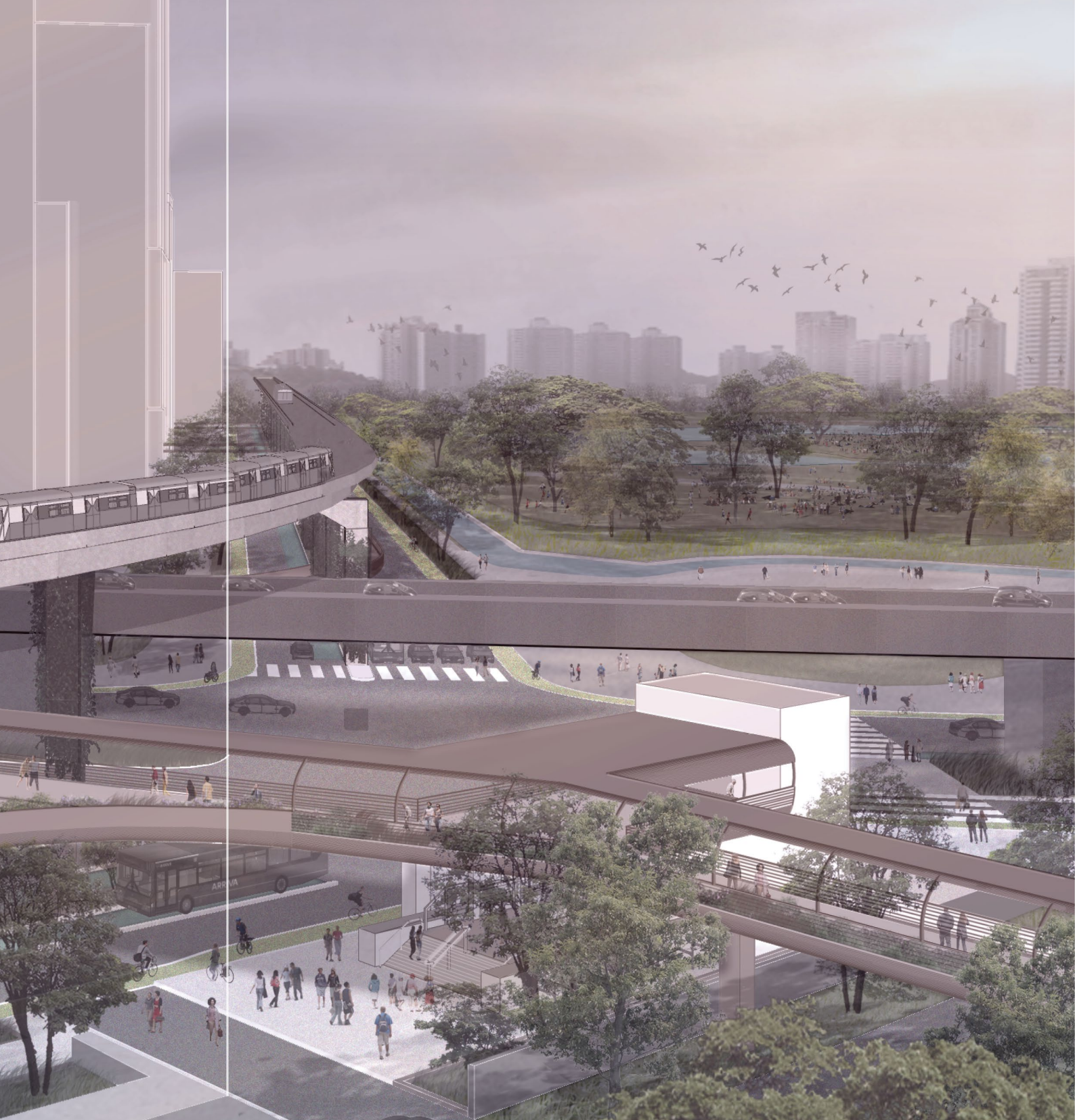
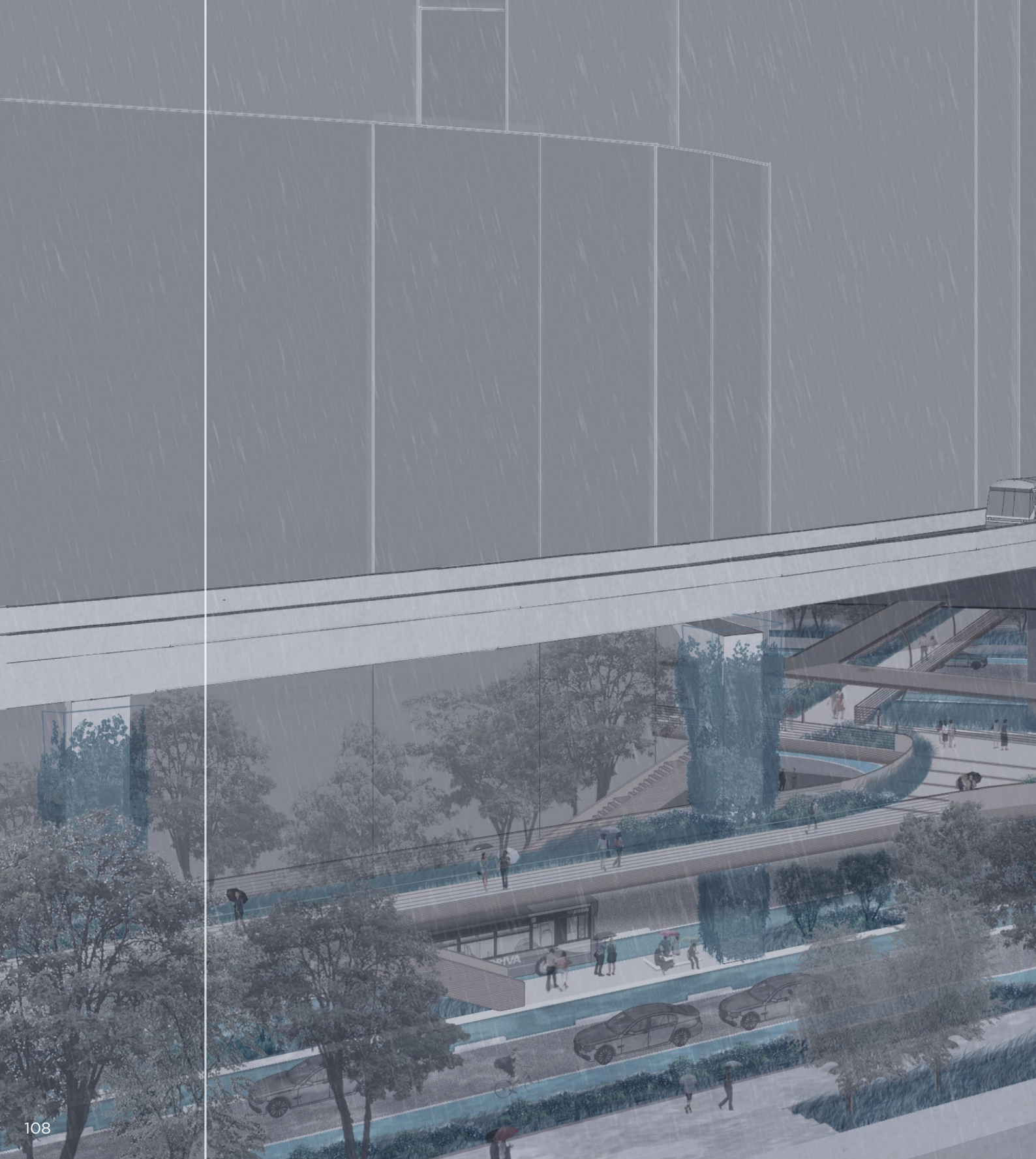


Fig.88 Commercial Artery (Dry Condition)
drawn by author



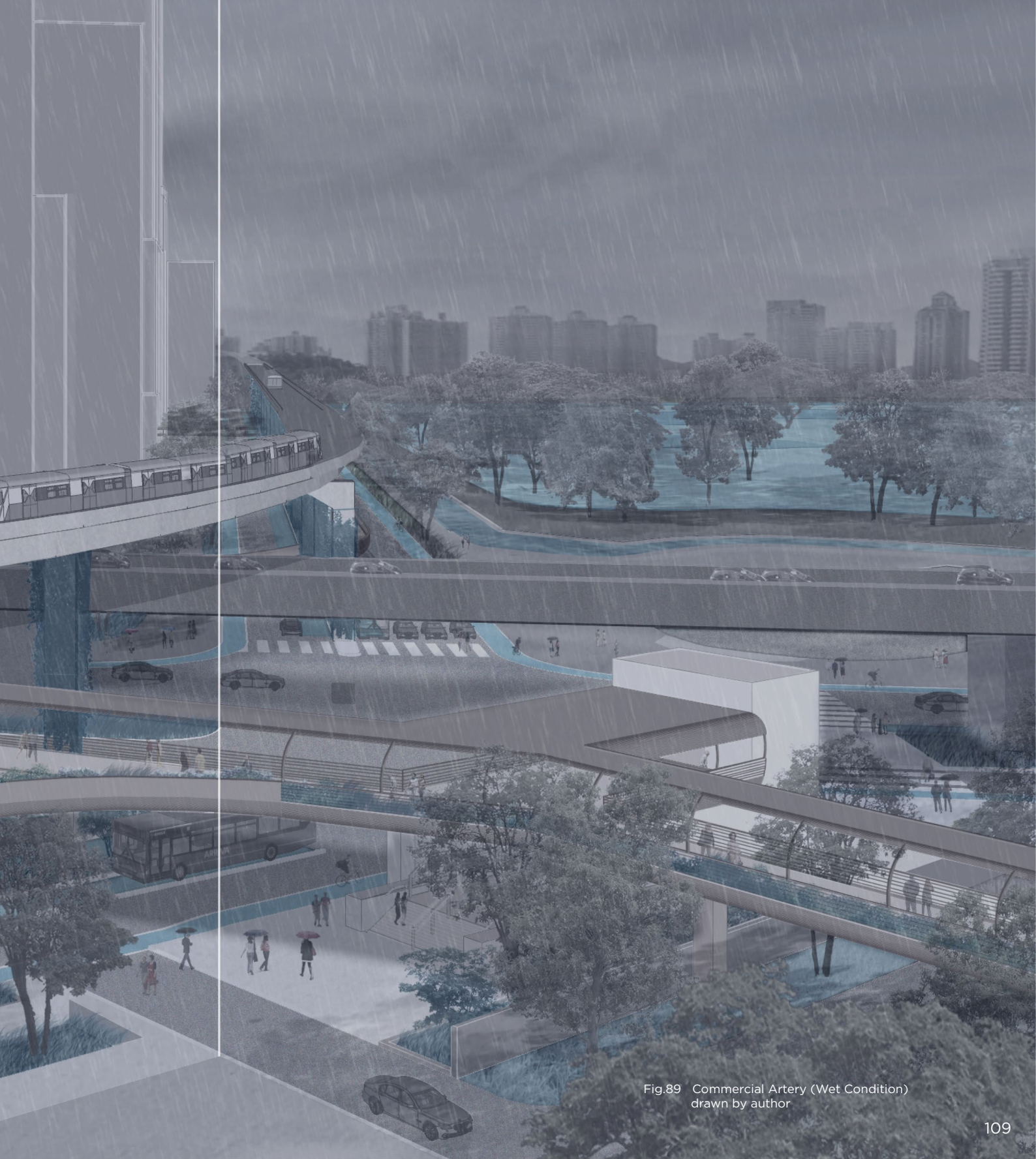


Fig.89 Commercial Artery (Wet Condition)
drawn by author

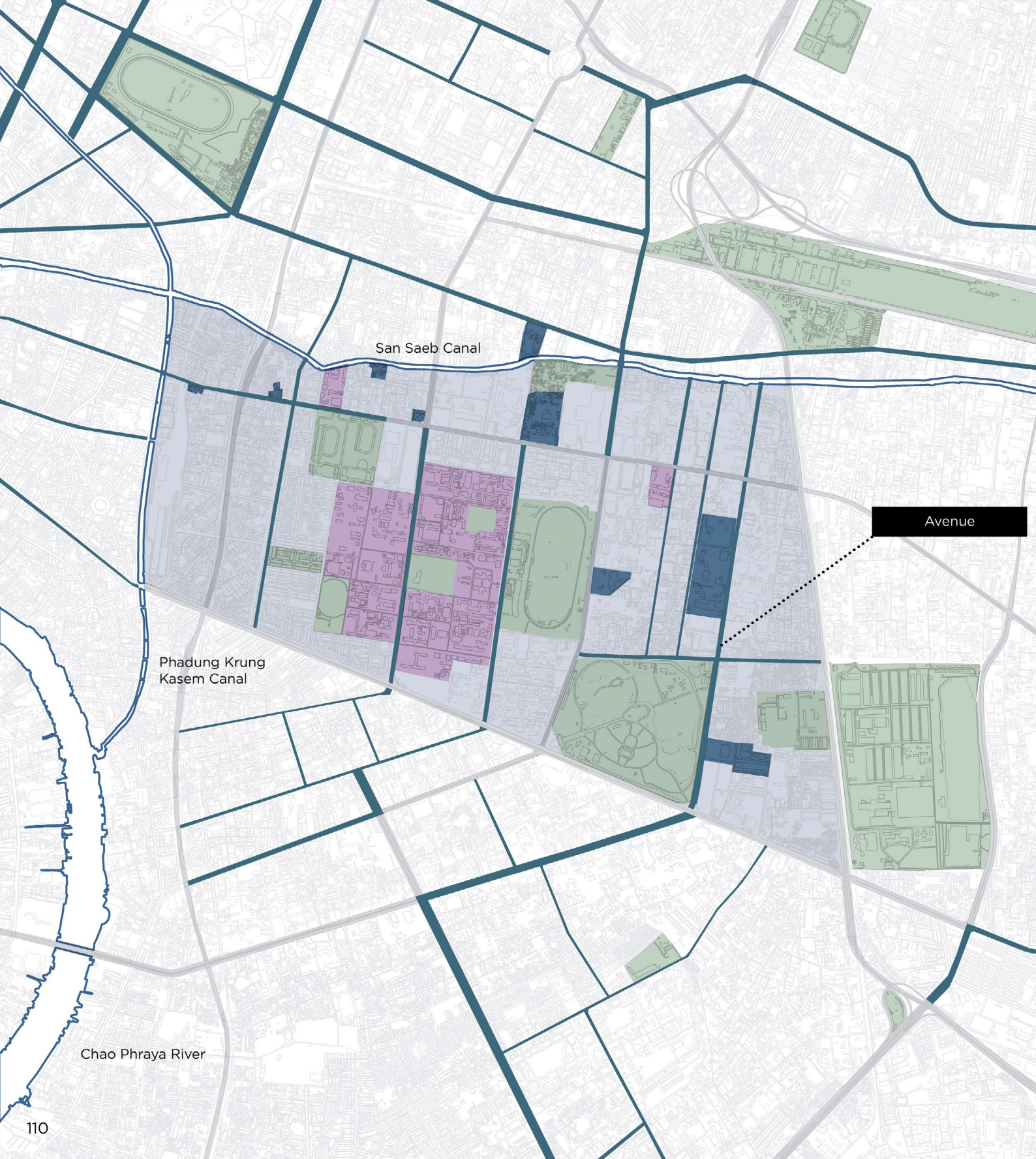

San Saeb Canal
Avenue
Phadung Krung
Kasem Canal
Chao Phraya River


Fig. 90

# Green Connector Route : Life Corridor

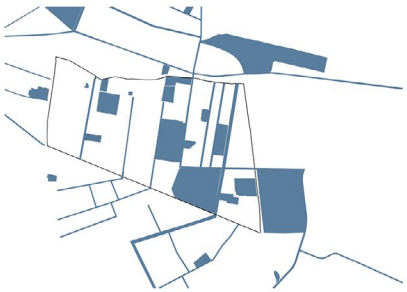
The green connector routes are meant to extend the social and ecology system from green patches such as recreational park. With addition of avenues as the new green connectors extend the reach of connection forming a larger network. However, this extended connections are rarely seen because of the wide traffic road system Fragments of small green spaces on both sidewalks and traffic island are more percieved as decorations without social or ecological benefits.


Connection with Temple Green Space


Connection with Embassy Green Space

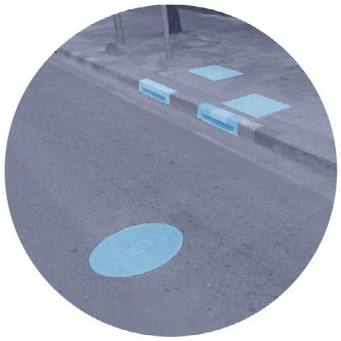

Connection with University Park

Fig.90 Green Connector Route and Urban Flow drawn by author
Fig.91 Pathumwanaram Temple (Limhussanaikul T., 2018)
Fig.92 Dutch Embassy (Leelawannasuk T., 2018)
Fig.93 Chulalongkorn University (Chulalongkorn University)

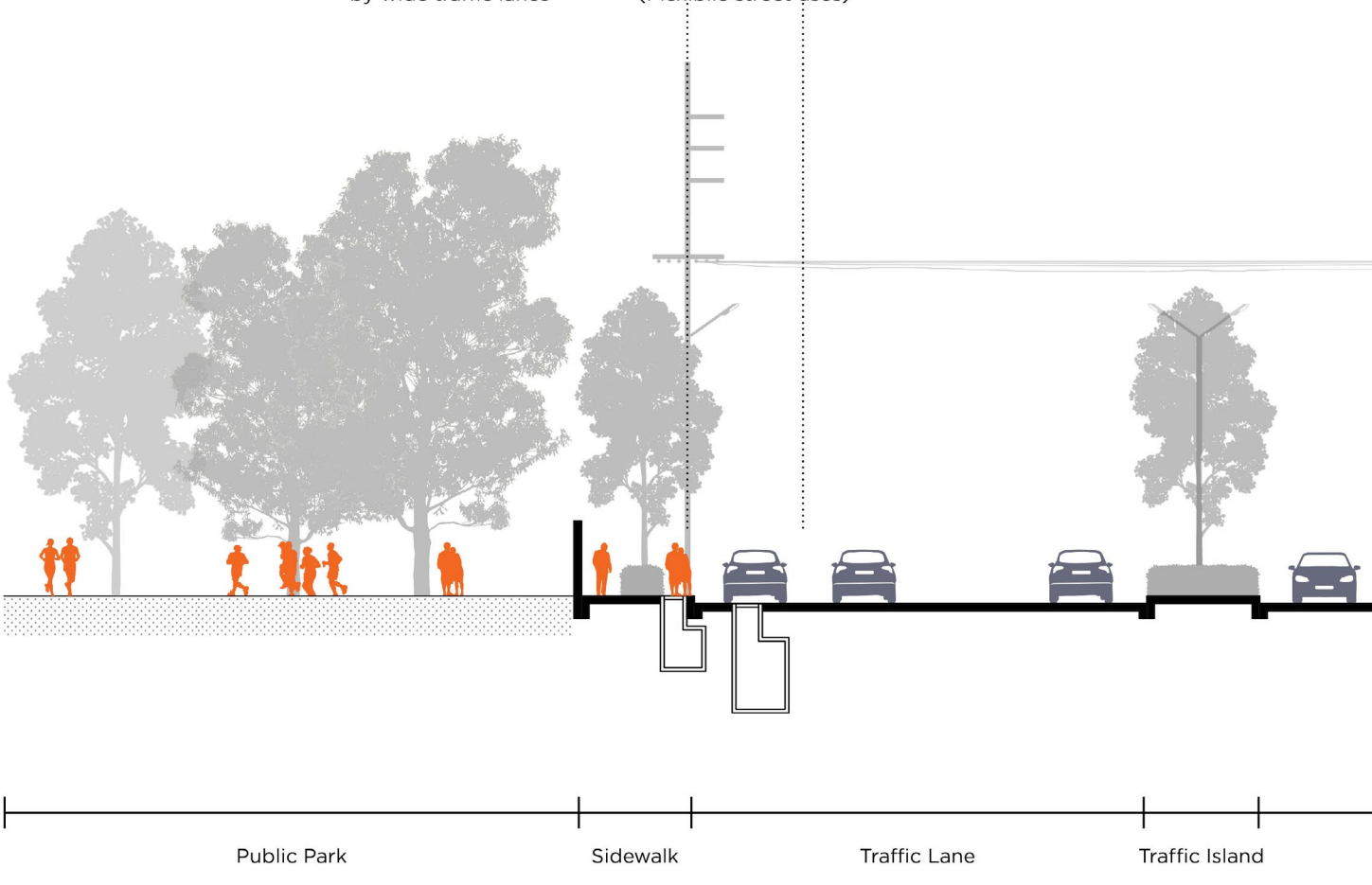


Disconnection of
social & ecology system
by wide traffic lanes


Limited period
parking space
(Flexibile street uses)



