



DESIGNING FLOOD RESILIENT AND INCLUSIVE URBAN  
COMMUNITY: A CASE OF AGELESS LIFESTYLE IN 1960s  
PRACHANIVATE 2 HOUSING, NONGTHABURI

BY

MISS YADA PONCHAMNI

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF MASTER OF URBAN DESIGN  
URBAN DESIGN AND DEVELOPMENT (INTERNATIONAL PROGRAM)  
FACULTY OF ARCHITECTURE AND PLANNING  
THAMMASAT UNIVERSITY  
ACADEMIC YEAR 2018  
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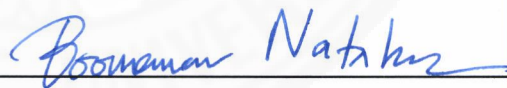
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DESIGNING FLOOD RESILIENT AND INCLUSIVE URBAN COMMUNITY:  
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was approved as partial fulfillment of the requirements for  
the degree of Master of Urban Design

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Chairman



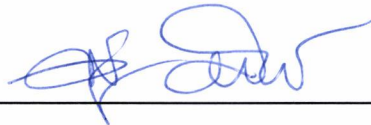
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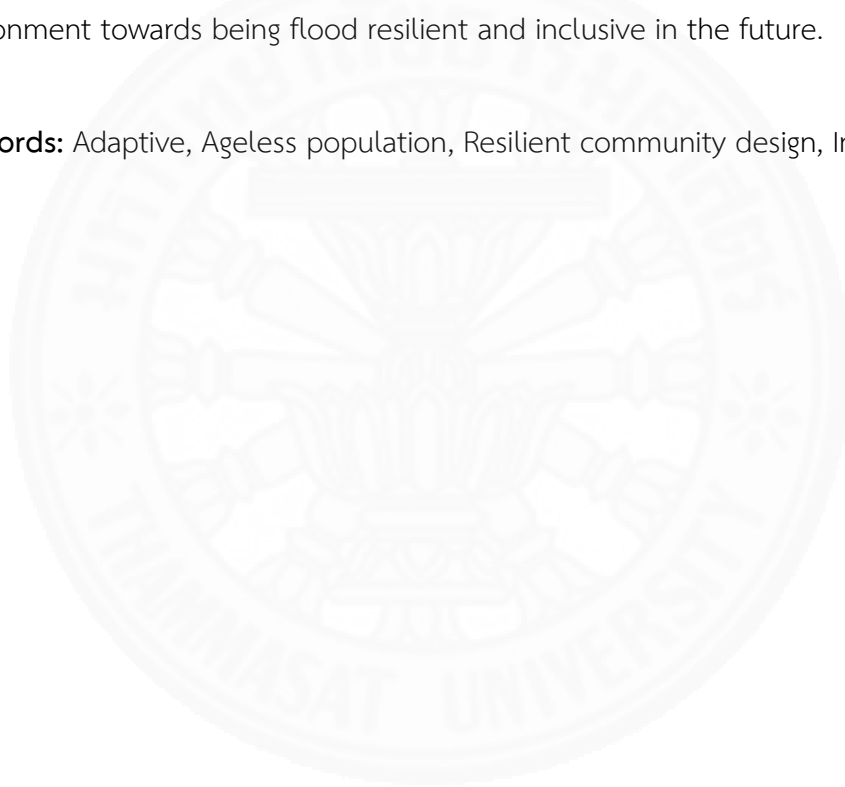
Thesis Title	DESIGNING FLOOD RESILIENT AND INCLUSIVE COMMUNITY: A CASE OF AGELESS LIFESTYLE IN 1960s PRACHANIVATE 2 HOUSING, NONTHABURI
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## ABSTRACT

From 1970s, Thailand has rapidly shifted towards the middle-income country (MIC), encouraging people to contribute to country's economic growth as national goal. This leads to rapid urbanisation as there are high job opportunities attracting people to migrate into big city. In order to accommodate large amount of migration influx, the government has to provide and manage new resettlement area by establishing National Housing Authority (NHA) as medium. The study area of Prachanivate 2 is one of the earliest projects designed and built by NHA during 1960s, locating within Bangkok and metropolitan Regions, Nonthaburi. Even though the community was built under a standard utilities and services though, the area is exposed to chronic flooding every rainy season for the past years. Moreover, according to the rapid urbanisation causes the loss of permeable grounds surrounded, leading to more often flood events after heavy rainfalls. Although, there are series of autonomous adaptation in different scales ranging from individual to community improvements towards flooding yet, the implemented autonomous adaptation would not be sufficient facing the changes of rainfall frequency and magnitude according to climate change (Wijitbusaba M, TARC 2016) shifted from 60mm/hour to 120 mm/hour. Furthermore, majority of the residents

are the population from 1970s which will turn to be an aging population within 5 years period (UNFPA, 2016) with more independent and active lifestyle comparing to the past generations, moving towards active aging and ageless society. The research aims to generate flood resilient and inclusive community by using adaptive and resilient design strategies using existing physical mechanisms and in-depth interview reflecting socioeconomic needs onto existing urban fabrics, enhancement and development along with the implementation of inclusive design concept consists of universal design and walkability principle providing an effective and efficient community programs and environment towards being flood resilient and inclusive in the future.