Underground drainage of
mixed sewage and run-off



## Green Connector Route : Avenue

1 : 150

Isolated & unutilized
green space of traffic island

Limitation of
urban ecology by
public utility systems

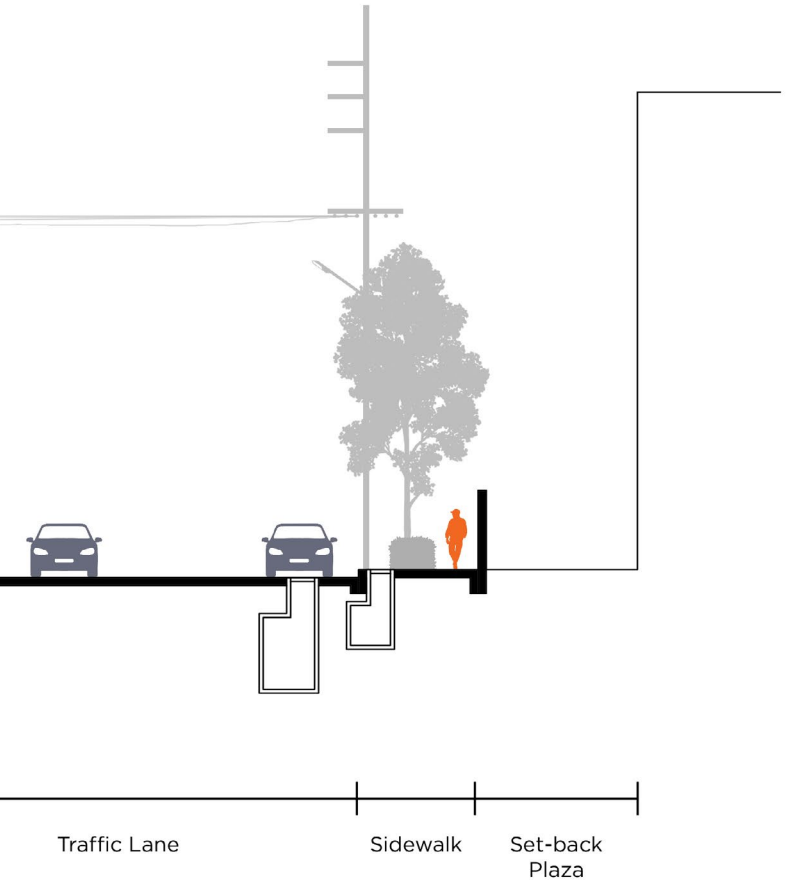
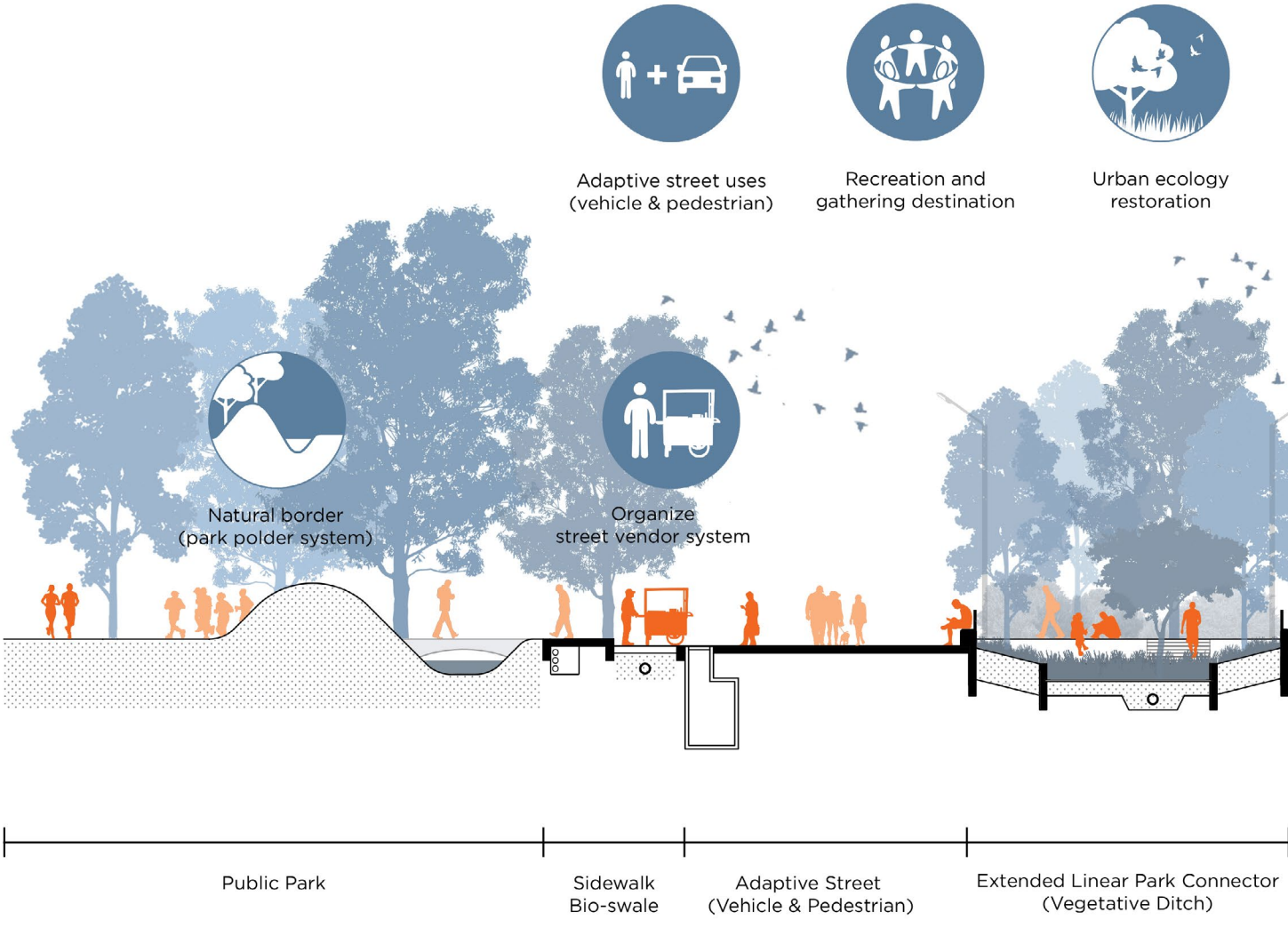



Fig.94 Existing Conditon of Green connector route
(Avenue 1) drawn by author


Adaptive street uses
(vehicle & pedestrian)
Recreation and
gathering destination
Urban ecology
restoration
Natural border
(park polder system)
Organize
street vendor system
Public Park
Sidewalk
Bio-swale
Adaptive Street
(Vehicle & Pedestrian)
Extended Linear Park Connector
(Vegetative Ditch)

## Life Corridor : Boulevard
## ( Convey + Tolerate )

The objective of the life corridor strategy is to create boulevards, the modification of existing avenues to enhance livelihood on street for both people and nature. Excessive traffic lanes and traffic islands are transformed to a flood tolerance linear park where excessive run-off or flood could visibly see, infiltrated and channeled to nearby urban storage of public park system. Mixed of vegetation create urban forest as sanctuary attracting wildlife, providing biodiversity to urban context. While Roads are redesigned with adaptable programs balancing uses between vehicle and people, creating public events or pedestrian street as new social platform. Food vendors are also allowed using the street in these occasions.

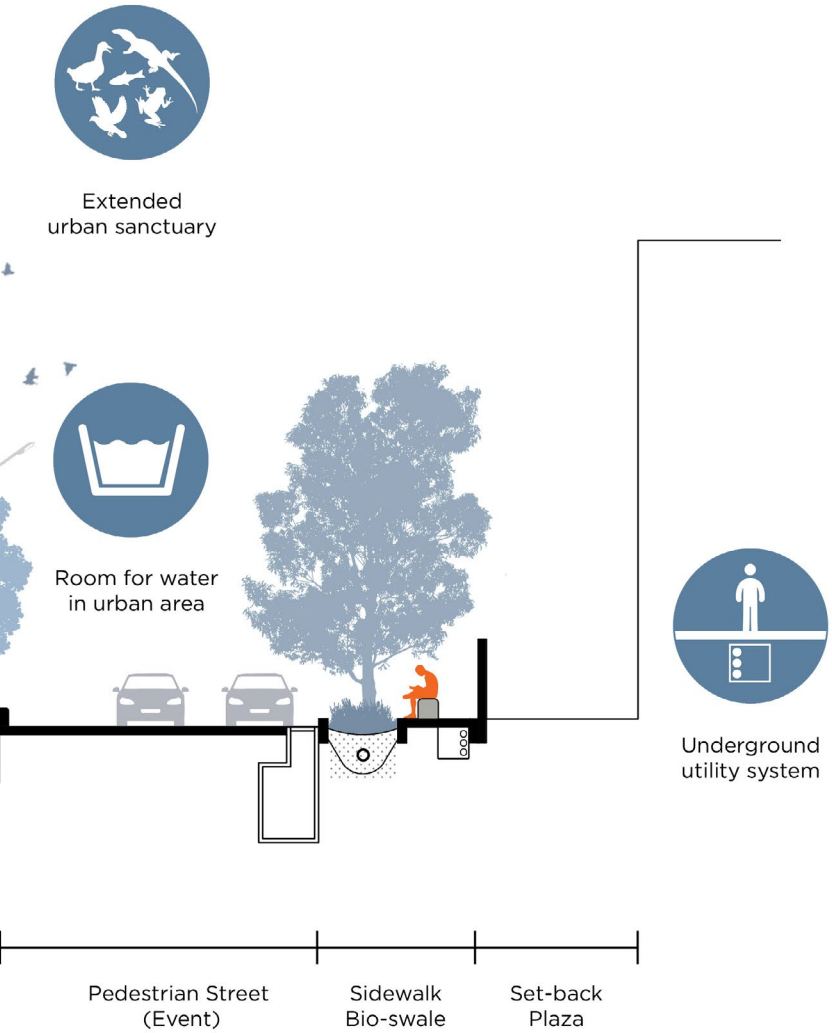



Fig.95 Life Corridor Solution (Boulevard 1)
drawn by author

Shaded tree

Samanea saman (Jacq.)

Deciduous

Cassia fistula L.

Scent

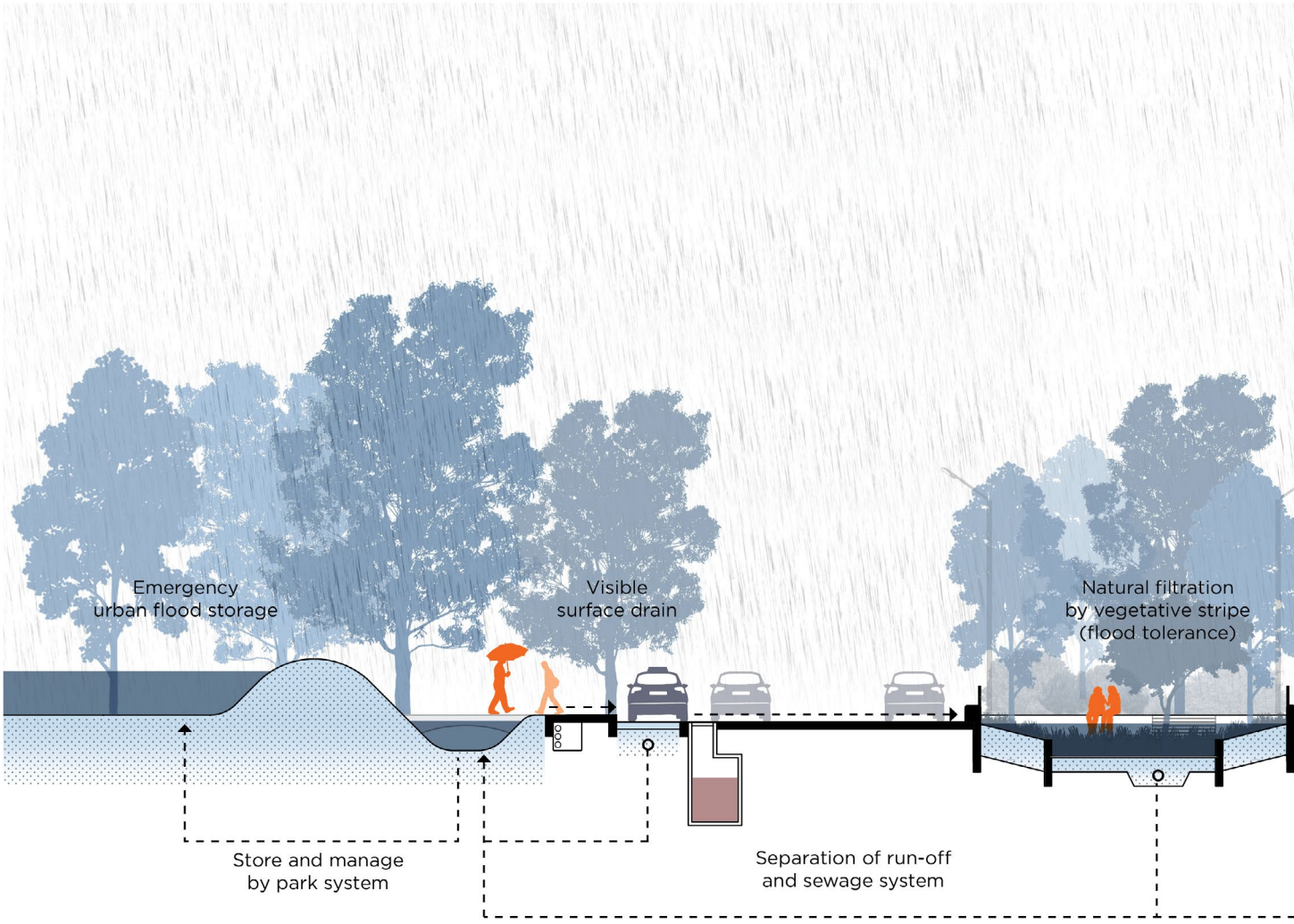
Shorea roxburghii G.Don

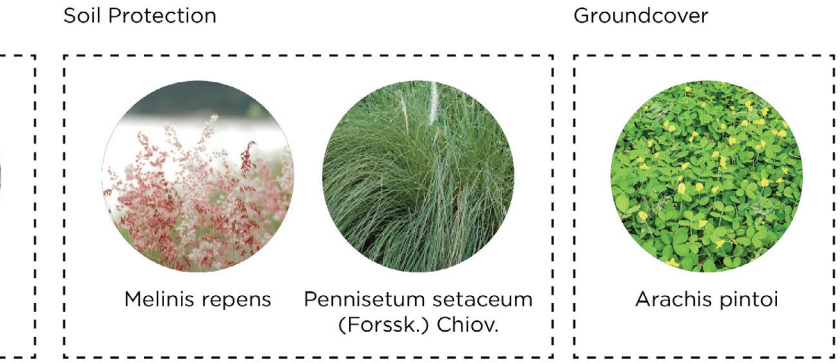
Millingtonia hortensis

Attractive to Widelife

Flacourtia rukam

Achyranthes aspera L.





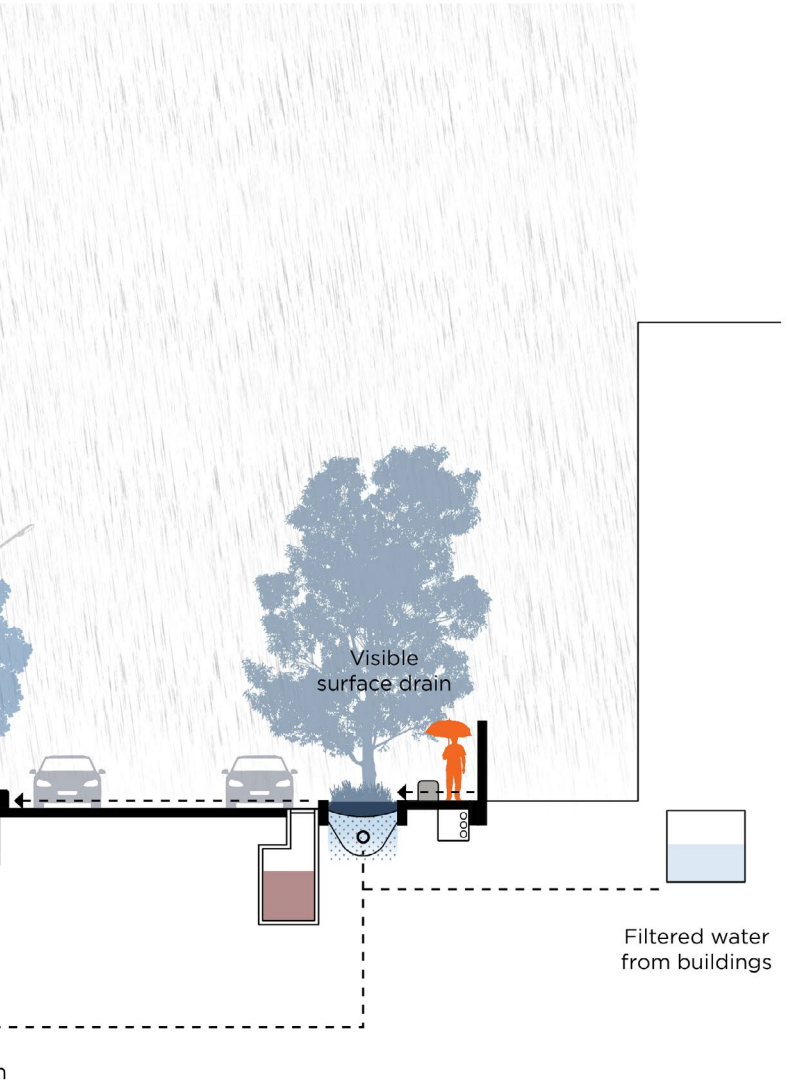
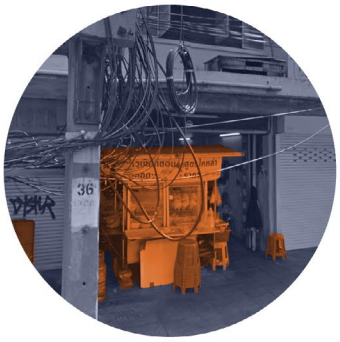




Fig.96 Life Corridor Solution (Boulevard 1)
drawn by author

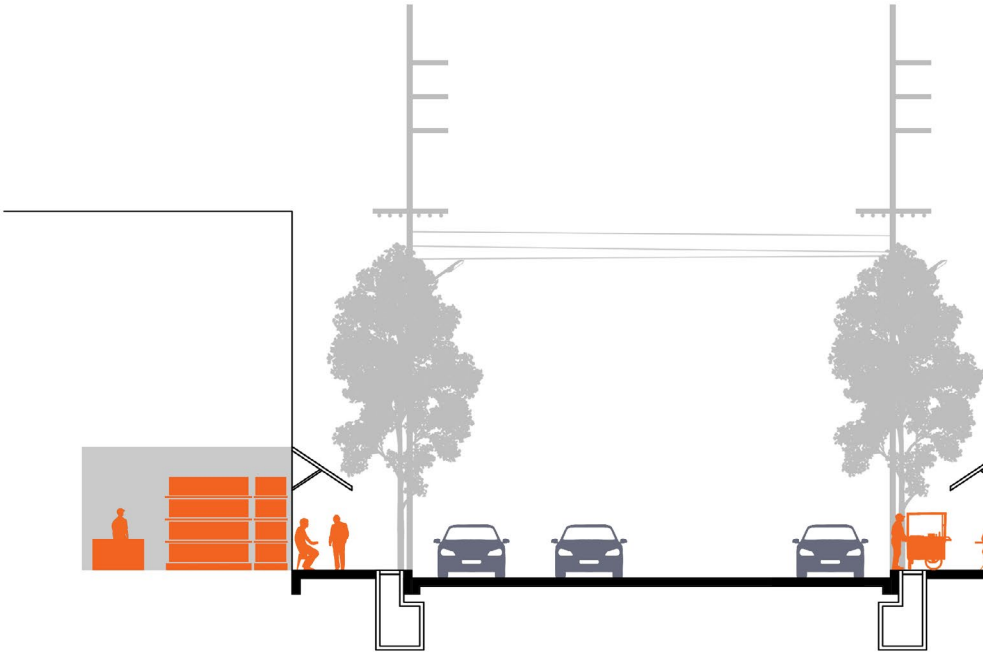
Fig.97 Existing Condition of Green Connector Route (Avenue 1) drawn by author

Fig.98 Life Corridor Solution
(Dry Condition Boulevard 1) drawn by author

Fig.99 Life Corridor Solution
(Wet Condition Boulevard 1) drawn by author



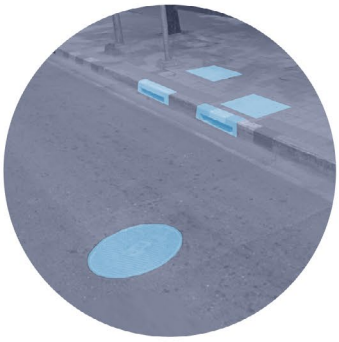
Extended use of sidewalk space
for Informal street economy



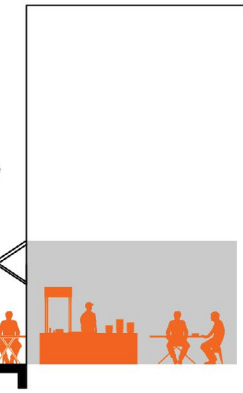
## Green Connector Route : Avenue

1 : 150

Limitation of
urban ecology by
public utility systems

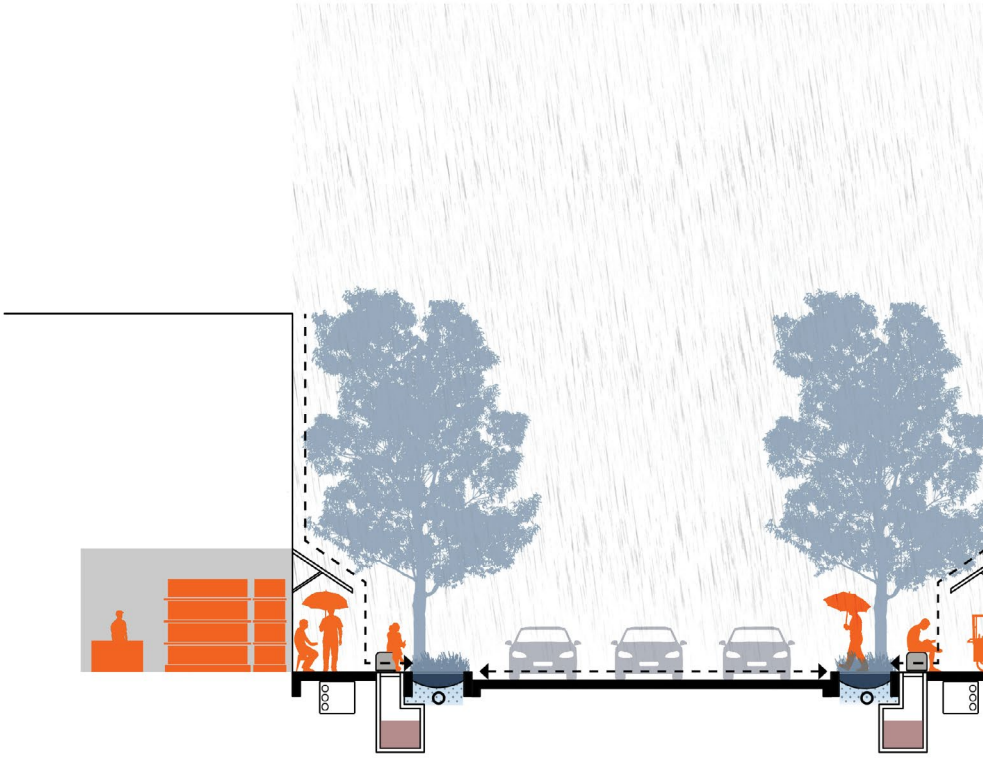


Underground drainage of
mixed sewage and run-off



k

Fig.100 Existing Conditon of Green connector route
(Avenue 2) drawn by author



Sidewalk
Bio-swale

Traffic Lane

Sidewalk
Bio-swale

Life Corridor : Boulevard
( Convey + Tolerate )

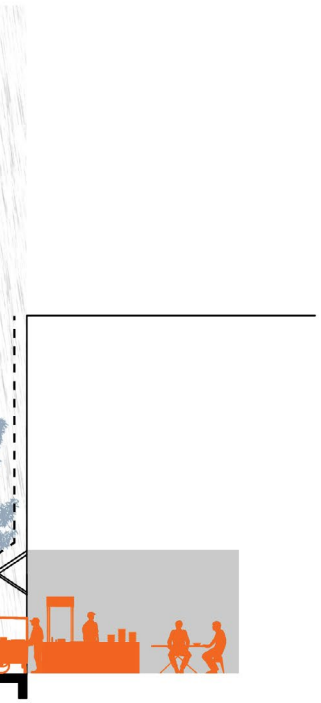
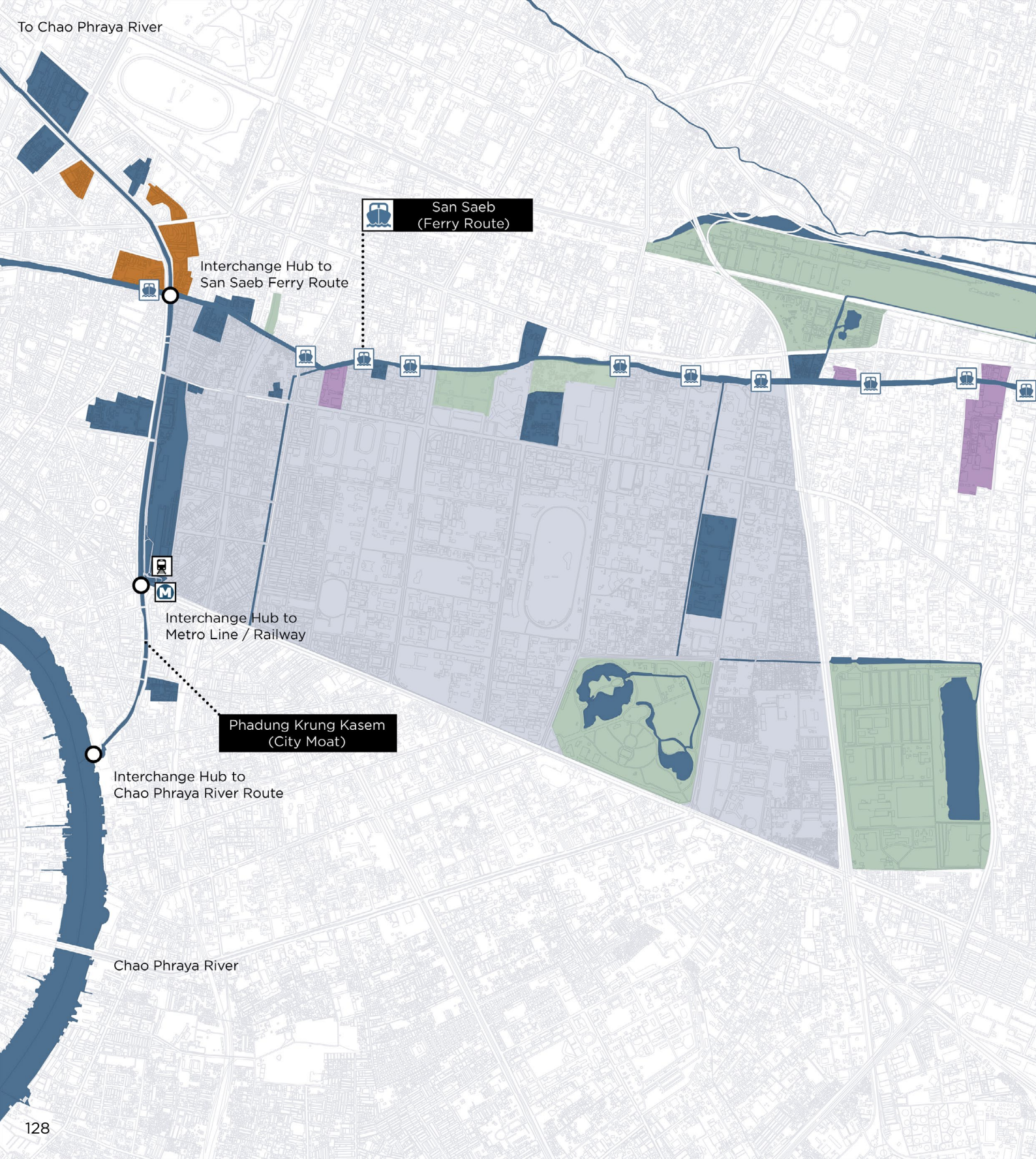


Fig.101 Life Corridor Solution (Boulevard 2)
drawn by author


To Chao Phraya River
San Saeb
(Ferry Route)
Interchange Hub to
San Saeb Ferry Route
Interchange Hub to
Metro Line / Railway
Phadung Krung Kasem
(City Moat)
Interchange Hub to
Chao Phraya River Route
Chao Phraya River

Recreational Green Space

Institution (Temple & Embassy)

Educational Institution

Low Rise Commercial (Local Market)

# Blue Connector Route : Life Corridor

As same as the avenues, the existing blue connector routes are treated and designed without social and ecology qualities, as drainage canals mainly function to get rid of water from the urban area, while the development of flood dikes create a clear border, separating water from surrounding life inland. Traditional water-related cultures are lost by the process.


Connection with Temple Green Space

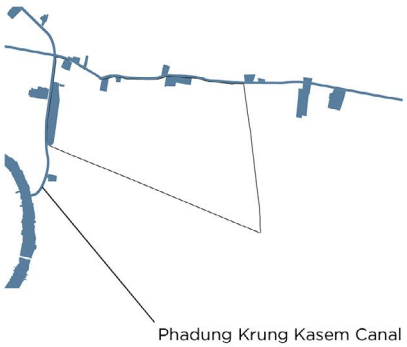

Connection with Transportation Transit


Connection with Local Market

0 250 500 1000
m.

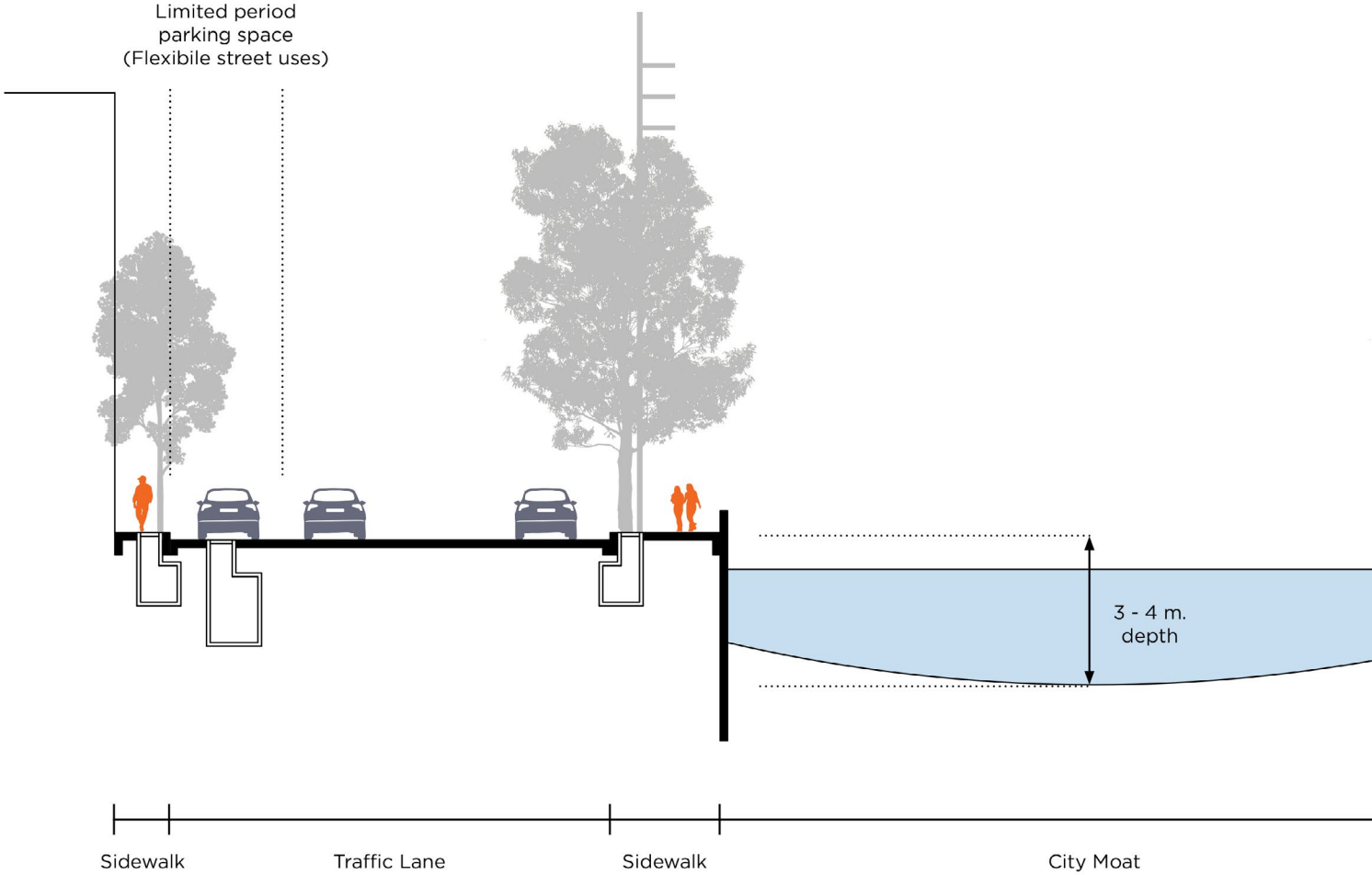
Fig. 102

Fig.102 Blue Connector Route and Urban Flow drawn by author
Fig.103 Boromniwat Temple (Rujirat J., 2019)
Fig.104 Bangkok Railway Station (The cloud, 2017)
Fig.105 Phadung Krung Kasem Local Market photo by author




Lost of water-related traditional uses
(Transportation and Water Market )


Limited period
parking space
(Flexibile street uses)



## Blue Connector Route : Drainage Canal (City Moat)

1 : 150

Difficulty of accessibility
wide traffic lane (car-based)

Disconnection with water
(social & ecology system)