**Keywords:** Adaptive, Ageless population, Resilient community design, Inclusive design



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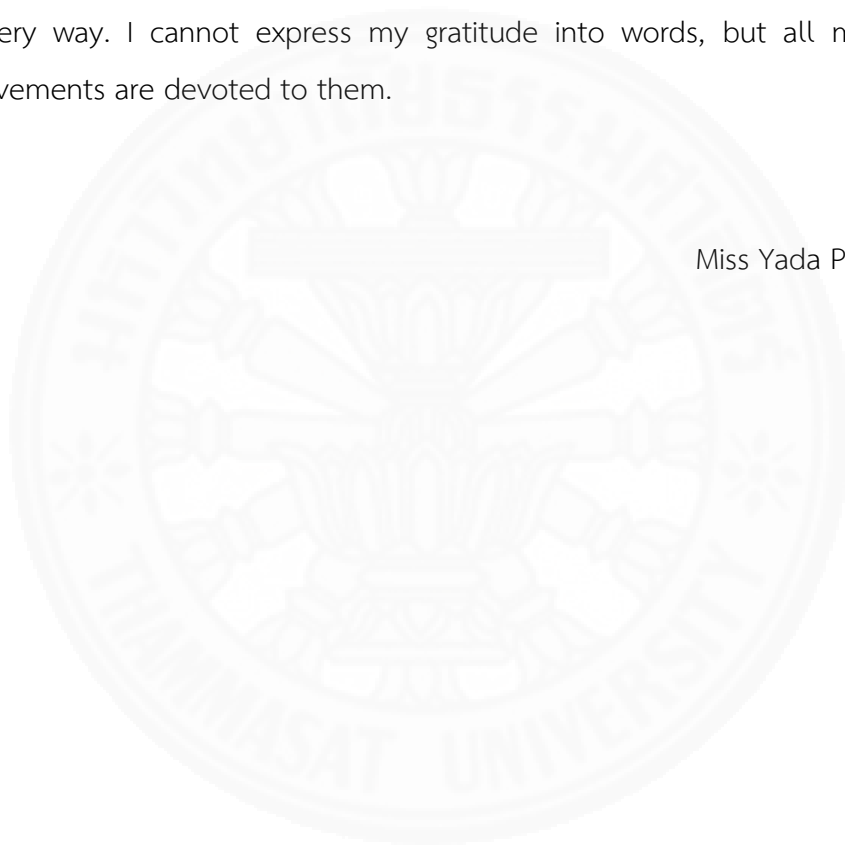
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Miss Yada Ponchamni



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## LIST OF ABBREVIATIONS

Symbols/Abbreviations	Terms
BMR	Bangkok Metropolitan Region
IPCC	Intergovernmental Panel on Climate Change
WHO	World Health Organisation
NSO	National Statistic Office
NESDB	Office of National Economic and Social Development Council
UNFPA	United Nations Population Funds
OECD	Organisation for Economic Co-operation and Development



## CHAPTER 1

### INTRODUCTION

#### 1.1 Research Background Information and Site History

Prachanivate 2 is an early 1960s housing which has been built by NHA in order to provide housing as the urbanization happened around the Bangkok and Metropolitan Regions (BMR) area requires higher demand of residential units. The community location indicated as medium to high density residential area according to the Nonthaburi comprehensive plan. This area is facing flooding events due to an extreme rainfall which occurs more often as climate change has taken places. Moreover, according to the rapid urbanisation, new housing developments started to occupy the surrounding spaces of the study area means that the existing drainage mechanisms will not be able to accommodate higher amount of water from both extreme rainfall and rapid urbanisation. Thus, there are many autonomous adaptations that has been done to mitigate flood in both community and individual scale such as bought a shared drainage pump, using SUV car, small water drainage pump in their own property or elevation of houses' level to be higher than the road level. However, the mentioned new housing developments around the site area are having a very high elevated ground, solving flooding problem on their property, means that, the area of Prachanivate 2 has turned into the lowest housing development that collects all the surface runoffs. Furthermore, another important to be concern is the changes of demographic in Thailand which affecting on the shift of social structure in Bangkok and Metropolitan area as the birth rate started to decline since 1970s because of governmental policy on generating a higher economic status (Impact of Demographic Changes in Thailand by UNFPA, 2017) leaving the present population of generation X and baby boomers to be living independently with no family. This population group is expected to be an aging population within 20 years' time. This implies that the lifestyle and characteristic of this group of aging population will shift to be an active aging group, living an ageless lifestyle reflecting

on their independent lifestyle when they were younger, so, the community requires to be an resilient towards climate change together with inclusive quality, providing ease, comfort, safety and convenience for the upcoming user group.

## **1.2 Research Question**

How does the spatial design strategy play a role in achieving inclusive flood resilient community?

## **1.3 Objectives**

1.3.1 To study social and physical changes and how these changes exacerbate flood risk from the past to the future.

1.3.2 To study existing adaptive mechanism in response to flooding.

1.3.3 To suggest resilient design strategies in order to manage changes and support inclusive community.

## **1.4 Research Boundary**

1.4.1 Population with the age 65 and above who has been living in the community for 10 years and over

1.4.2 The generation X and Baby Boomers (age of 50 and above) as they are the next generation that moving towards being an aging population

1.4.3 Site study area: NHA's Prachanivate 2 gated housing estate

## **1.5 Expected Outcome**

Tangible outputs consisting of integrated spatial design strategy and designed masterplan with intervention suggestions are the expected outcome for this thesis, as it needs to provide alternative ways for the focus group to live resiliently with water

by themselves. This can be developed into adaptive design strategy package, which can be used to adjust and implement onto site with similar context that is to be flood resilient and inclusive community later in the future.

## 1.6 Keywords

1.6.1 Adaptive — Term defining something that is ready to be adapt towards persuasive guideline which will be beneficial for group of users that has been affected.

1.6.2 Ageless population — New term for the aging-aged population with the active and independent lifestyle

1.6.3 Resilient community design — the community design which is adapted to all the changes in both social and physical aspects

1.6.4 Inclusive design — a concept that emphasized on including every individual, by understanding the differences and diversity in as many groups of users as possible.