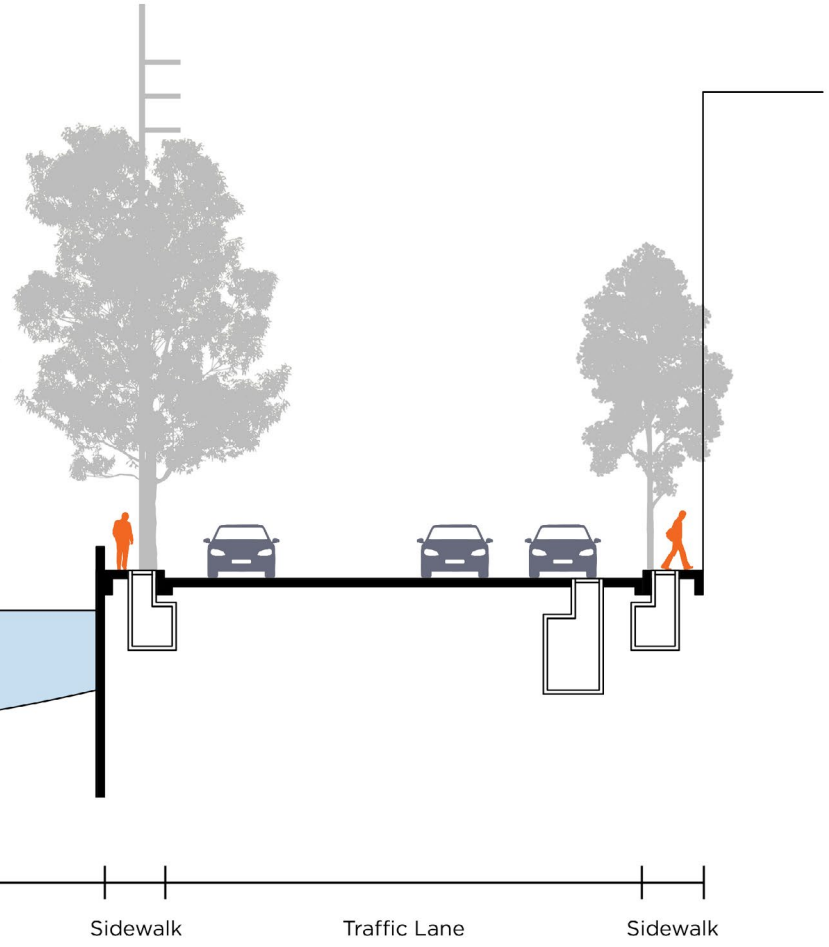
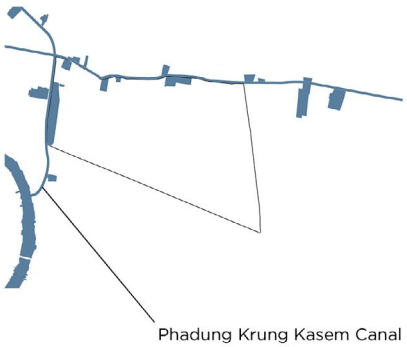
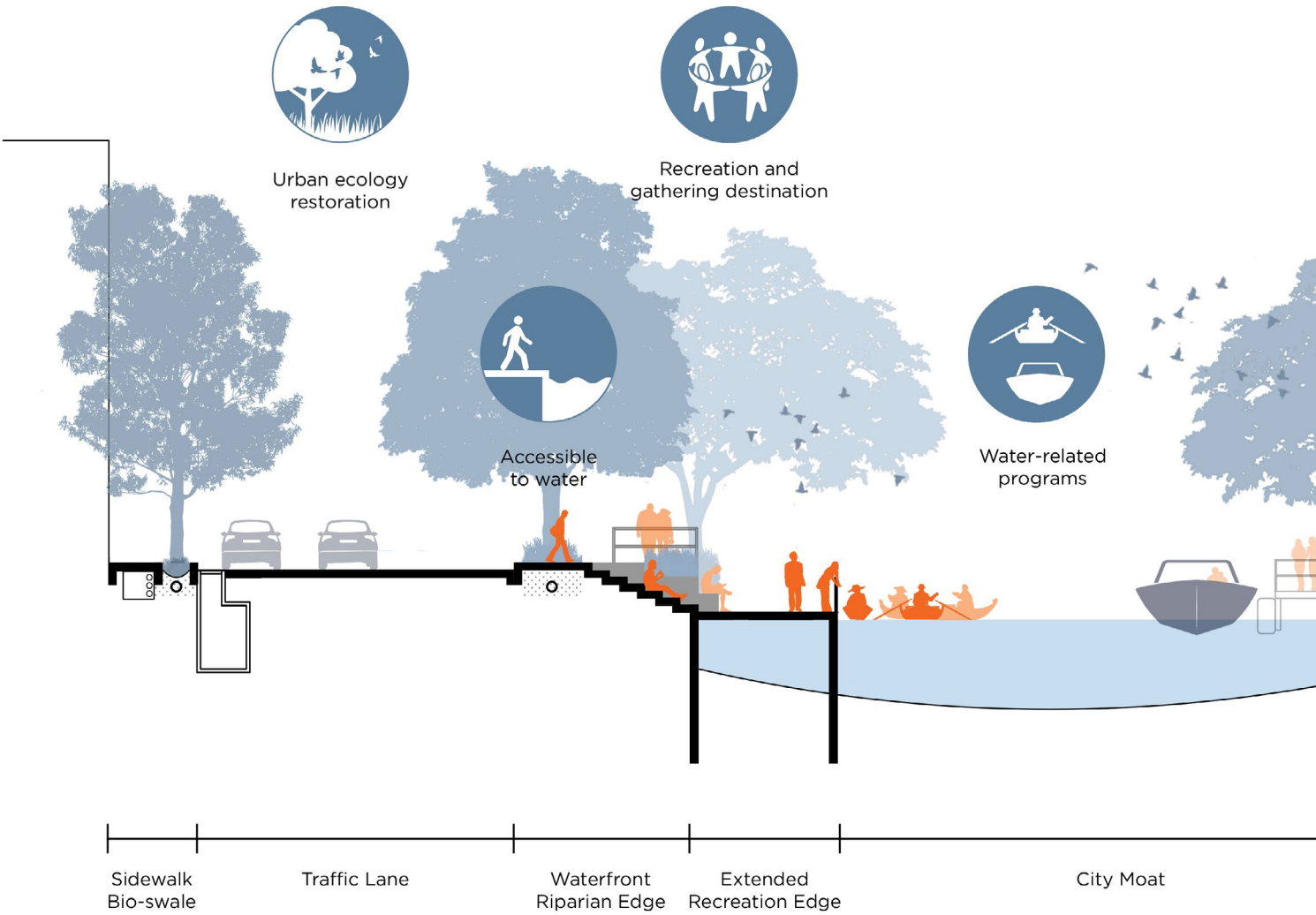



Fig.106 Existing Conditon of Blue connector route
(Drainage canal 1) drawn by author


Phadung Krung Kasem Canal


Urban ecology restoration
Recreation and gathering destination
Accessible to water
Water-related programs
Sidewalk Bio-swale
Traffic Lane
Waterfront Riparian Edge
Extended Recreation Edge
City Moat

## Life Corridor : Ecological Canal
## ( Convey + Tolerate )

Life corridor focus to transform the existing drainage network into ecological canal reconnecting people with water once again. The principles are mutual for both city moat and ferry route as modification of water edges is the most crucial, allowing recreational activities and natural restoration process to occur. Flood tolerance structures and floating platforms take people closer to water as waterfront provide spaces for water market and ferry transit, managing uses in relation with changing water levels.

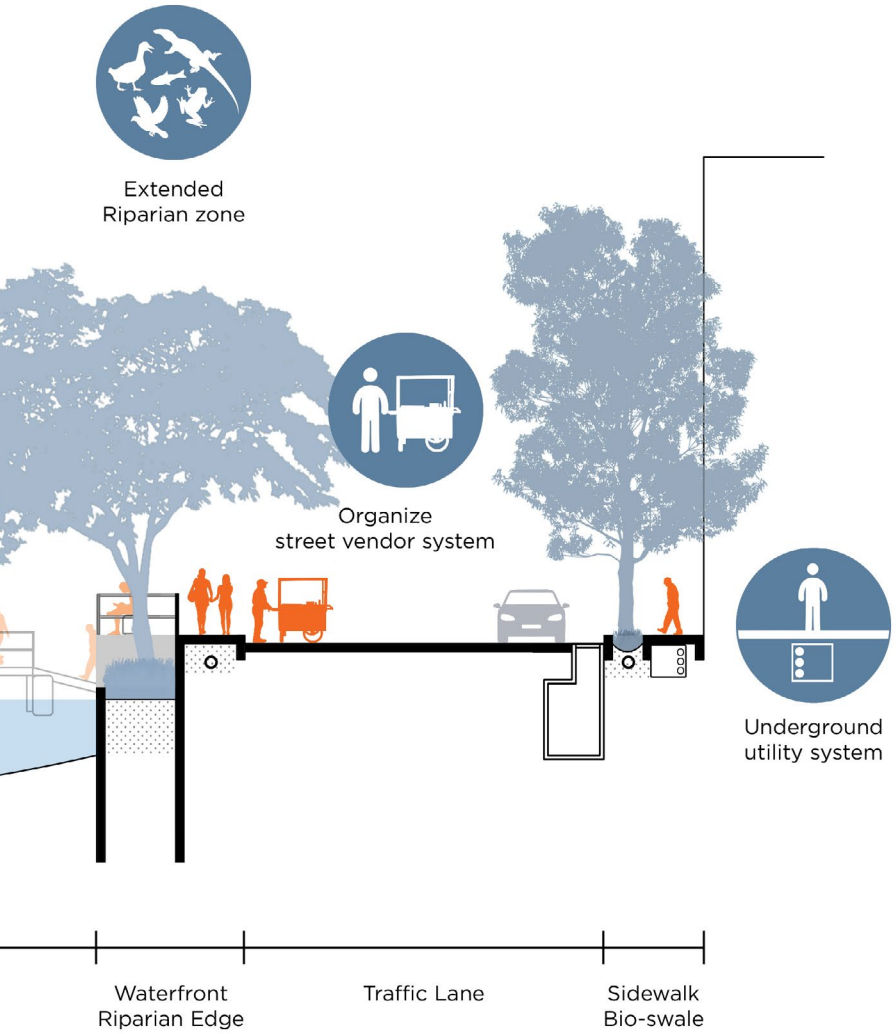



Fig.107 Life Corridor Solution (Ecological canal 1) drawn by author

Canalside - Flood Tolerance + Shaded Tree

Tamarindus indica

Ficus religiosa

Salix babylonica

Elaeocarpus hygrophilus Kurz

Water Filtration Edge

Lepironia articalata

Cyperus papyrus

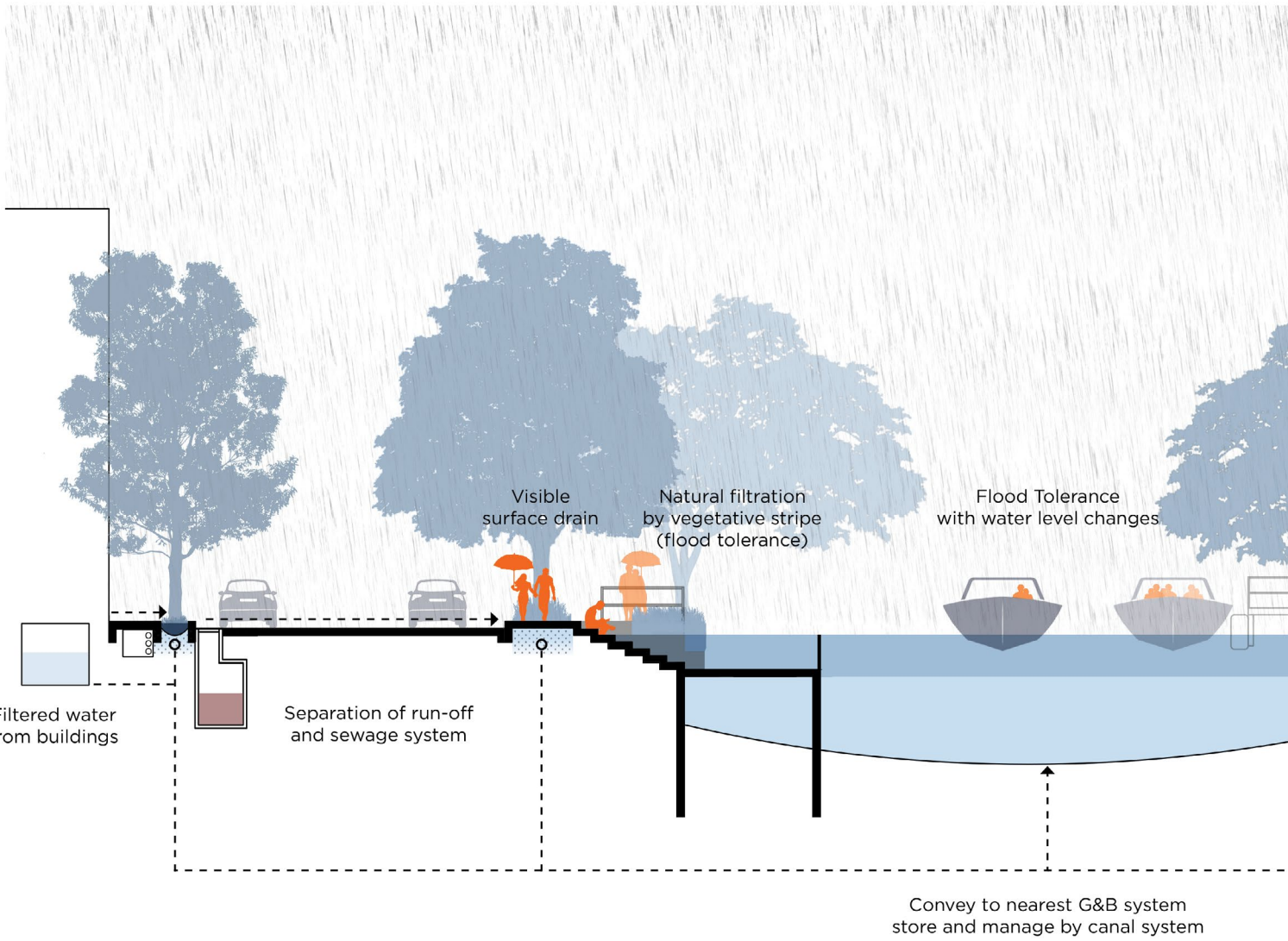
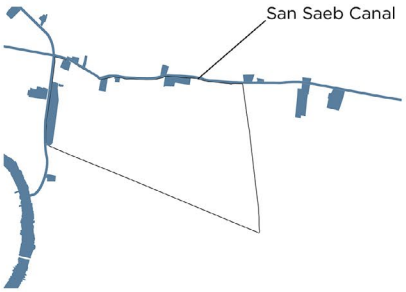
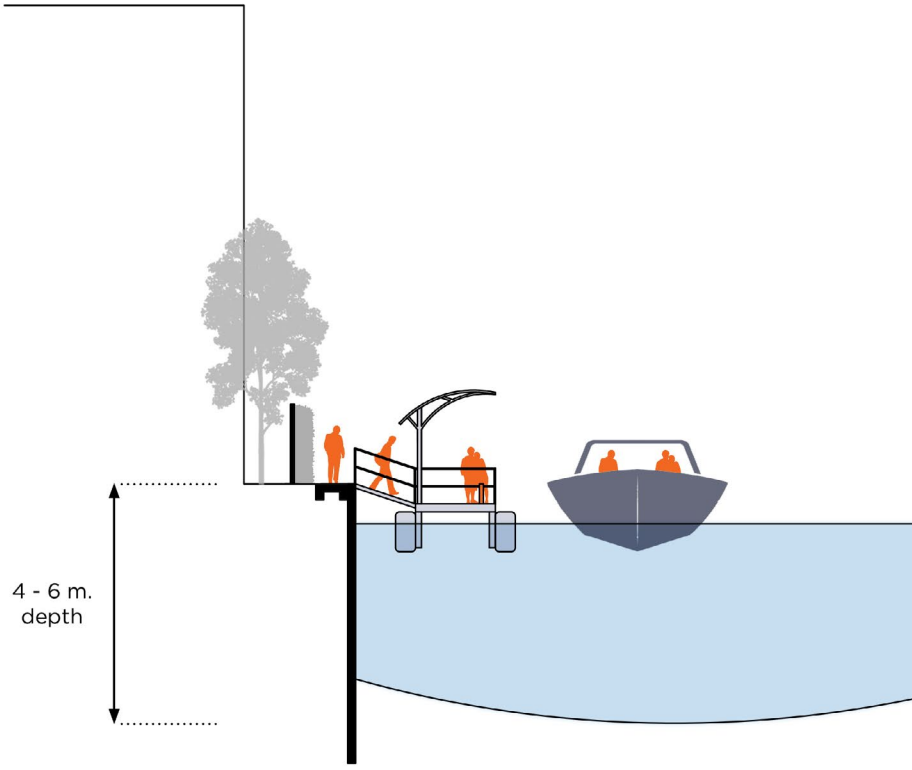



Fig.108 Life Corridor Solution (Ecological canal 1)
drawn by author



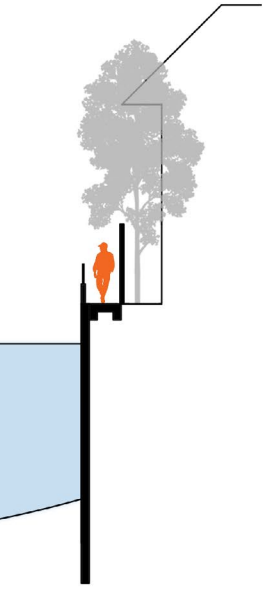

Narrow typical pathway
connector between station



## Blue Connector Route : Drainage Canal (Ferry Route)

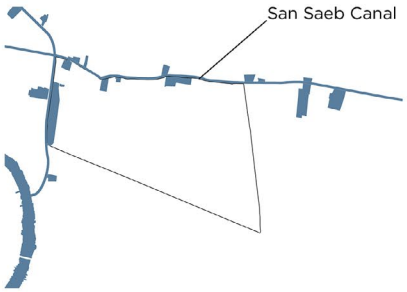
1 : 150

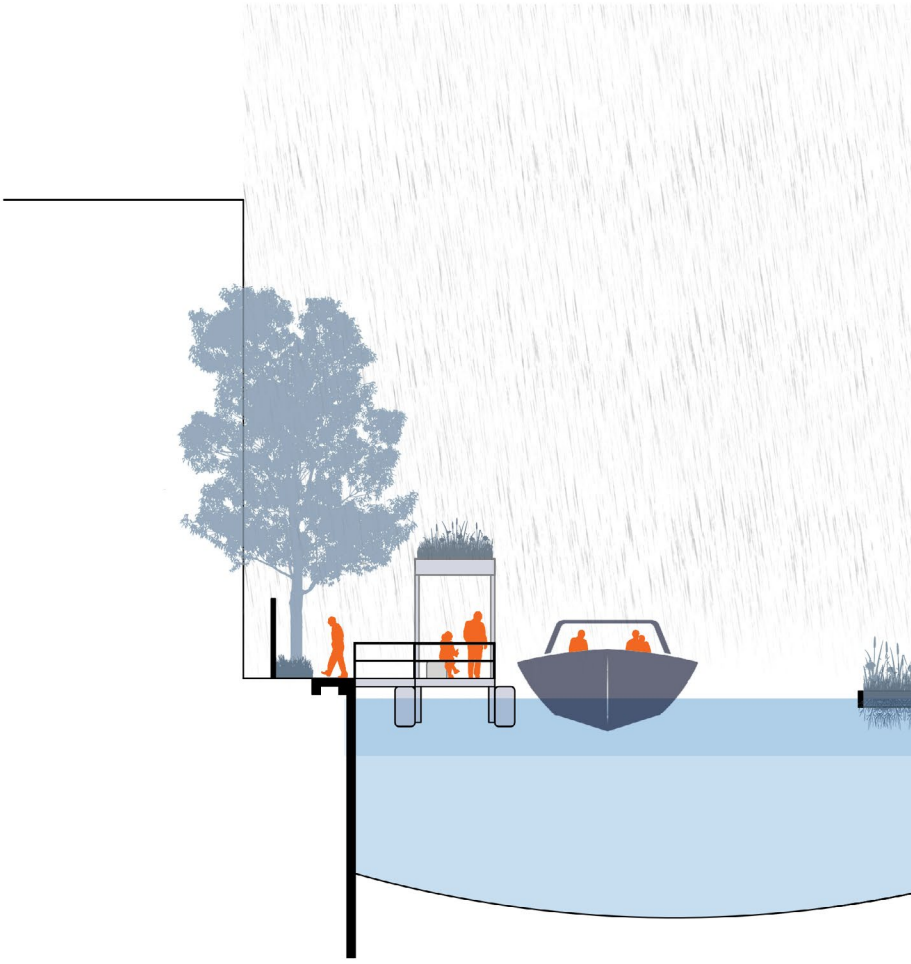
Disconnection of pathway and green space
related to surrounding landuse



Pathway

Fig.112 Existing Conditon of Blue connector route
(Drainage canal 2) drawn by author



Varies 16 - 30 m.

Pathway

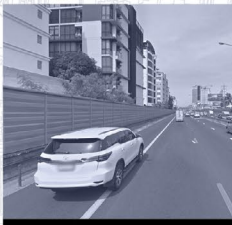
Transportation canal

Life Corridor : Ecological Canal
( Convey + Tolerate )

Extended
Ecological Edges
(Potential Public Areas)

Fig.113 Life Corridor Solution (Ecological canal 2)
drawn by author

Typical Elevated Highway
(with space underneath)



On-ground Toll
(disconnect from sur

Low Rise Commercial (Mixed Use)

Institution (temple)

# High Speed Traffic Route : Underline Park

Overlaid mega structures of highway over the existing urban contexts create several unutilized spaces underneath. Unlike the busy and chaotic traffic on the elevated level, several spaces are left abandoned with occupations of local informal activities from parking services to informal street economy or the uses as individual storage spaces, creating unsafe and unfriendly atmosphere. The undeveloped spaces could be considered as intangible border separating the communities of both sides.


Fig. 115

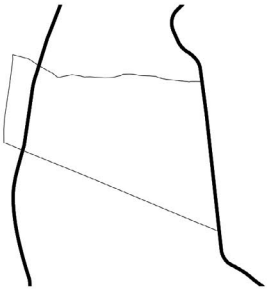

Fig. 116

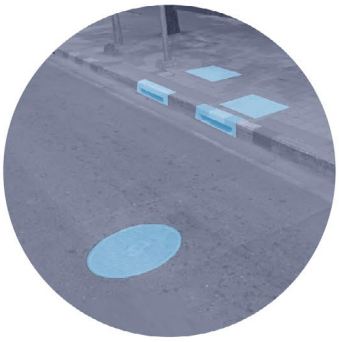
Local Mixed-use Shophouse


Fig. 114

0 250 500 1000
m.

Fig.114 Highway Route and Urban Flow drawn by author
Fig.115 Sam Yan (Sam Yan's Congee, 2017)
Fig.116 Sam Yan (Sam Yan's Congee, 2017)

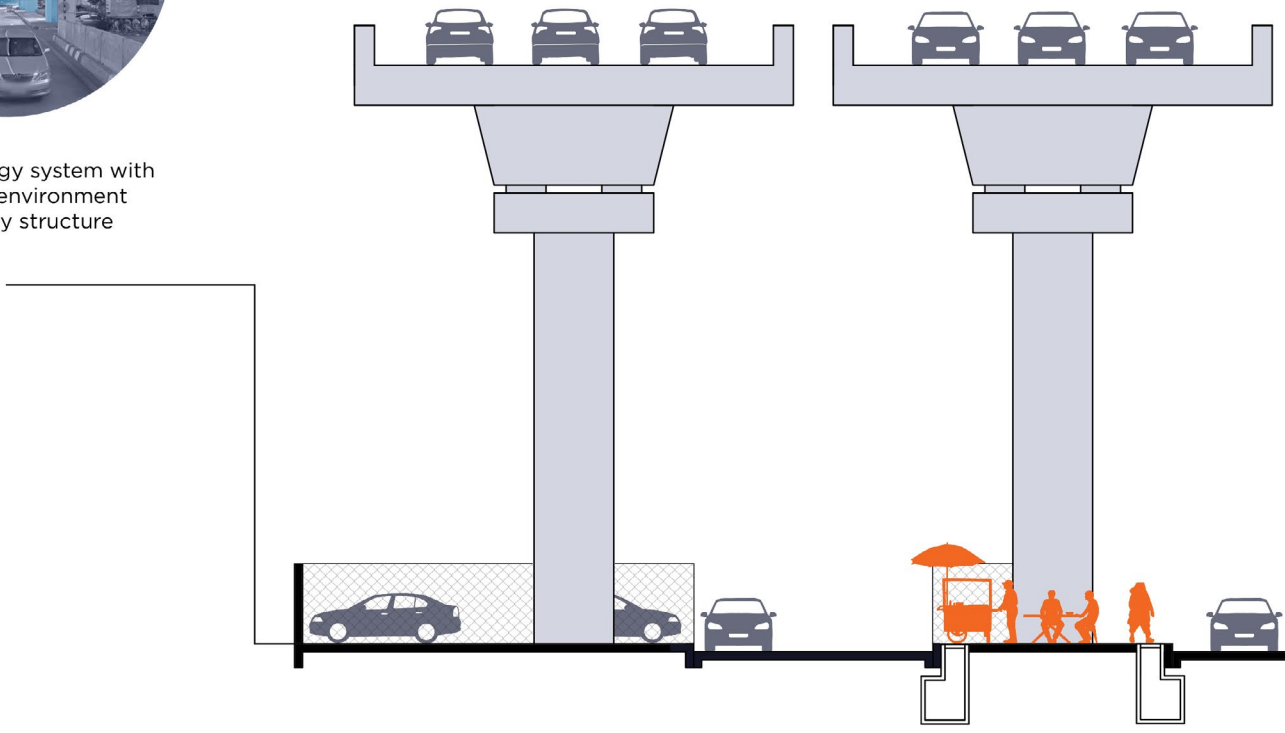




Underground drainage of
mixed sewage and run-off

Unutilized area a
locals underne

Lack of ecology system with
unfriendly environment
of highway structure



20 - 40 m. (varies to highway structure)

Parking Space / Local Street Food Vendor

Ma

## High Speed Traffic Route : Highway

1 : 150

and misused activities by
eath highway structure

Seperation from
surrounding communities

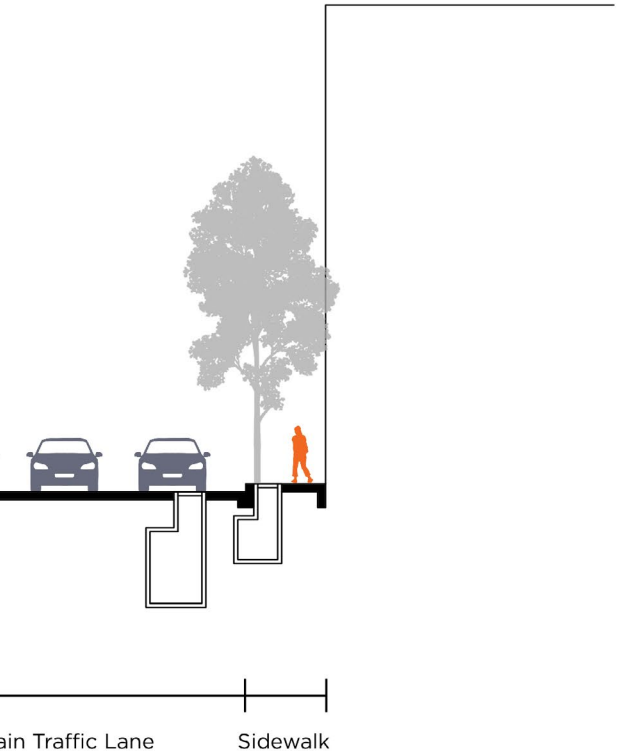
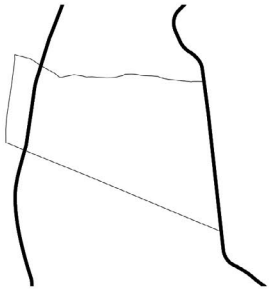
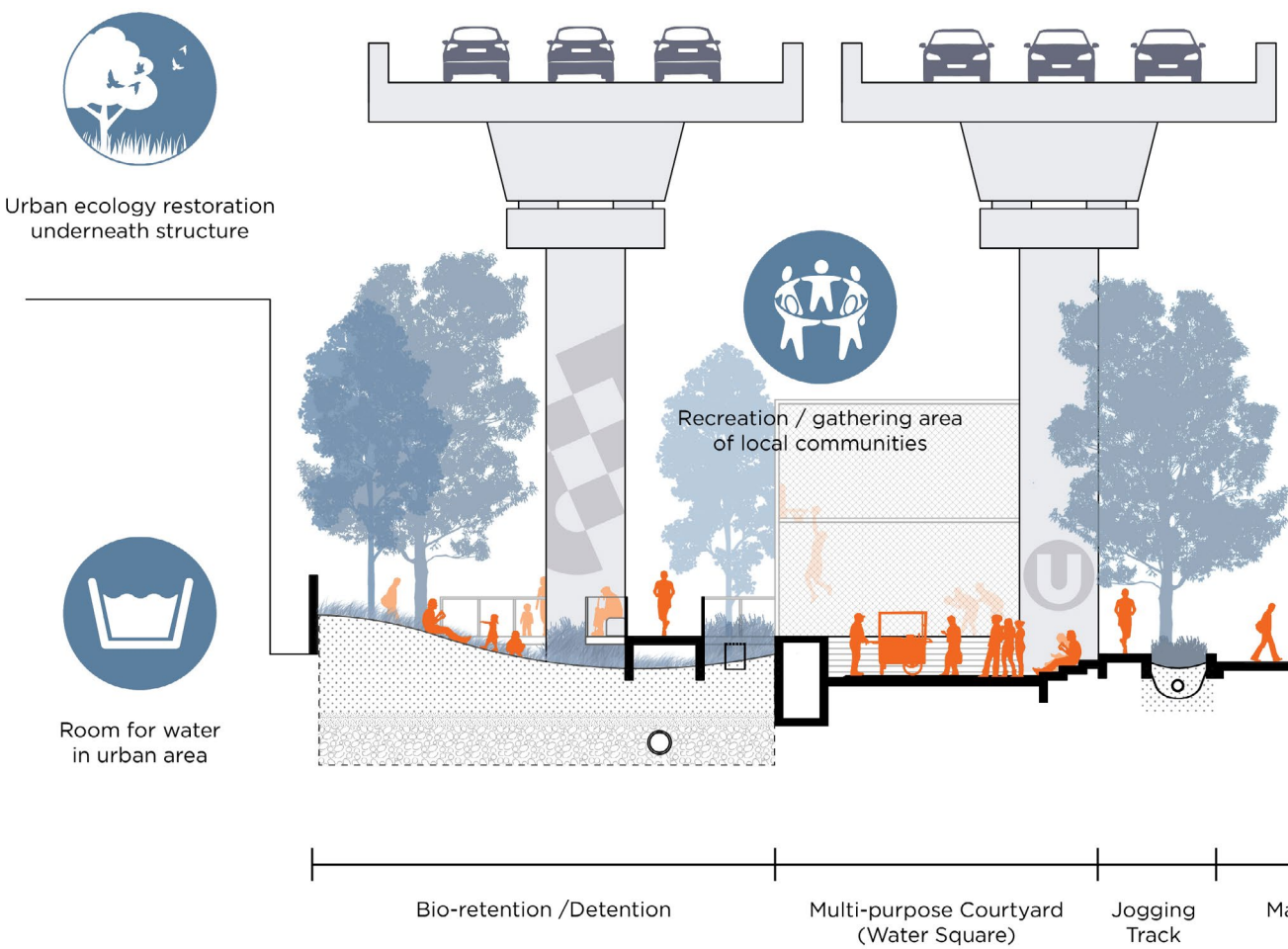
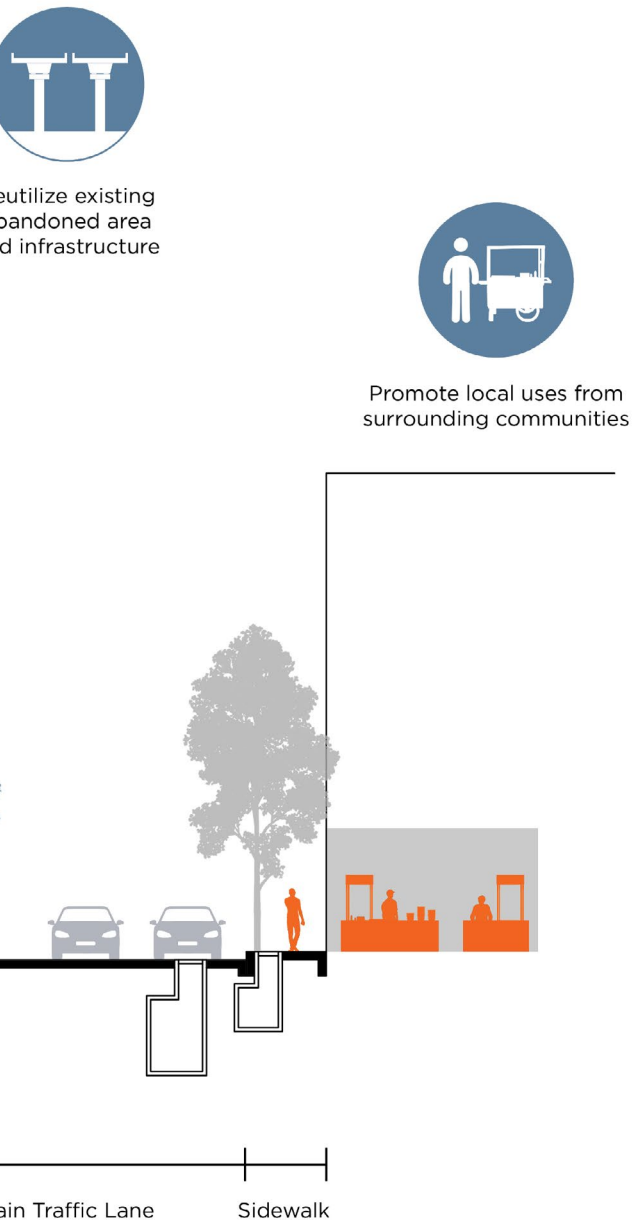



Fig.117 Existing Condition of Highway
drawn by author




Urban ecology restoration
underneath structure
Recreation / gathering area
of local communities
Room for water
in urban area
Bio-retention /Detention
Multi-purpose Courtyard
(Water Square)
Jogging
Track

## High Speed Traffic Route : Underline Park
## ( Store + Tolerate )




The principle of underline park is to transform the unutilized spaces under the highway structures into multi-purpose community parks for daily recreation inducing social participation amongst the inhabitants from surrounding areas. The park integrate flood management strategies of store and tolerance, allowing rooms for excessive run-off and water collected on highway inside the adaptive spaces of retention wetland and detention water square. The flexibility of space design allows local activities such as, sport fields, multi-purpose plaza, playground, local market, and event plaza during normal condition. While during rain, these spaces are transformed to urban ponds where water is stored both on surface and underground, primary filtered and purified with vegetation and engineering system, before the excessive capacities are drained out to the nearest urban drainage system. Meanwhile, people can still use the space for recreation and fishing under the structure shades.