## CHAPTER 2

### REVIEW OF LITERATURE

#### 2. Topic of Study

Topics will be focusing on climate change and its impact factors: climate-related factors and socioeconomic on the study area, using changes in time period from past to present and future dataset to identify problems and risks. Moreover, there are case studies and design methodology leading towards designing an adaptive and resilient design strategy with inclusive qualities.

##### 2.1 Social Structure

###### 2.1.1 Social Structure Changes in Thailand

###### 2.1.2 Nonthaburi Social Structure Changes

###### 2.1.3 Prachanivate 2 Household Structure Changes

##### 2.2 Ageless Society and Active Aging Population

##### 2.3 Climate Change

###### 2.3.1 Climate Change Impacts in Bangkok

##### 2.4 Urban Adaptation and Urban Resilience

###### 2.4.1 Urban Resilient Principles

###### 2.4.2 Risk Framework

##### 2.5 Inclusive Design and Related Concepts

###### 2.5.1 Walkability Principle

###### 2.5.2 Universal Design

##### 2.6 Water Buffering and Infiltration

###### 2.6.1 Bioswale

###### 2.6.2 Rain Garden

## 2.7 Case Study

2.7.1 From Grey to Green, United States

2.7.2 Waterplan 2, The Netherlands

2.7.3 Kokkedal Climate Adaptation Community, Denmark

2.7.4 Strategic Flood Masterplan, Denmark

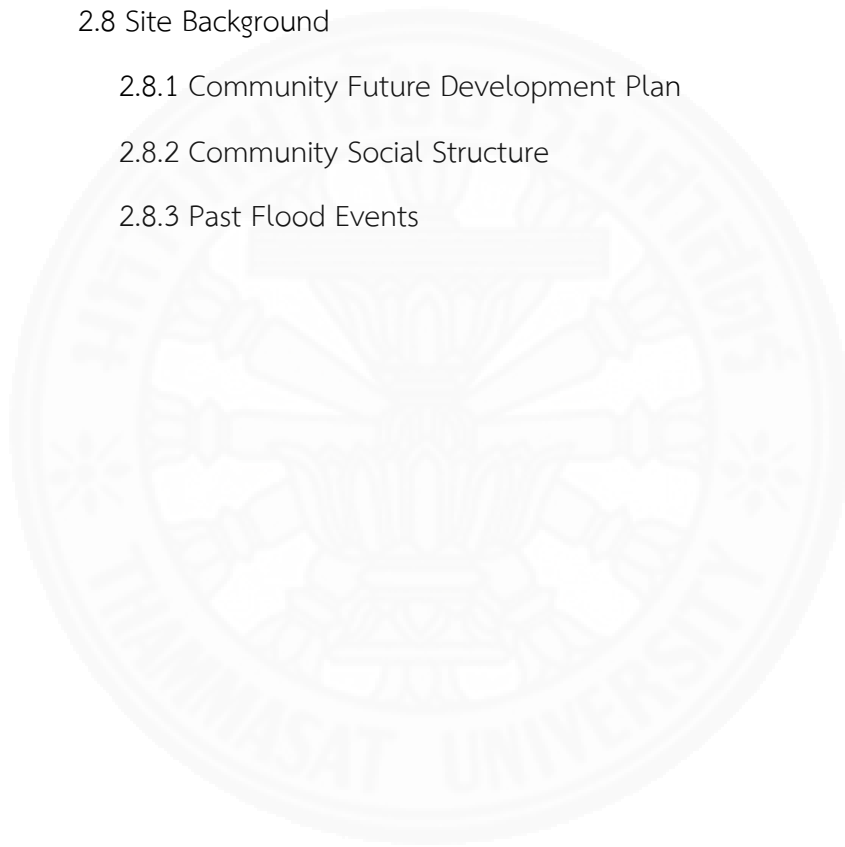
2.7.5 Amsterdam Rainproof, The Netherlands

## 2.8 Site Background

2.8.1 Community Future Development Plan

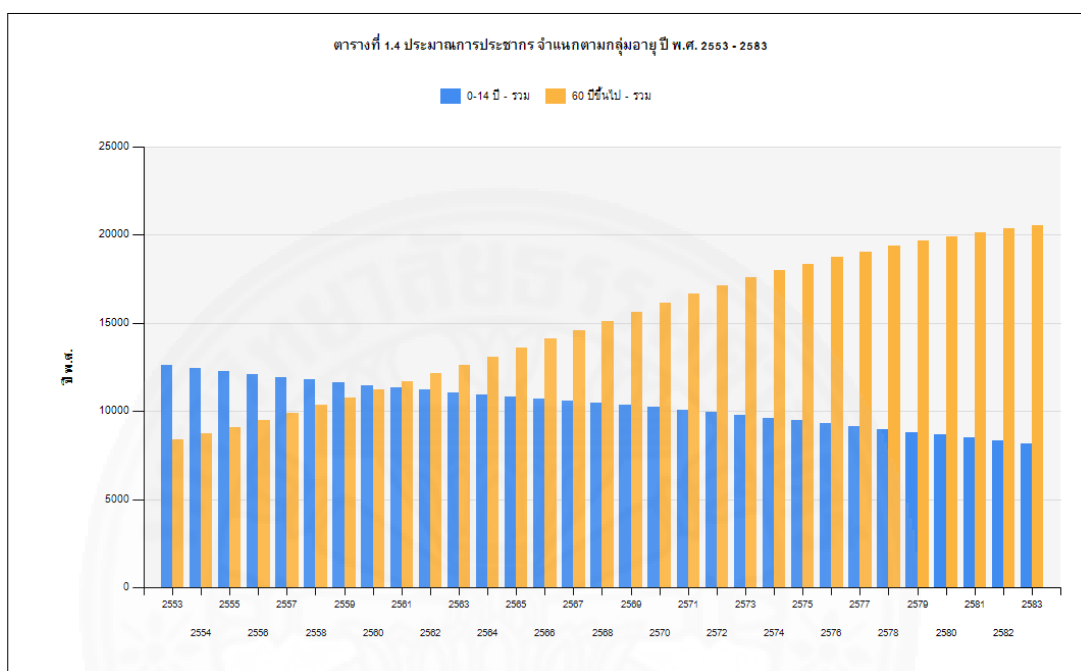
2.8.2 Community Social Structure

2.8.3 Past Flood Events



## 2.1 Social Structure

### 2.1.1 Social Structure Changes in Thailand



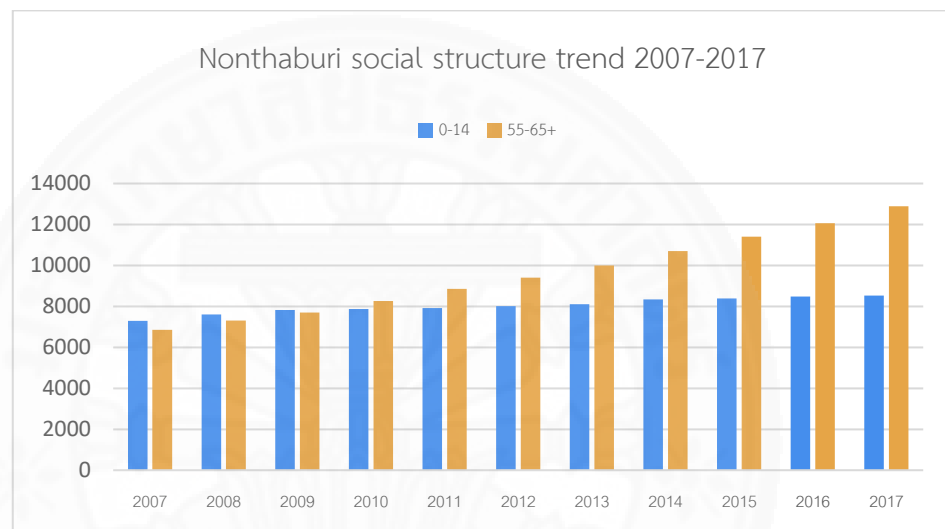
**Figure 2.1** Population categorised by age group

Source: National Economics and Social Development Council (NESDB), 2019

The statistics graph above (NESDB, 2019) illustrates Thailand's population trend from the year 2010 to 2040, by plotting the population of new-borns to 14 years old against the population of age above 60. The graph clearly displays a constant decrease in the younger generation, as the elderly population of the age above 60 years continued to increase. From the graph above, the elderly population is approximately 12,000 in 2019, whereas the predicted elderly population in the next 10 years will rise to almost 18,000. This implies that Thailand is moving towards being an aging society within the next 10 years. Moreover, according to UNFPA, the birth rate has been declining since the 1970s, as the government supported Thailand is working towards rapid growth of country's economics means that the working population creating a windows of opportunities for the country with the downfall of not having

any family, referring to the mentioned country trend and governmental encouragement means that within the next 20 years, this group will be expected to be an aging population with active lifestyle as they have already living an independent lifestyle (Impact of Demographic Changes in Thailand, UNFPA 2017).

### 2.1.2 Nonthaburi Social Structure Changes



**Figure 2.2** Nonthaburi social structure trend 2007-2017

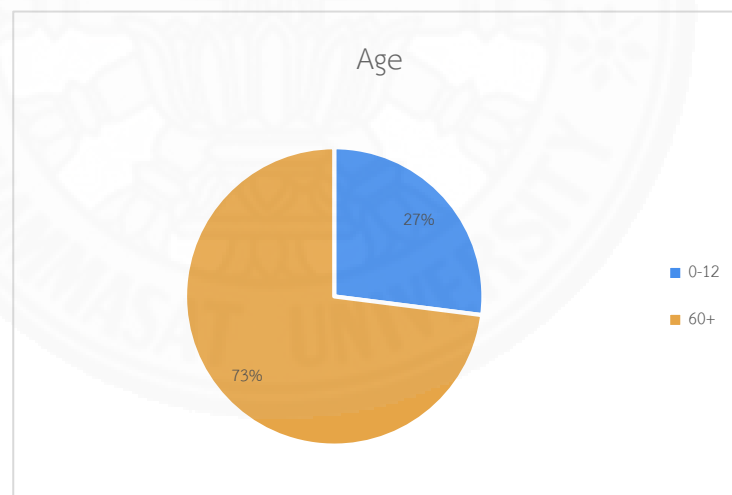
Source: Researcher adjusted from National Economics and Social Development Council (NESDB), 2019

The graph above illustrates 2 different age group populations, which are 0-14 years old and age 55 years old and above, in Muang Nonthaburi district from 2007 to 2017. The graph displayed a distinct gap between the two age groups, which has become even more significant between the 5 years period of 2013 to 2017. It can also be seen that the 0-14 years old population has been relatively constant for the past 10 years. However, the aging population (55-65 and above) has been rapidly increasing. Comparing between the year 2007 and 2017, the population increased from approximately 6,500 to 12,500. The 100% increase in population is an evidenced of the growing elderly group. Thus, the future prediction of population growth trend

can be assumed that the elderly population will increase rapidly within the next 5 years. Furthermore, this can illustrate clearly on how the population group that will grow into an aging population within 5 years (generation X and Baby boomers) are having no family and children, interpreting from the huge gap between the two independent age groups. This means that, Nonthaburi social structure changes is growing in the same direction as Thailand (National Statistical Office, 2017).