Fig.118 Underline Park Solution drawn by author

Waterside - Flood Tolerance

Cerbera odollam

Lagerstroemia speciosa

Barringtonia acutangula

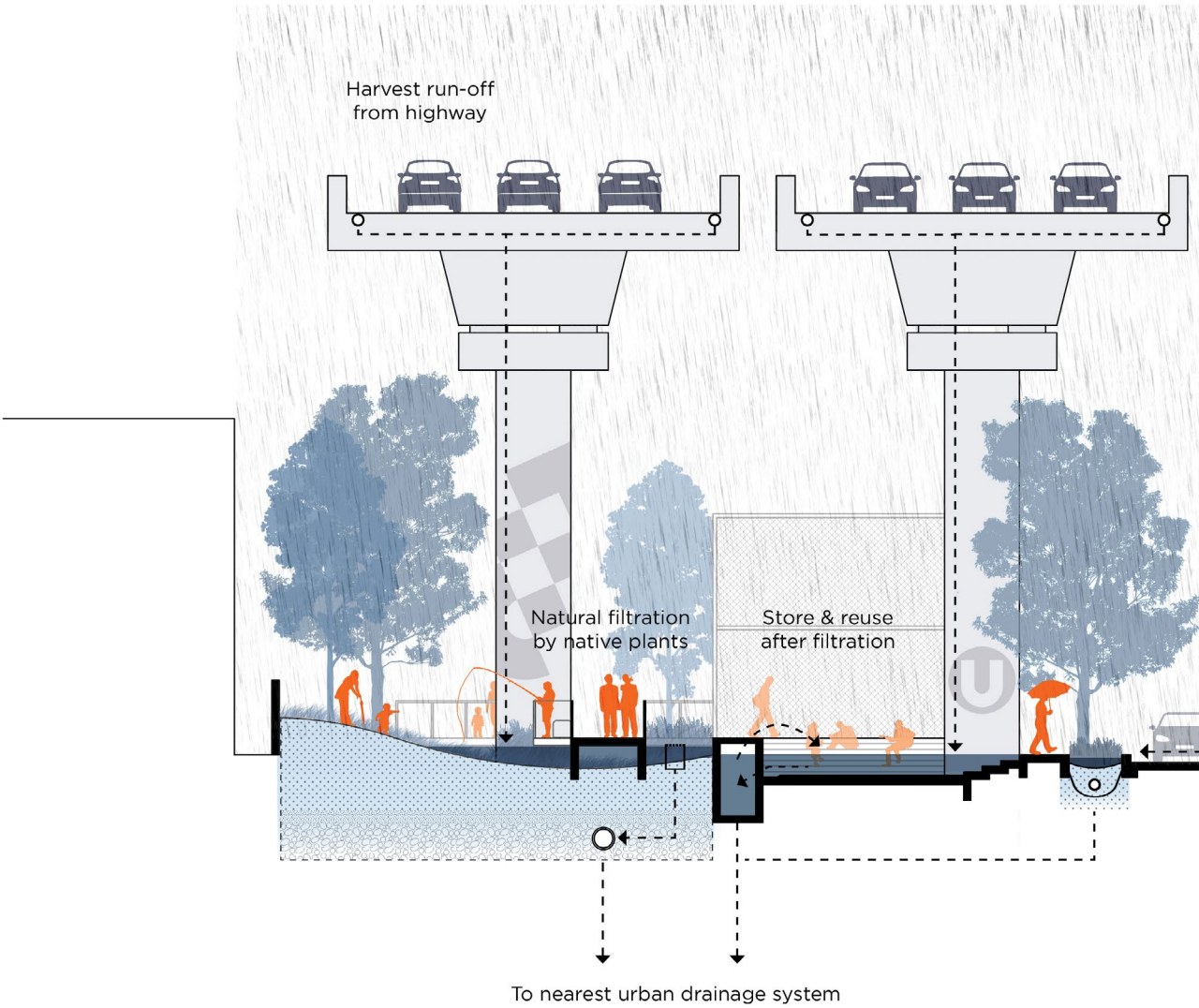
Wetland - Soil Protection

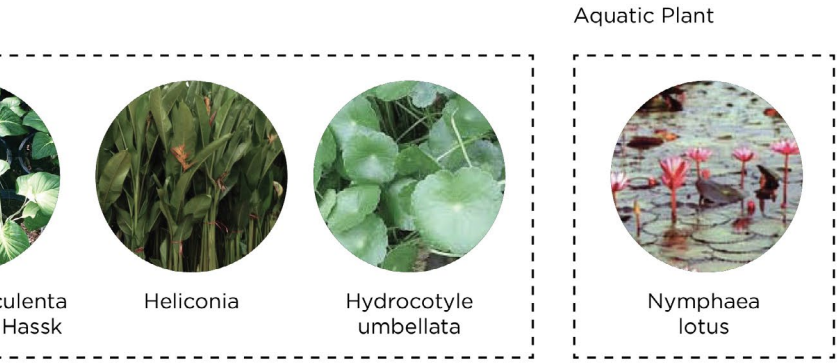
Cannaceae

Crinum asiaticum

Water Filtration

Colocasia esc
var. aquatilis





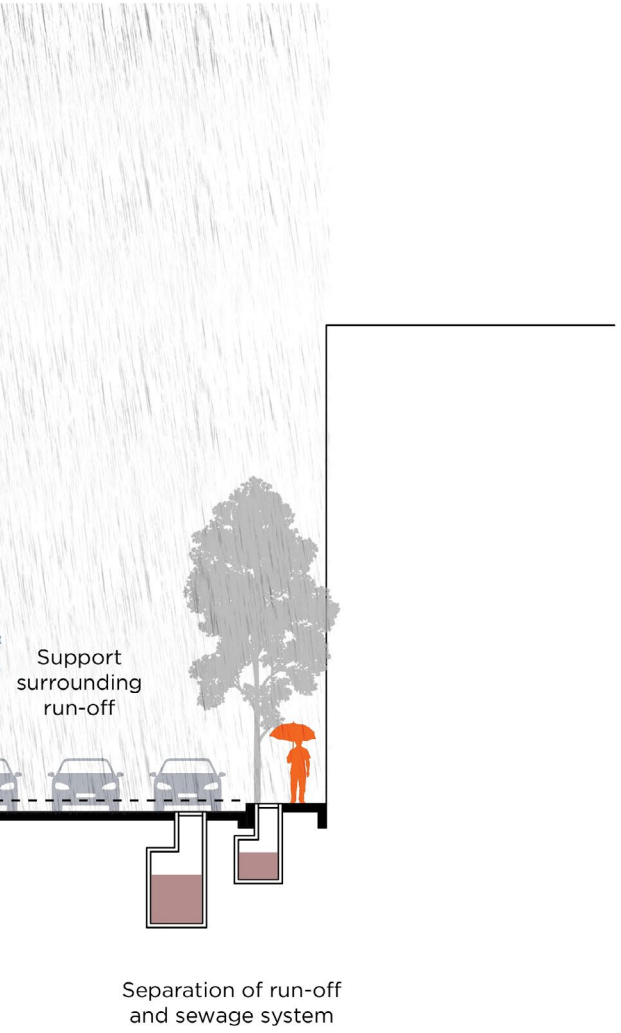




Fig.119 Underline Park Solution drawn by author


Benelli

Fig.120 Existing Condition of Unutilized Highway
drawn by author

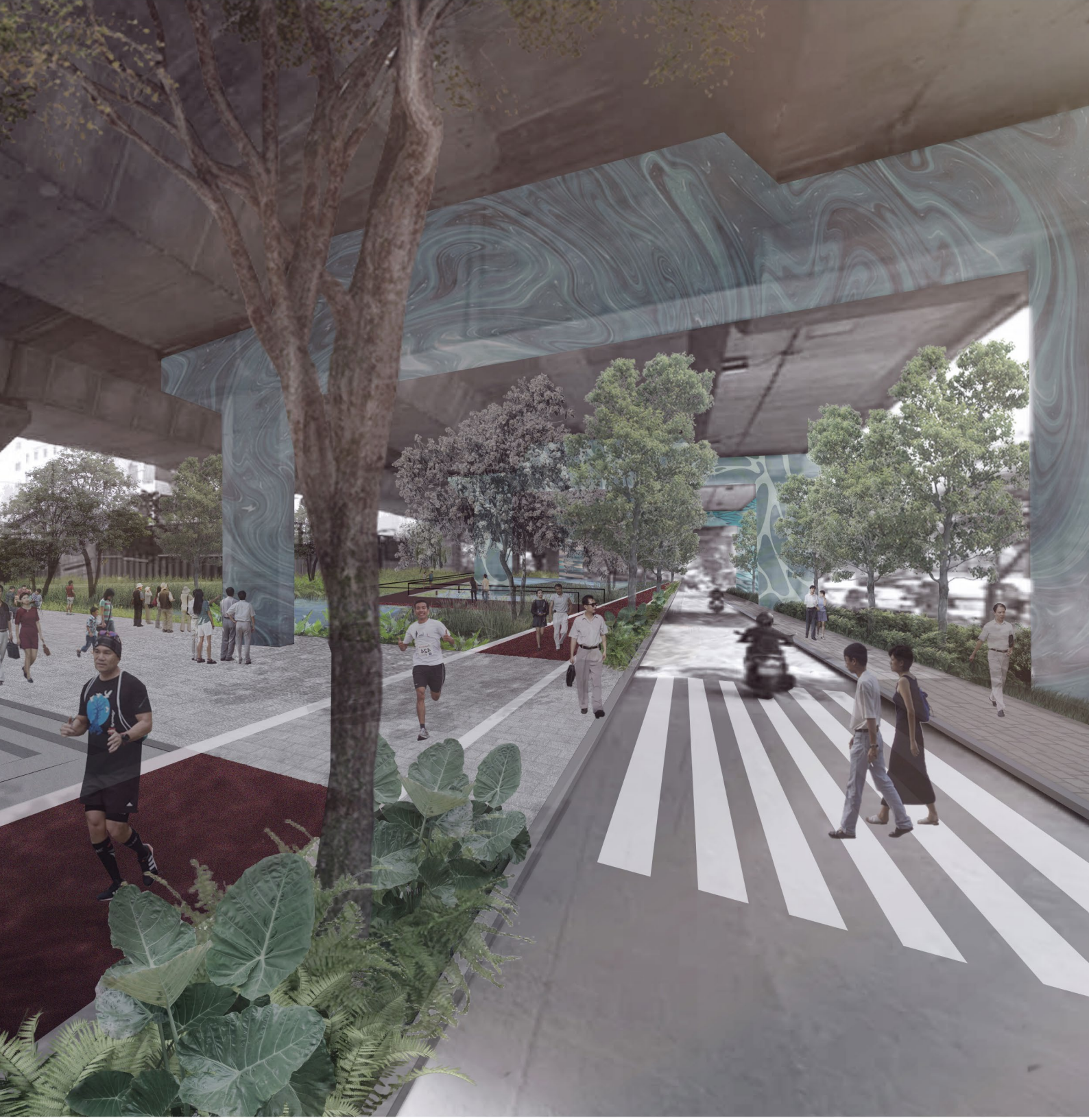
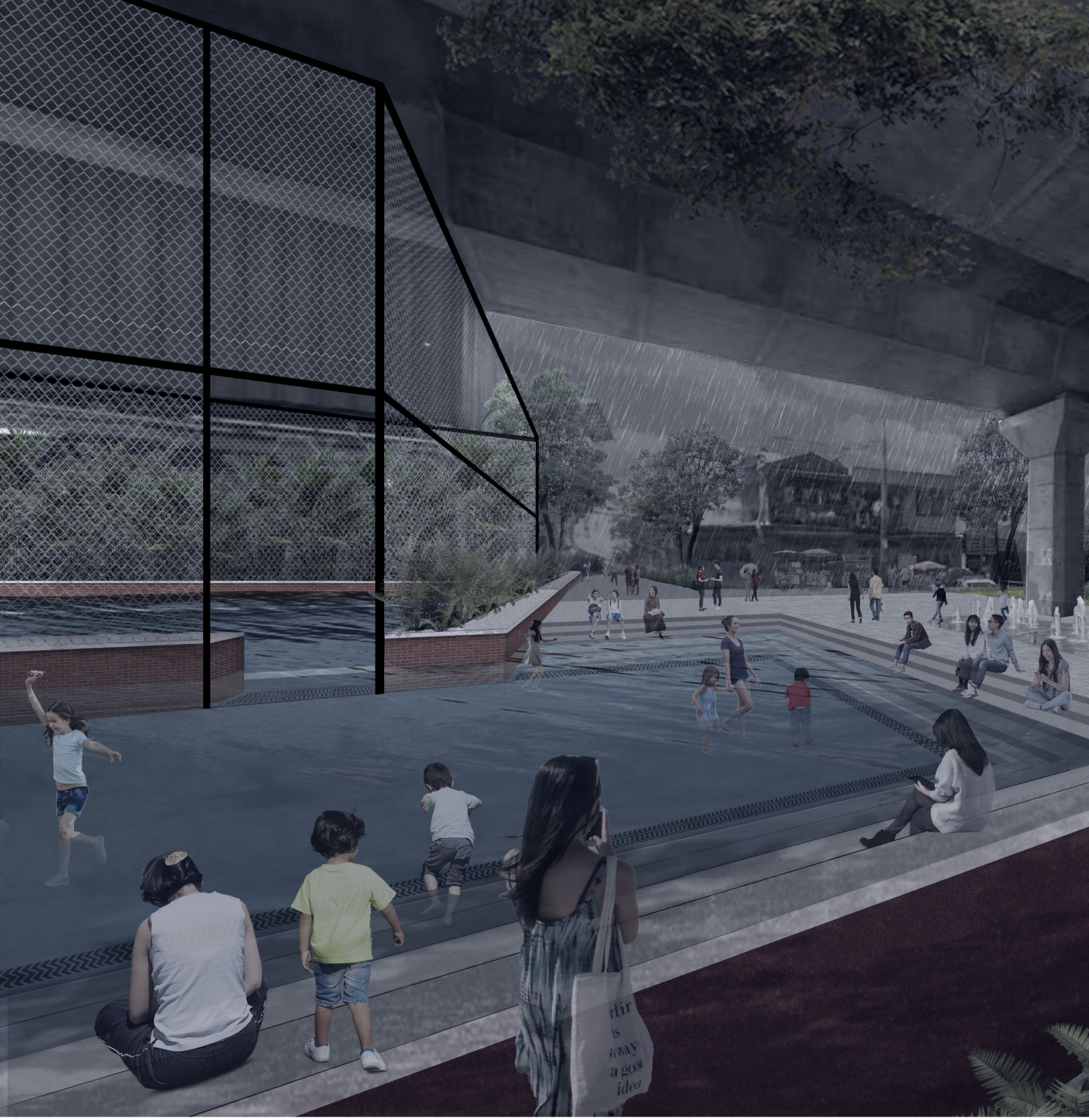


Fig.121 Underline Park Solution (Dry Condition)
drawn by author



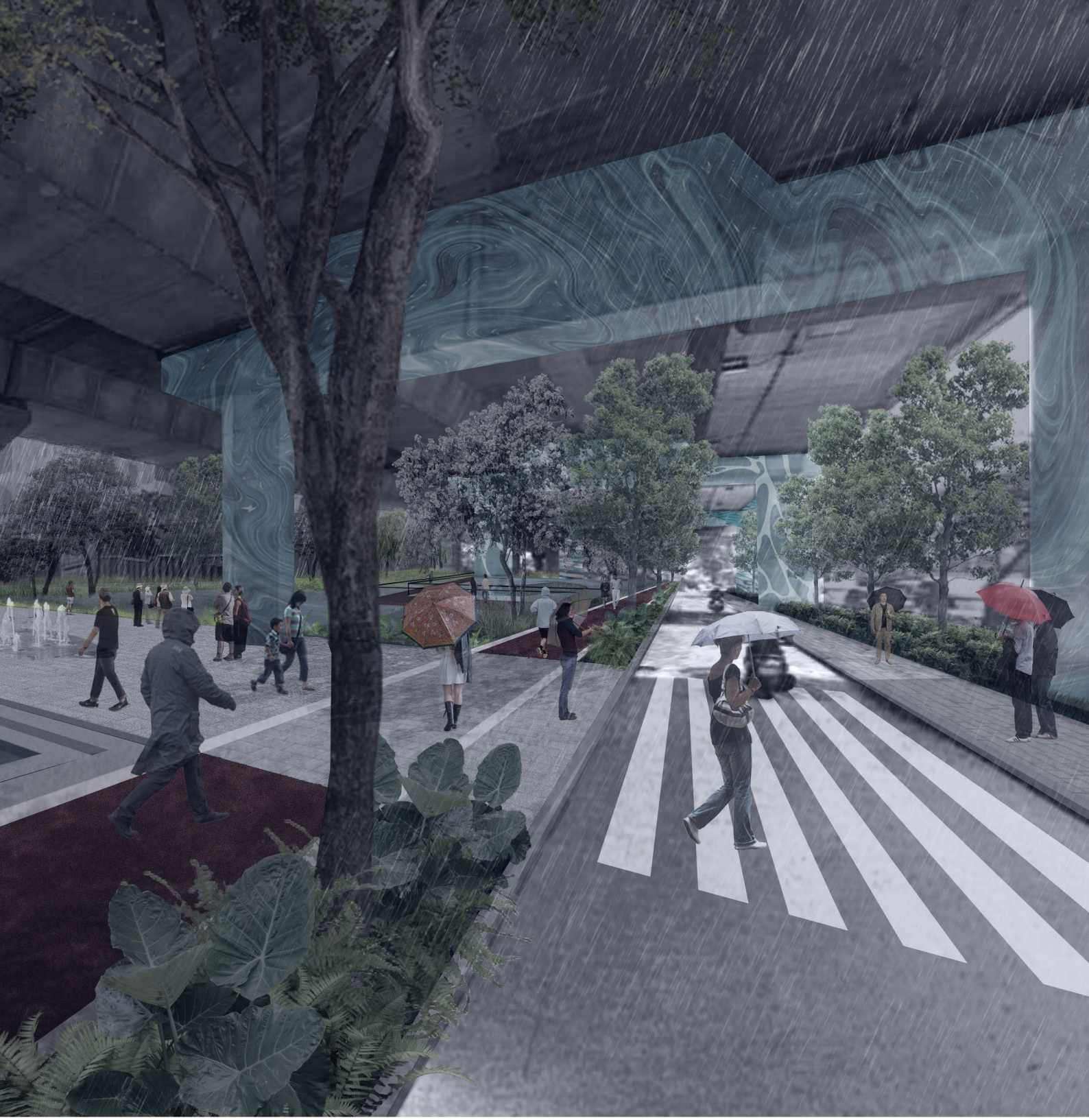


Fig.122 Underline Park Solution (Wet Condition)
drawn by author

Suan Luang Square
(Pedestrian friendly planning)

Siam Square
(Car-based planning)

Chulalongkorn University

Sam Yan
(Individual mixed-use shophouse)

Educational Institution

Low Rise Commercial (Mixed Use)

Crown Property of Chulalongkorn

# Slow Traffic Route : Soaked Community

Two different types of landuse with individual traffic management are selected as study areas, the institution model of Chulalongkorn university and the low-rise commercial model of Siam Square.

The secondary road systems inside the university provide a control of traffic within campus fence. Pedestrian walkways, bicycle lane and small traffic lanes are organized with adjacent green spaces and pocket plazas in different sizes.

Siam square is chosen from three different types of low-rise commercial project, as it is the current development model of car-based design in general.

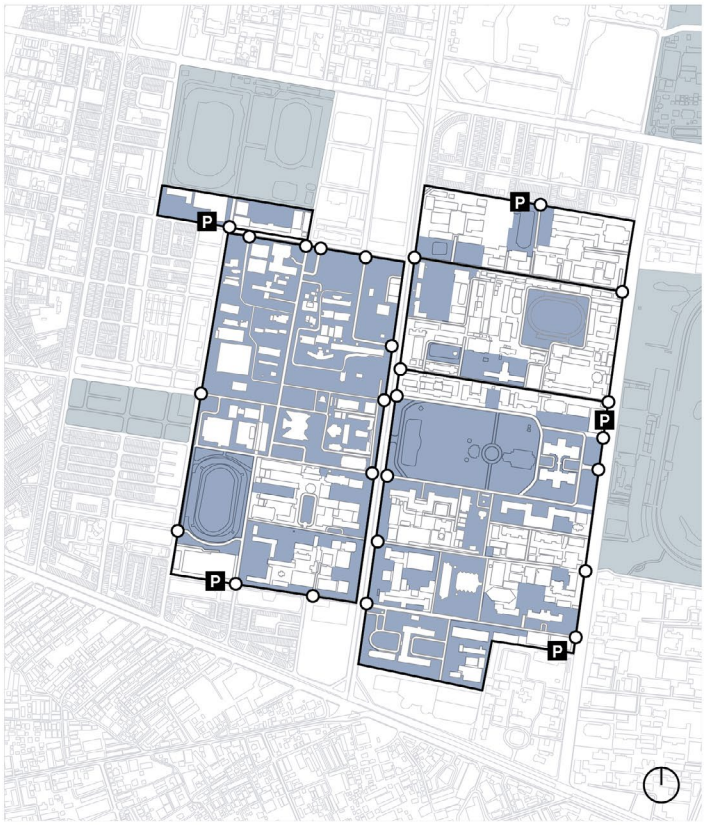

Institution : Chulalongkorn Green University


Low-rise Commercial : Siam Square Complex

0 250 500 1000
m.

Fig. 123

Fig.123 Slow Traffic Route and Urban Flow drawn by author
Fig.124 Chulalongkorn University (Chulalongkorn communication department)
Fig.125 Siam Square Project (Collin J., 2017)




Urban Green Spaces

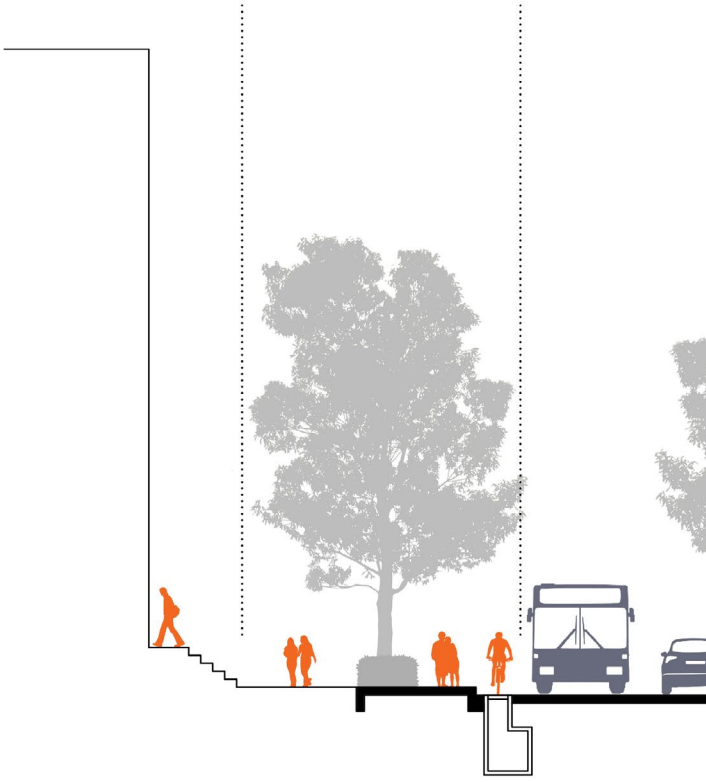
Plaza and Green Spaces inside the Project

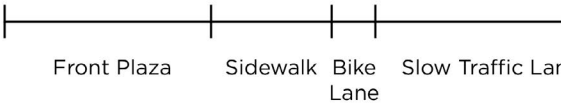
Project Boundary

Entrance Gate

P Parking Building

Pedestrian friendly pathway network





## Slow Traffic Route : Institution

1 : 150

Connection with green & blue infrastructure
service for both social and ecological systems