### 2.1.3 Prachanivate 2 Household Social Structure Changes

The study area of Prachanivate 2, Nonthaburi has clear social structure changes of the residents living within the community. Referring from community database in 2016, the distinctive measures which can be used to evaluate the changes of social structure is the “dependent age group”, which consisted of 2 groups: (1) population with the age between 0-12 years old and (2) population with the age 60 years old and above.



**Figure 2.3** Dependent Age Group

Source: Researcher adjusted from Community 2016 Database, 2019

The chart illustrates the social structure of the community, focusing on two dependent age groups of Prachanivate 2 community in 2016 consists of (1) population between 0-12 years old and (2) population with the age 60 years old and

above. From the chart, the younger generation accounted for only 27% of the community. This shows that the community is moving towards being an aging community as the population of age 60 years old and above are 73% and will continually be increased along with Nonthaburi social structure changes. Furthermore, this can use as tool to determine the possibility and the direction of how the community population going to grow towards. In this case, it is growing rapidly to become an aging society in the near future, with the younger generation as the minor group of the community. As a result, the design needs to achieve inclusiveness in order to reflect the needs of both the major and minor population groups of the community (Community database, 2016).

## 2.2 Ageless Society and Active Aging Population

### 2.2.1 Ageless Society

Ageless society is an emerging term where the city with high aging population, such as Japan, use as a concept to propose policies that fits with their situation. The term of 'ageless' simply means to never be retired; achieving timeless way of being, as it is the concept that helps the seniors to generate more self-satisfaction and self-enrichment as the population of 60-65 years old and above will soon become the majority of the world population. So, everything will be less determining on age across the area such as career, leisure, media consumption, etc. This means that, it will not only be keeping the seniors healthy but also improve their self-worth as *the council of the elders' society* has been distributed to be the part of finding job opportunities, social activities and improving physical built environment in order to improve elders' society (Appendix C).

A major example ageless society, Japan is known as the oldest citizenry in the world as of 2014, with the aging population accounting for 26.3% of the country. Additionally, the number is likely to increase to 32.2% in 2030. This is because Japan uses 'ageless society' as the term of its new government policy planning to encourage their seniors to stay healthy and remain in the labour force.

The government will be an important mechanism that helps the after-retirement population to continue working by enhancing seniors' well-being, reducing the needs for nursing, and also preventing isolation of the independent elder from their own community. This means that, the term ageless society will soon be commonly use in different dimensions other than in planning and social development, but in physical dimension since the built environment also has to match with the needs of the majority of the population in the future (The Organisation for Economic Co-Operation and Development, 2018).

### **2.2.2 Active Aging**

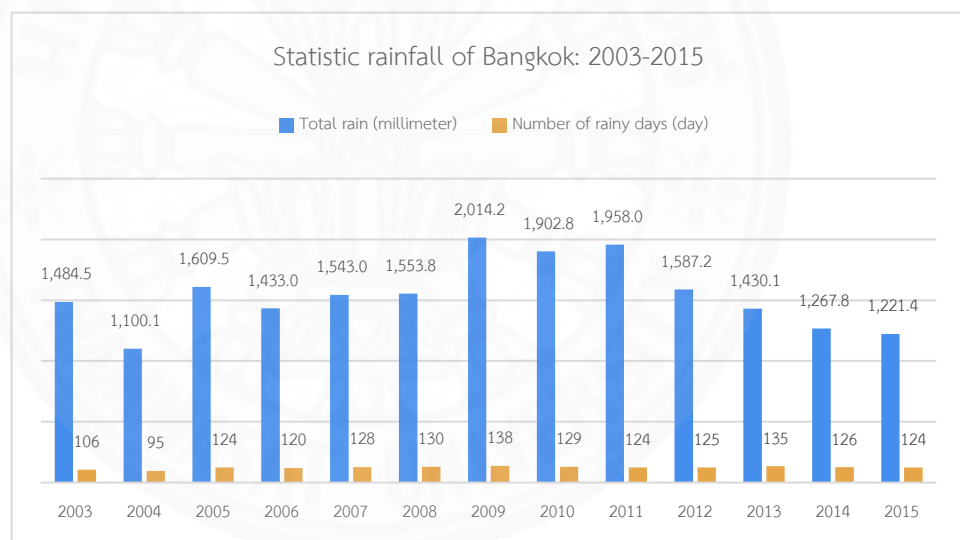
Active aging population, a new term defined and adopted by the World Health Organisation in the late 1990s, was developed from the term of healthy aging by inputting more inclusive perimeter. It is the progress of optimising opportunities for health, participation, and security in order to enhance quality of life as people ages. Thus, the term reflects the independency of individuals to be able to live independently in both social participation in every aspect, referring to the definition of the word 'active' means the right to continue to participate in every social activities either it is cultural, spiritual or civic affair not only as labour workers. Moreover, it applies in both individual and population group as it has allowed people to acknowledge the potential, social and mental states of the active aging population in both physical and social aspects. Also, providing sense of security to the upcoming age group (World Health Organisation, 2002).

## **2.3 Climate Change**

As the urbanisation grows rapidly, the cities expanded into other areas creating more sub city centres and districts. Therefore, the facilities and services have to expand along with the population and housings, together with economics and industrial estates, to become sufficient to the increasing numbers of population. This establishes rapid increase of greenhouse gases emission, such as Carbon Dioxide and

Methane, and consequently leads toward global warming which is the cause of climate change. As a result, the temperature in the atmosphere has increased by 1-3 Degrees Celsius, compared to the year 1990 (appendix A). By IPCC, climate change is the state of climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, creating impacts in many forms including disasters (a severe changes from the normal functioning of a community or society due to the hazardous physical events causing vulnerable social conditions, leading to unfortunate events on human, economic and environmental effects requiring urgent respond in order to satisfy human needs towards recovery, IPCC).