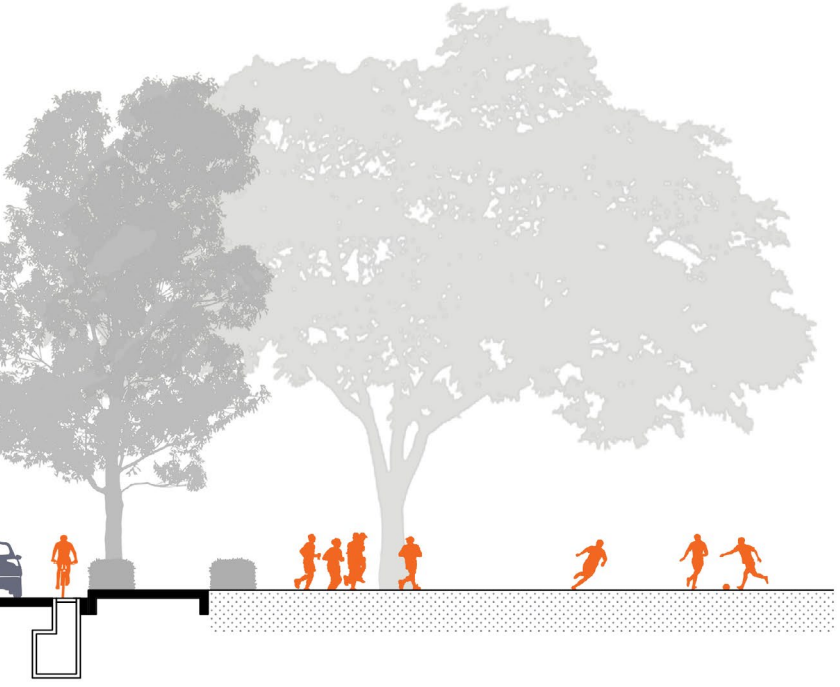
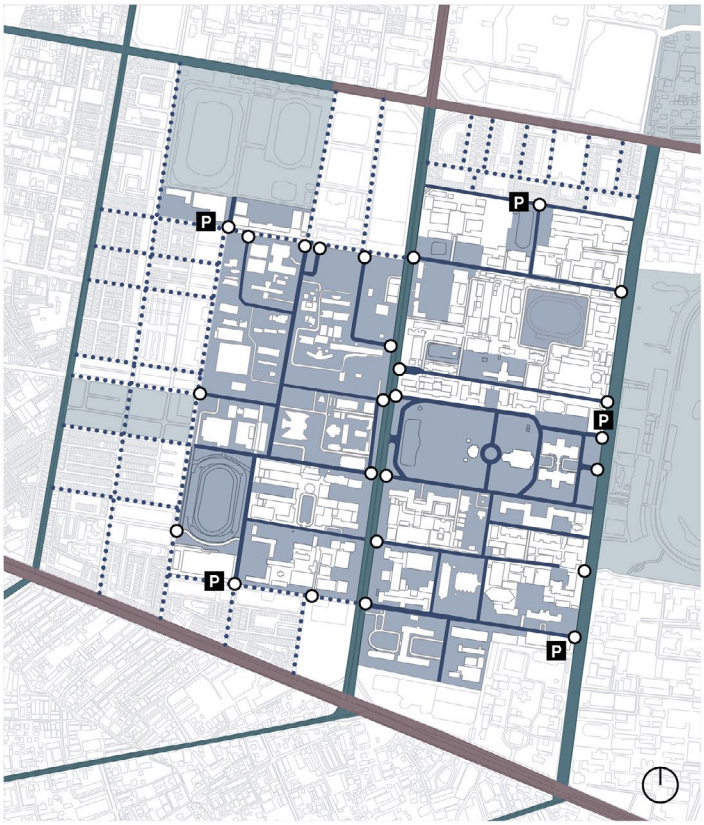



Fig.126 Existing Condition of Slow Traffic Route (Institution) drawn by author

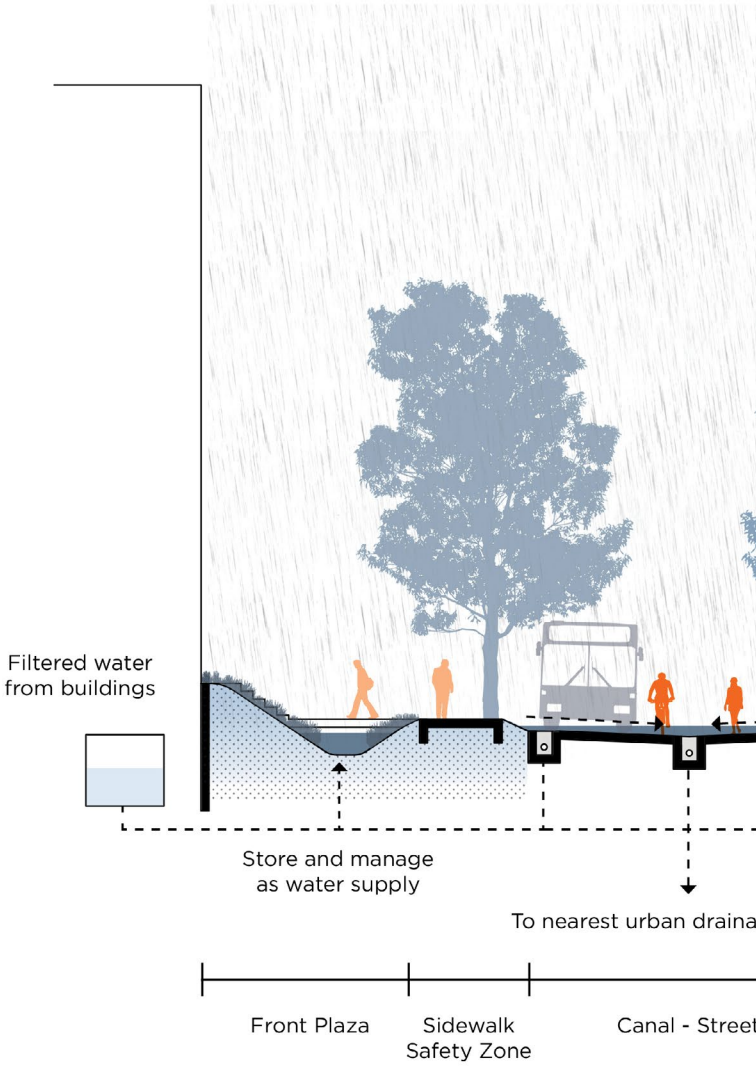



Commercial Artery (Public Transportation Route)

Life Corridor (G&B Connector Route)

Canal - Street Network

Extended Network



## Soaked Community : Institution
## ( Store + Infiltrate )

Soaked community principle focus to extend the flood management performances on adaptive pedestrian friendly street where the soaked streets function together with surrounding green spaces, convey excessive water as an individual flood management system before merging with the surrounding urban drainage system.

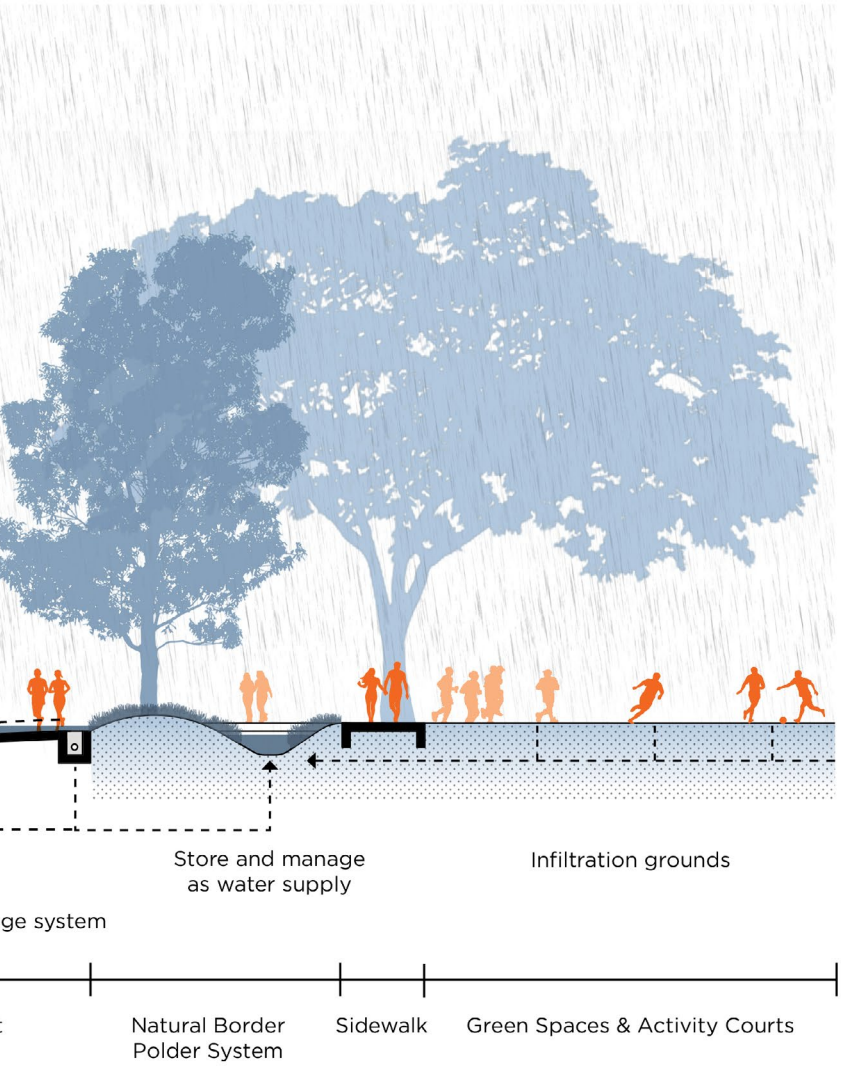
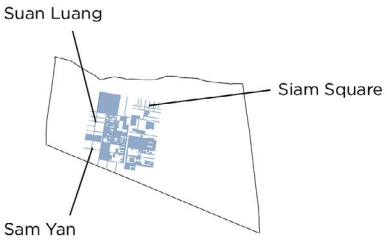
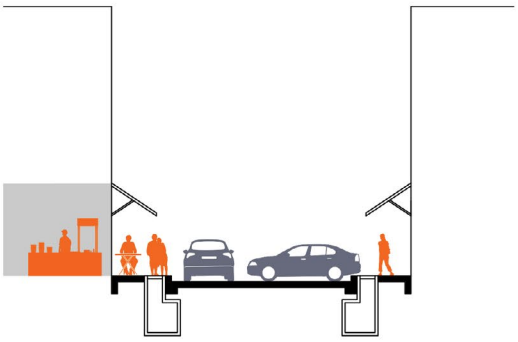


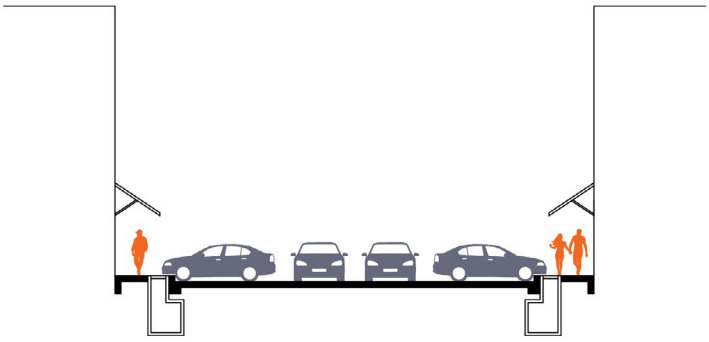

Fig.127 Soaked Community Solution (institution) drawn by author



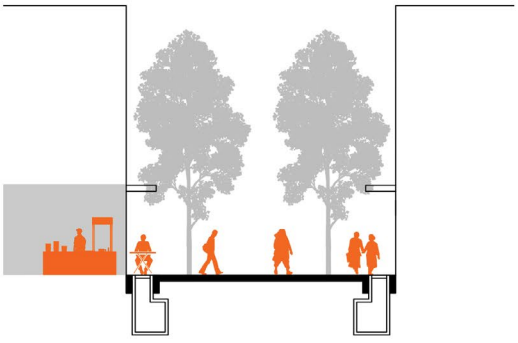
Sam Yan

Local mixed-us



Siam Square

Low-rise comm
with car-base



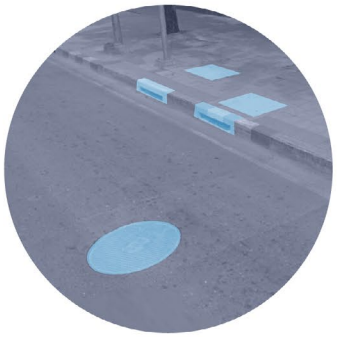
Suan Luang Square

Low-rised comm
with pedestrian fr

## Slow Traffic Route : Low-rise Commercial

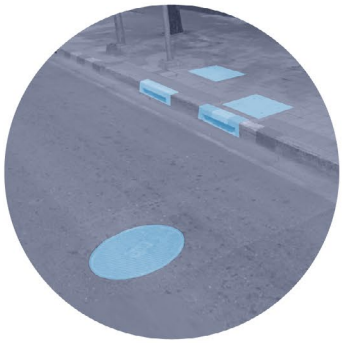
1 : 200

e Shophouse



Underground drainage of
mixed sewage and run-off

ercial project
ed planning

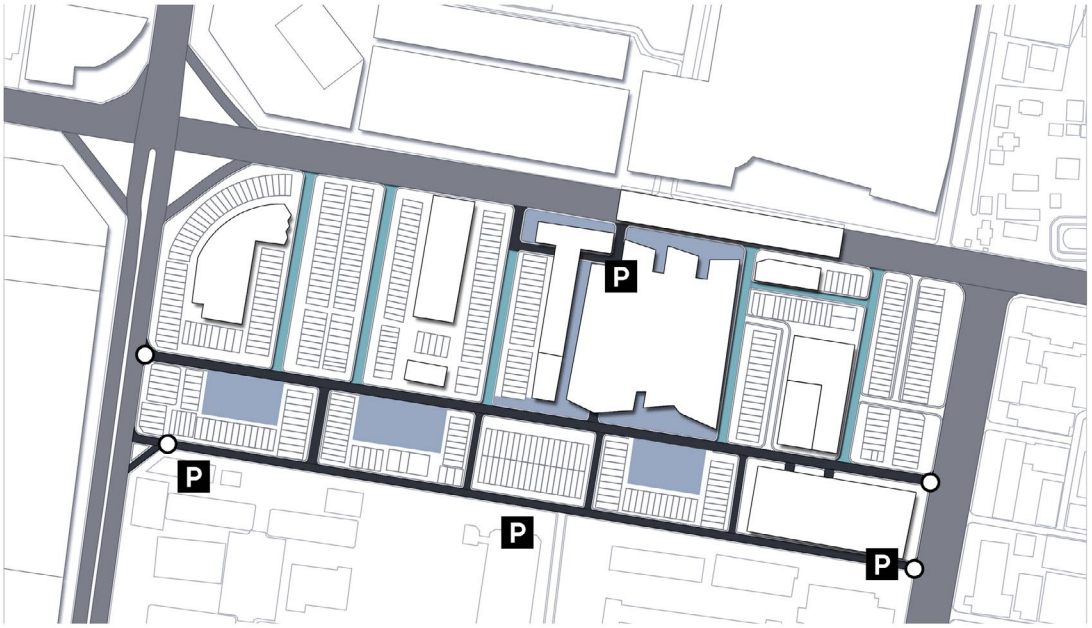


Underground drainage of
mixed sewage and run-off

ercial project
iendly planning

Mix of on-ground green solution
with exisitng engineer solution

Fig.128 Existing Condition of Slow Traffic Route
(Low-rise Commercial) drawn by author




Surrounding Main Street Network

Main Street (Car Access)

Pedestrian Friendly Street / Urban Plaza

Potential Urban Plaza Connection

Project Boundary

Entrance Gate

Parking Building

Soaked Community : Low-rise Commercial
( Store + Infiltrate )

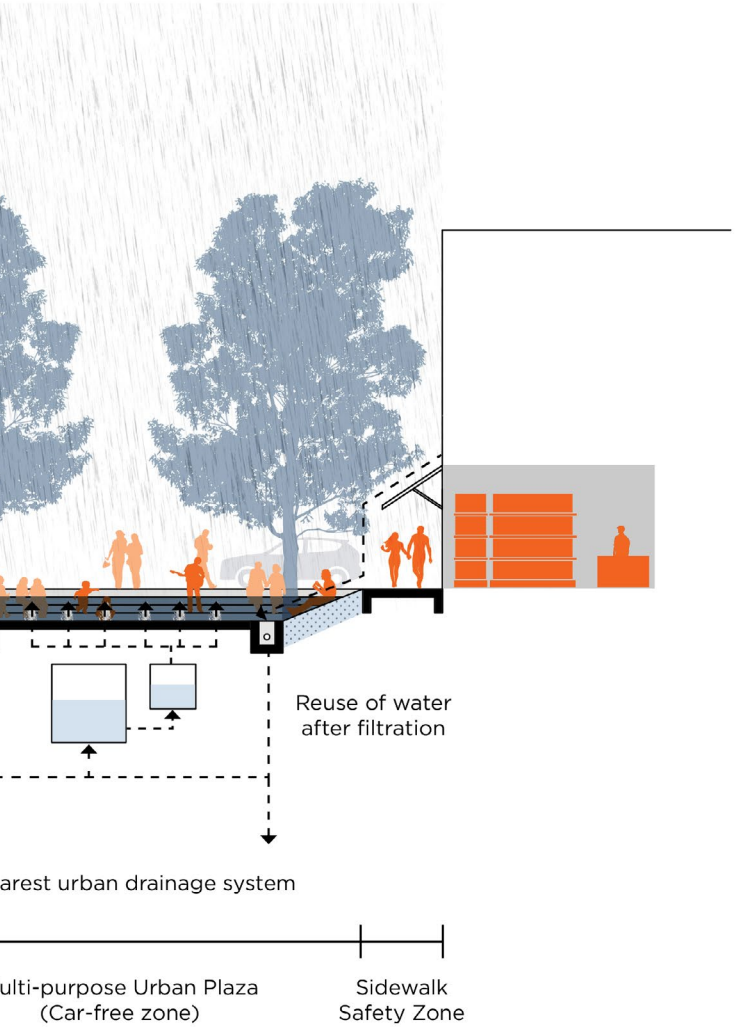
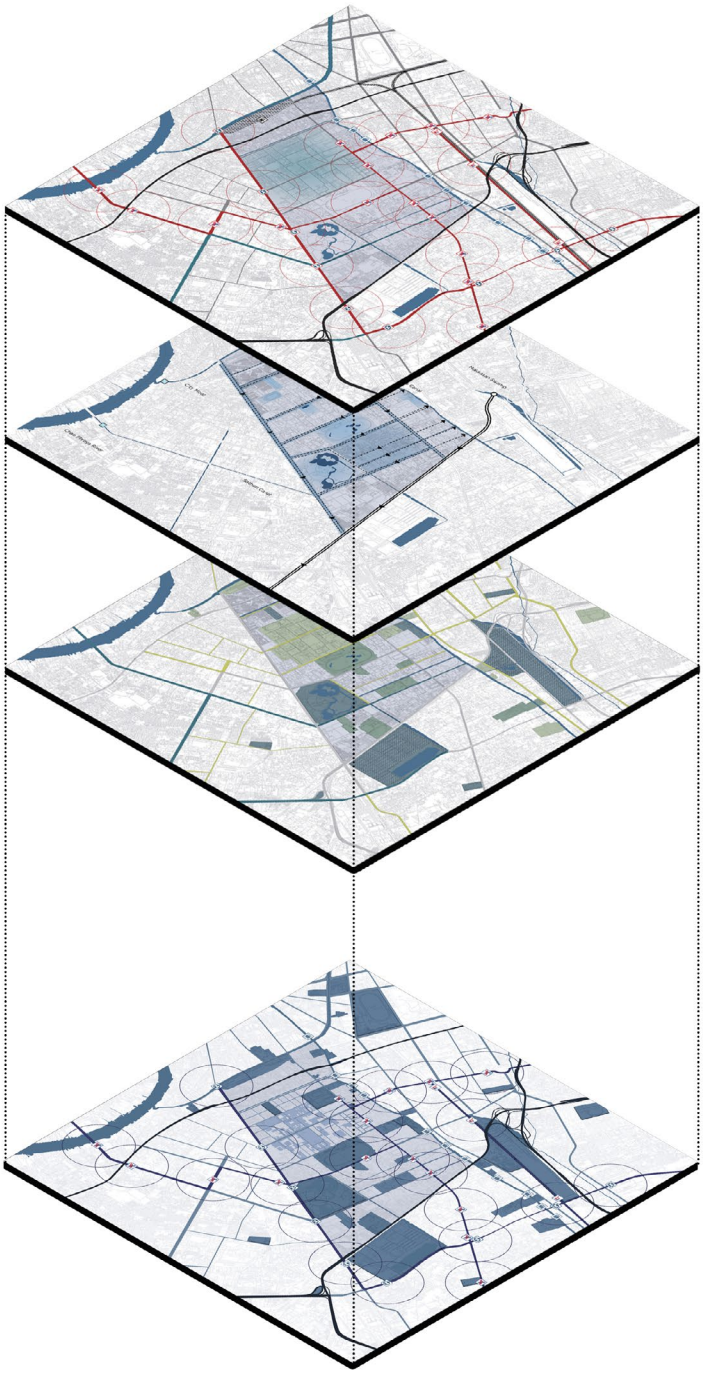



Fig.129 Soaked Community Solution
(Low-rise Commercial) drawn by author

# CHAPTER IV
# EVALUATION

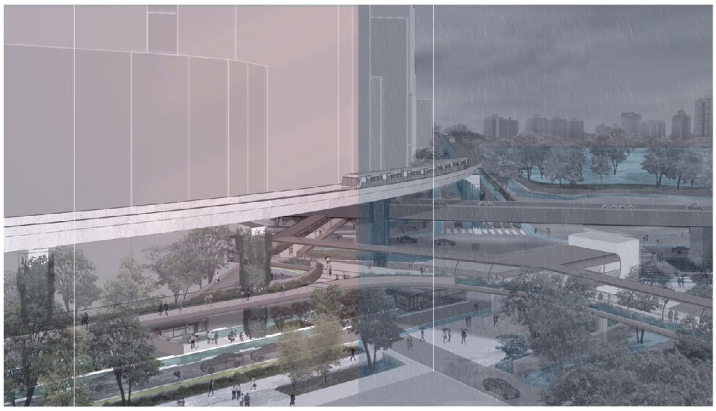
4.1 Socio-Ecological Transformation in Relation with Flood

4.2 Influence and Potential of Future Developments across Scales



Integrated Hybrid Infrastructure Network
Functioned as Interrelated Performative Flood Management

Co-benefit of Social and Ecology Services
through Public Space Development



Water-based Identity / Part of Living Condition
Induce Adaptation of Perception and Lifestyle

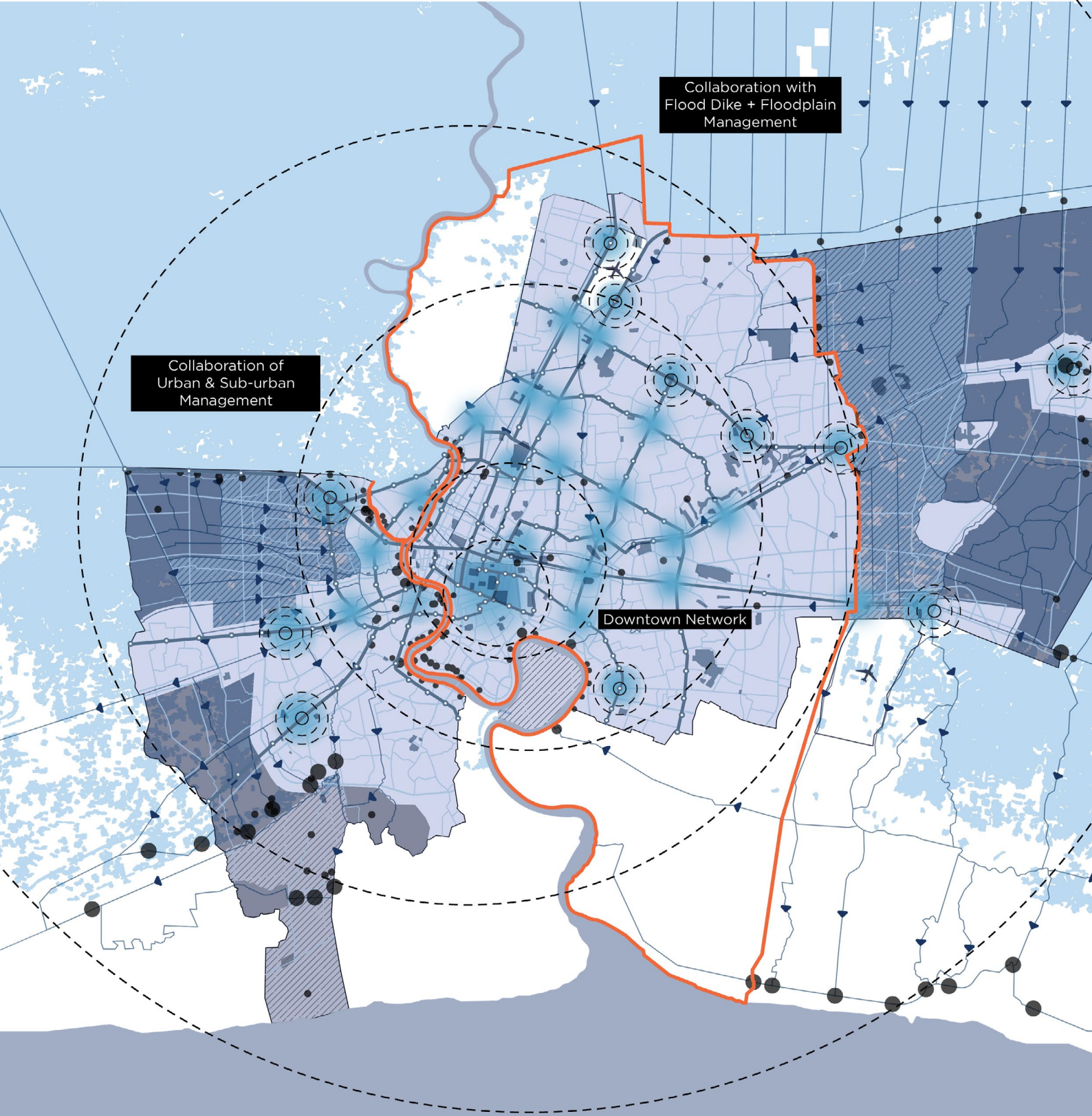
## Socio-Ecological Transformation in Relation with Flood

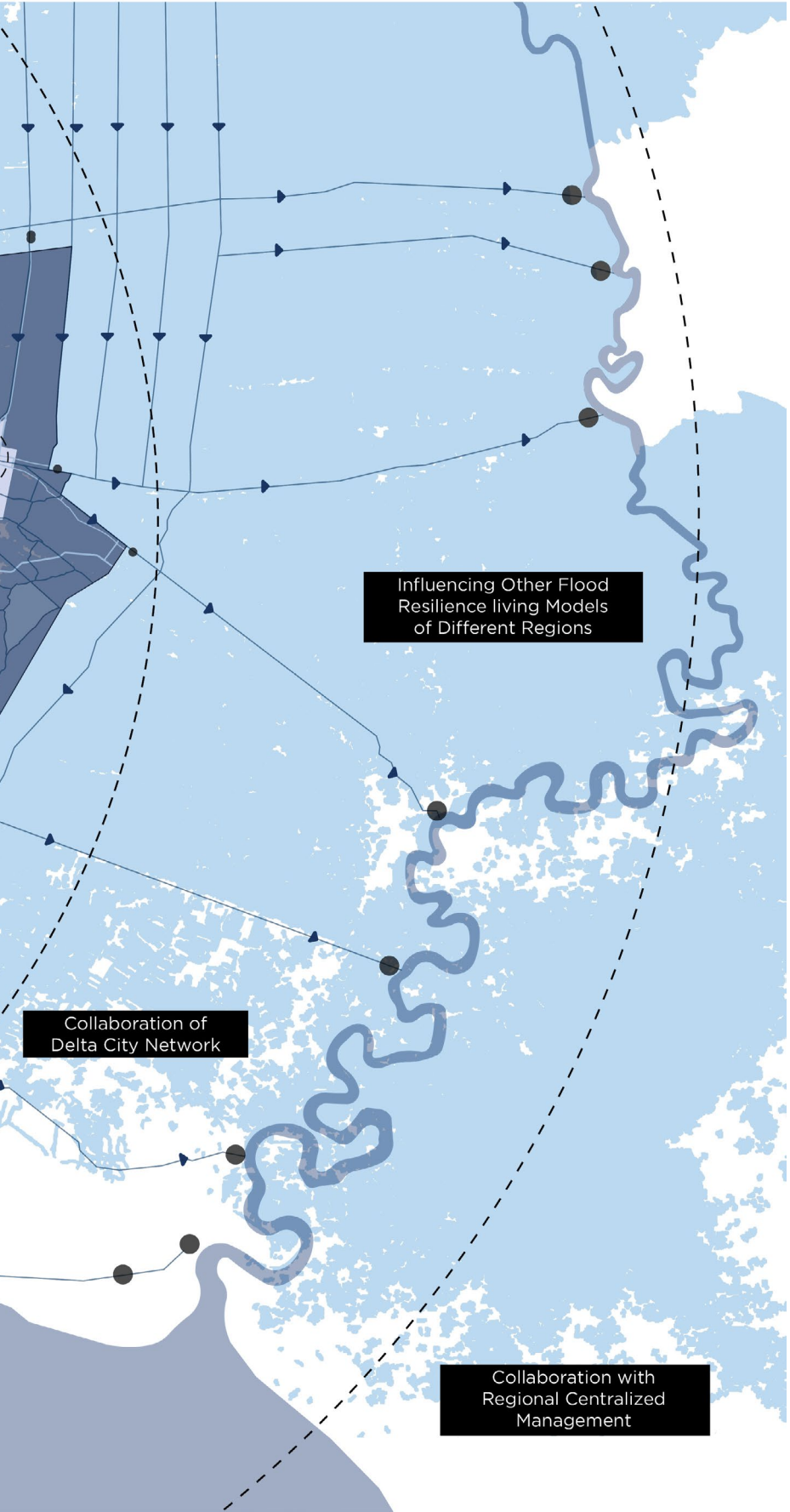
The goal of revolutionary resilience could be achieved by expanding learning capacity of people, to have awareness and understanding of living with nature. For people to learn, they must have constant experience to cope with environmental changes as a habit.

With hybrid infrastructure approach, eco-services from green and blue infrastructure is integrated along with the daily grey infrastructure systems of transportation and water management, functioned together as flood management network, improving social and ecology system of the inhabitants through public space in daily basis.

Furthermore, new water-based identity is created as water becomes part of daily living condition, inducing adaptation of lifestyle and change of perception towards water which could have influences for other flood management solutions across scales.

Fig.130 Outcome Conclusion drawn by author

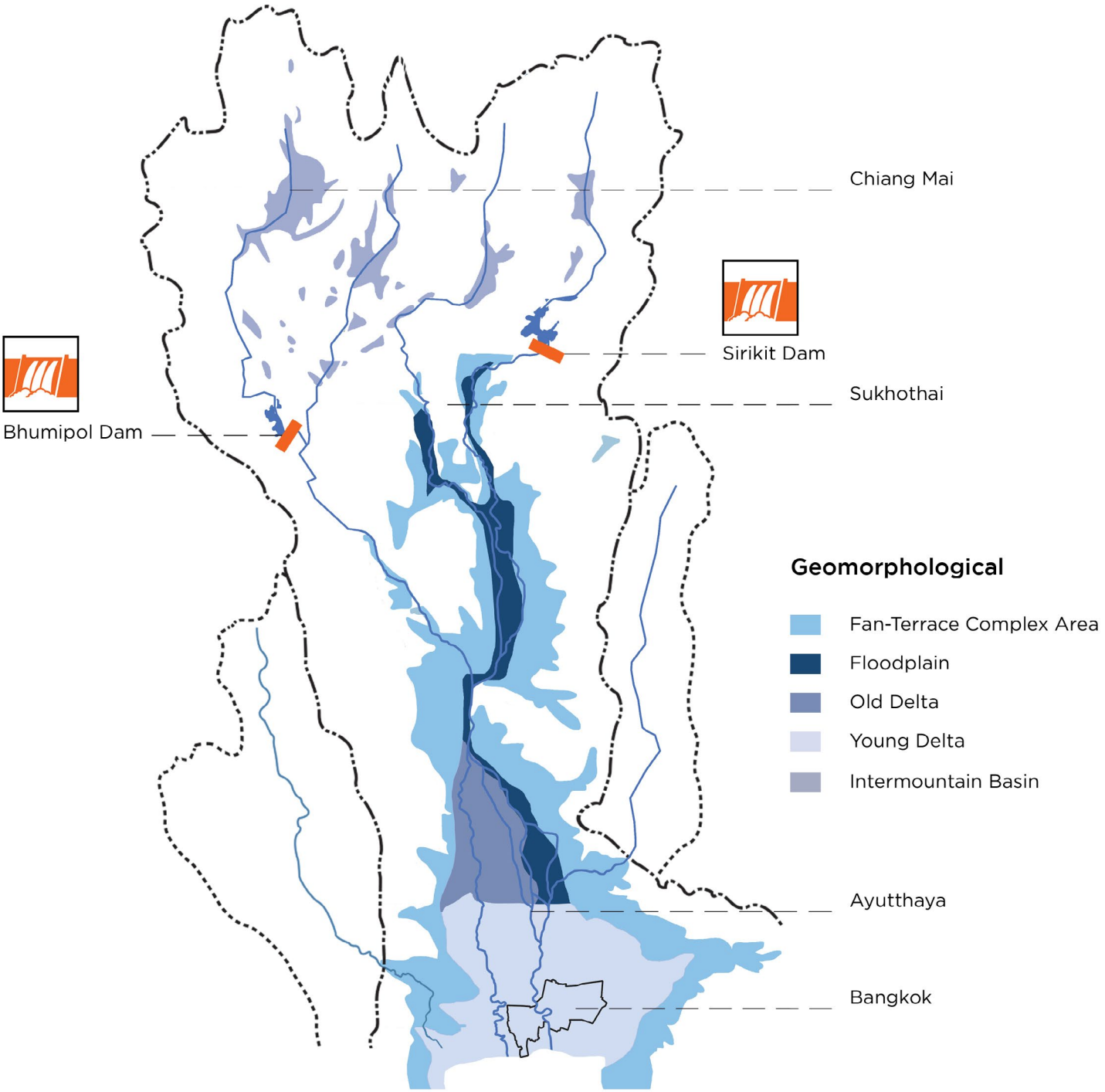

Collaboration with
Flood Dike + Floodplain
Management
Collaboration of
Urban & Sub-urban
Management
Downtown Network

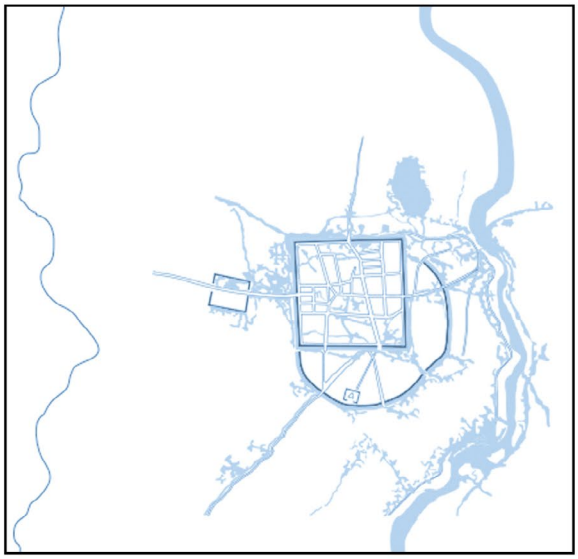



## Influence and Potential of Future Developments across Scales

Pathum Wan Downtown model could be considered as the Initial phrase of flood resilience network development of Bangkok. The model principles are meant to apply as development guideline for future emerging commercial and transportation transit districts, forming larger urban flood resilience network of Bangkok. Moreover, collaboration of different flood management systems across scales is expected with the sub-urban model together with the city's flood management of protective dikes and floodplains. With the evolving perception of the inhabitants inland, traditional defensive driven strategy could be compromised allowing more water in the urban area. Since Bangkok has always considered as the city development prototype, the flood network could also get promoted and applied for other provinces with similar contexts of central Delta cities, in the same time, influencing changes with new flood resilience living idea of other water cities in different regions as seen in Fig. 132. Finally, with the stronger flood network and people adaptive mentality of living with nature, new regional water management of the country could be further conducted.

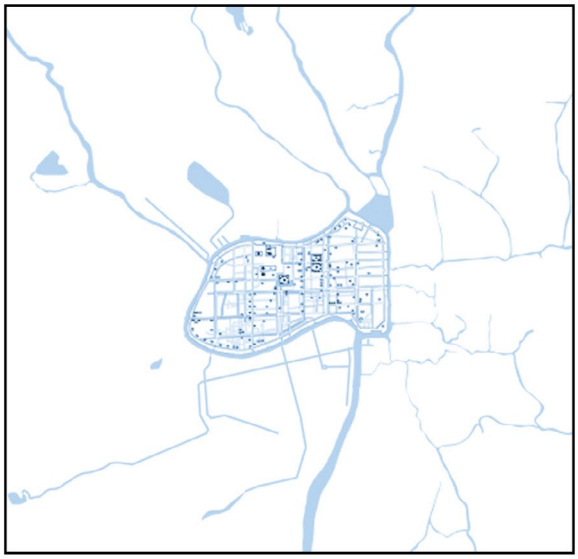
Fig.131 Potential of Development drawn by author


Chiang Mai
Sirikit Dam
Sukhothai
Bhumipol Dam
Geomorphological
Fan-Terrace Complex Area
Floodplain
Old Delta
Young Delta
Intermountain Basin
Ayutthaya
Bangkok



Chiang Mai : Intermountain Basin Model

Sukhothai : Fan Terrace Model



Ayutthaya : River Confluence Model

Bangkok : Delta Model

Fig.132 Chao Phraya Watershed Tributary and Distributary System, Thailand's Water Cities (McGrath, Tachakitkachorn, & Thaitakoo, 2015)

# REFLECTION

### Societal & Environmental Relevance

Perception of people to nature is profoundly significant to our future. Unconsciously, driven factor such as economy easily influences widespread developments exploiting over nature. Currently, most people live in the built-up habitat controlled by grey infrastructure while nature has become irrelevance for daily living. However, for the last two decades, signs in form of several natural disaster incidents strike back to most countries globally. As we try to avoid and defense ourselves apart from nature, societies get even more vulnerable. New solutions are needed. But without awareness and understanding of how to live with nature, it is impossible to cope in this rapid climate change era. Bangkok's inclusive water-based society is a great illustration of strategic landscape-urban design, challenged to influence perception and relation between people and flood, to regain water back as part of urban living, encouraging living with environmental changes.

### Design Methodology

Since the goal of this thesis is to influence changes with perception and relation between people and water, the researches and strategies are conducted focusing on landscape and urban qualities, not by the performances. The design outcomes are considered as strategic planning and design principles which are needed for future elaboration on capacity calculation before implementation on real site. The design principles function as guidelines for new emerging nodes of commercial and transportation transit in the Delta area.

### Process of Data Collection

With poor government system and law provisions in Thailand. Data collection processes are considered as a significant challenge for the project as the information is not for public and scattered within various administrations. Moreover, parts of the information needed for the projects are confidential. The solution of the author is to gather information through alternative resources including the published researches related to the project topic. The data gathered mainly are series of map which needed authorization or hard to get from the administration.

### Research Results

The goal of revolutionary resilience could be achieved by expanding learning capacity of people, to have awareness and understanding of living with nature. For people to learn, they must have constant experience to cope with environmental changes as a habit.

With hybrid infrastructure approach, eco-services from green and blue infrastructure is integrated along with the daily grey infrastructure systems of transportation and water management, functioned together as flood management network, improving social and ecology system of the inhabitants through public space in daily basis.

Furthermore, new water-based identity is created as water becomes part of daily living condition, inducing adaptation of lifestyle and change of perception towards water which could have influences for other flood management solutions across scales.

### Ethical Issues

The design focuses mainly on the development of public spaces as they are considered as common entity of shared concerns which function to accommodate everyone equally. In exchange, the design allows water to be part of daily living conditions which force people to change their lifestyle to co-exist with nature.

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