### 2.3.1 Climate Change Impacts in Bangkok

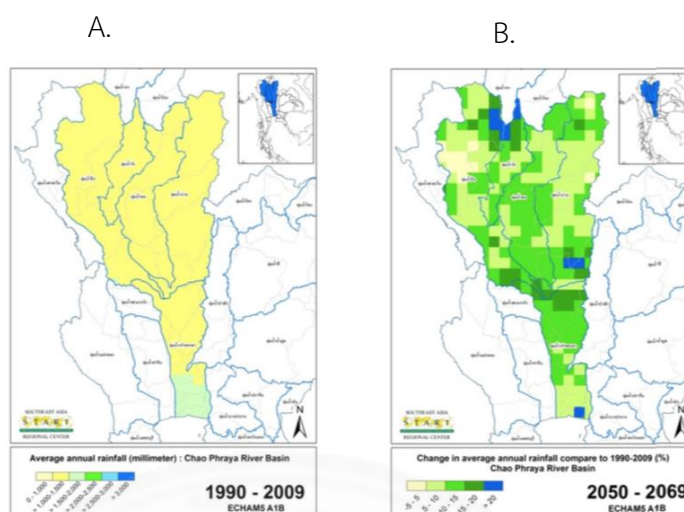


**Figure 2.4** Statistic rainfall of Bangkok

Source: Meteorological Department, Ministry of Information and Communication Technology, 2016

Climate change impacts Bangkok in many ways; for example, drought, rising of sea level, and extreme rainfalls. The mentioned problems can create vulnerability in the city contexts such as human settlement and infrastructure damage. This

research, however, will only be focusing on the extreme rainfall and its impacts. The graph above illustrates statistical data focusing on the changes of frequency and magnitude of the rainfall in Bangkok during the year 2003 to 2015. From the given data, it can be interpreted that the number of rainy days has been gradually declining starting from the year 2009. Even though the number of days is lower, the amount of total rainfall does not exhibit the same pattern. Thus, the year 2009-2011 has very high precipitation magnitude comparing to the rest of the years, reflecting the climate change impacts, which causes the unsteady amount of precipitation. Moreover, the challenges of long-term adaptation towards being a resilient city needs to concern on socioeconomic factors as well as how the individuals are going to adapt towards the changes. This means that, implementation of each adaptation mechanism has to connect with the daily routine of the citizens in order to illustrate the risks from climate changes, and correspondingly put direct pressure upon the urban population to acknowledge the upcoming problems. Furthermore, in climate change context, there are 2 main factors consisted of (1) climate-related factors, which refers to the factors related with climate change events and create a direct impact on urban area, and (2) non-climate factor or the factors creating impact with no relations of climate change events such as economics and urbanisation. However, this section will be focusing on (1) climate-related factors in Bangkok context. The diagram below, illustrates future prediction of total rainfall in Chao Phraya river basin comparing between 2 models of different decades: (A) 1990-2009 and (B) 2050-2069. From the data, the total rainfall (mm) increased by 11%.



**Figure 2.5** Diagram displaying percentage of changes of total rainfall (mm.) in Chao Phraya river basin comparing between 2 decades: 1990-2009 and 2050-2069

Source: Wijitbusaba (SEA START RC), Chapter 2-TARC2, 2016

In addition, the table below shows the predicted level of impact from extreme rainfall. The table compares the 3 days rainfall amount (mm) between 2 models with series of repetitive years of 2 years, 5 years, 10 years, 20 years and 50 years. By 2 years, the percentage of changes will increase tremendously (17%) meaning that there is a higher chance of Bangkok being affected by extreme rainfall in the near future.

**Table 2.1** Rainfall return period, SEA START RC 2016

Return period: 3 days rainfall	2 years	5 years	10 years	20 years	50 years
A: 1990-2009 (mm)	91	122	152	189	253
B: 2050-2069 (mm)	106	140	172	211	278
Percentages of changes	+17%	+15%	+13%	+12%	+10%

Source: Wijitbusaba (SEA START RC), Chapter 2-TARC2, 2016

## 2.4 Urban Adaptation and Resilience

Adaptive and resilient has been defined under the framework of climate change by IPCC. Adaptation has been defined as the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. For example, human interventions can be mechanisms to facilitate adjustment towards expected climate change activities. Moreover, the concept of adaptation will be developed to be climate resilience. Resilience can be defined as the ability of the system and its components to anticipate, absorb, accommodate or recover from the hazardous events' effect in a timely and efficient ways. Also, it needs to ensure the preservation, restoration or improvement of its state after got affected by the event. In other words, it has to be able to adapt and respond to changes in a very effective and efficient way (Intergovernmental Panel on Climate Change, 2017).

Furthermore, looking at resilience in a city scale, in order for the city to be resilient towards future changes caused by climate change events such as flooding, the city needs to improve on its infrastructure to accommodate for the worst possibilities that can occurred in any urban system, regardless of whether it is physical or socioeconomics. So, the city has the ability to bounce-back, and become better after faces with hazardous events. Furthermore, it has to be improved along with sustainable development framework in order to maintain the ability to be resilient (Wijitbusaba, Chapter 2 TARC 2016).

### 2.4.1 Urban Resilient Principles

Resilient cities are defined by its urban system and the settlement areas generating a relationship in holistic and systematic way, and can be fulfilled using an urban resilience principle (ResilientCity, 2014) consists of 6 measures:

(1) Diversity: The increasing of systems' diversity in the city. As the city has greater diversity, the ability to bounce back from stresses also increased. Moreover, diversity can reduce the negative impacts on the city as the different

systems can function in different aspects, also supporting the systems with failure after survived from stresses and shocks.

(2) Redundancy: Increasing complexity of city systems, providing an alternative system to support the central system while it is facing failure after exposing to stresses. This method will not increase resilience efficiently but will support the needs of the city towards future changes.

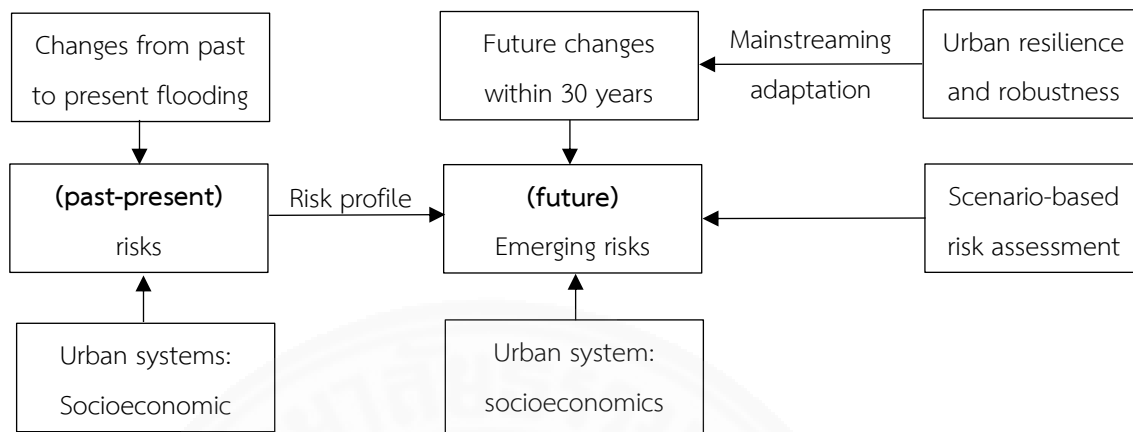
(3) Modularity and independence of system components: The city should have an independence within urban system, meaning that if one system fails the other urban systems need to have an ability to continue working.

(4) Feedback sensitivity: The ability of the system to detect and respond towards problem independently. The more it can reflect, the more efficient it is to tackle with problem and enhances city's robustness. Moreover, the city should have a tight and connected feedback loop to increase efficiency and effectiveness responding to stresses.

(5) Capacity for adaptation: A city's robustness can be improved and enhanced by the ability of infrastructure to adapt together with urban system reflecting towards stresses. The faster it can adapt, the more robust the city will be.

(6) Environmental responsiveness and integration: The ability of the system that can respond and integrate with natural resources and environment. This can reduce possible costs and negative impacts caused by climate change.

### 2.4.2 Risk Framework

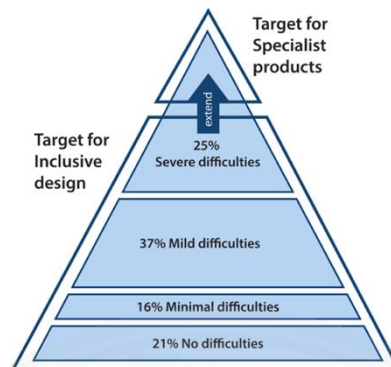


**Figure 2.6** Urban Risk and Vulnerability in Bangkok

Source: Wijitbusaba, Resilient city 2012

This risk profile framework evaluates the risks from past and present situation using past-present data on existing urban system, based on socioeconomic factors together with changes caused by climate change, which is flooding in this context. This can be used to predict emerging risk, generating a 30 years data prediction from the existing trends, and also the future urban system where it has a risk management planned. By using this framework, the city needs to be evaluated and analysed with a holistic picture. Seeing connections, relationships and networks between each system, leads to a scenario-based risk assessment to measure urban system dynamics, evaluating urban resilience, and robustness of the city.

## 2.5 Inclusive Design and Related Concepts



**Figure 2.7** Inclusive design toolkit

Source: Cambridge 2017

Inclusive means to include everyone, creating diversity within the focus space. (appendix B) So, Inclusive design is a concept that emphasized on including everyone in the users, understanding the differences and diversity in many groups of users as possible. This is to include variations in aspirations, capabilities and needs as much as possible. Referring to British Standards Institute (2005), inclusive design defined as ‘the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible ... without the need for special adaptation or specialized design’ to stated simply, it’s the design of one product that aimed to address the needs of the entire population. The pyramid illustrated the model of diversity that can be used to show how inclusive design aims to extend the target market, including those who are less able and accepting the solutions from specialist that may require in order to satisfy the needs of those at the top of the pyramid. Comparing inclusive design and universal design, both of the terms have the same literal meaning but for universal design approaches pragmatically, but it is not always possible for one product to meet the needs of the entire population. However, these approaches still be able to maintain the mainstream products that should be provided and accessible to as many people as possible. On the other hand, inclusive design intends to extend the reach of the mainstream designed product, maximizing

the product performance for each individual target users as inclusive design focuses on choosing appropriate target users in order to create particular design. (University of Cambridge, 2015)

### 2.5.1 Walkability Principle

Walkability index is a tool uses to measure the scale of walkability level in the neighbourhood, later on it was adapted to fit an urban design context by Bradshaw, 1993. This aims for the walkability index to be able to implement physically using urban design, creating a walkable environment. However, it has no clear definition of walkability as most of the indexes are intangible characteristics, the term walkability was defined by Abley, 2005 as ‘... the extent to which the built environment is walking friendly and as ‘... a useful way to assess the characteristics of an area or a route, although it can be subjective.’

Walkability index consists of 7 dimensions (7Cs) defining a walking friendly environment (CityLab, 2014).

(1) Connectivity: extent where the pedestrian environment is linked and networked.

(2) Convenience: extent where the pedestrian environment is useful and time-saving.

(3) Comfort: extent where the pedestrian environment is pleasant, protected and relaxed.

(4) Conviviality: extent where the pedestrian environment is lively and sociable.

(5) Conspicuous: extent where the pedestrian environment is provided with clear sense of direction.

(6) Coexistence: The pedestrian and other transport modes can coexist in the same time and spaces with hierarchy and peace.

(7) Commitment: the engagement of users towards having responsibility towards the pedestrian environment.

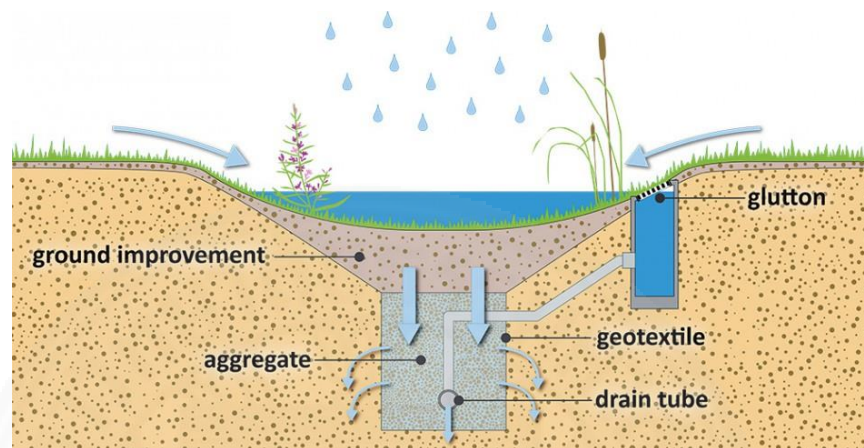
Moreover, this can be use together with numbers of urban design qualities to create a more justified physical design features which impacts on both users' reactions and overall walkability scale of the area. The examples of urban design qualities are human scale where it refers to size, texture and articulation of physical environment which create a suitable proportion for human, linkage refers to the physical and visual connections of physical environment, unifying and providing sense of direction for the users and legibility is the ability of understanding the spatial structure of places and navigated as a whole, linking with the linkage where it helps to provide clearer sense of direction.

### **2.5.2 Universal Design**

Universal design is a composition of physical architectural or environmental design, finding solutions which can be fixed physically by design, also can be access and used in many ways and many groups of users possible without the users adaptation means it needs to achieve the needs of all people who wish to use it. Means that, Universal design is a fundamental of good design, considering the ability of accessibility, convenient and usability of many groups of users possible. However, the concept of universal design is quite different compare to inclusive design where it focuses on diversity ways of generating sense of belonging through social interaction and discussion to achieve a more accessible and meeting all accessibility standards in both physical and socioeconomic aspects, achieving a barrier free community (Fastcompany, 2019).

## 2.6 Water Buffering and Infiltration

### 2.6.1 Bioswale



**Figure 2.8** Bioswale section, GROENBLAUW 2006

Source: GROENBLAUW, 2006

Bioswale is a landscape element designed to accommodate huge surface runoff water from impervious surface, also an effective stormwater mitigation tools for urban spaces as the system is very robust. However, this design intervention consumes high space usage as it requires at least 16% of the total district area for it to be effective. This method can enhance biodiversity along with improving environment and aesthetics of the area, the swale has to have approximately 10% depth with connections on the surface. Usually the implementation of bioswale will locates at the connector area between districts or community within city fabric. Moreover, there is a drainage pipe underneath in the second layer of the swale, accommodating high amount of rain water from extreme rainfalls, it also can minimise overflowing water and acted as alternative drainage system because of the mentioned drainage pipe underneath. In addition, the implementation of bioswale is recommended on public ground for its maximum effectiveness and maintenance (urban green-blue grid for sustainable and resilient cities, 2005).

### **2.6.2 Rain Garden**

Rain garden is a perennial or native shrub located on natural slope, designed to collect, slow down and filter stormwater as it can filter up to 90% of chemicals and nutrients together with 80% sediment removal. The design implementation will be taken on the downside of slope where the existing soil needs to be removed for 15-30 centimetres with a replacement of composts and sand mixture to increase water infiltration, this landscape element only requires minimum maintenance with high effectiveness draining water as it can be dry by 12-48 hours period (Groundwater foundation, 2018).

## **2.7 Case Study**

### **2.7.1 From Grey to Green, United States**

From grey to green project locates in Portland, Oregon. The main concept of this project is to create advanced green infrastructure which can provide sustainable storm water management that can be used as a tool for public education activities on storm water management issues within dense and compact city centres towards the lower density in the suburbs with the context area of 376.5 square kilometres and 940 millimetres of annual rainfall. Moreover, the aim of the project is not only for sustainable storm water management but also to provide habitats for wild life and recreation spaces for activities. The implementation has been applied using a decentralised method in order to implement what is best for each of the areas using different measures such as green roofs, planters, rain gardens in small scale but generating huge impact as it can ease the overflow of sewage-storm water mixture which goes directly to Willamette River. Thus, this project also encourages private sectors to participate as they are giving out incentives of fee discounts for the property owner who manage storm water on their property, furthermore, it raised awareness and knowledge on the storm water management widely in public as all the data are publicly accessible, providing public education by holding free seminars and setting



problem, especially among the working people so this masterplan has to be integrated between water management and utilising water as a new city attraction under 4 main aims which is:

- 1) providing protection for Rotterdam against flooding
- 2) ensure the water quality to be in the European framework standards
- 3) integrating urban design and water management to enhance city's attractiveness under the concept of *live, work and relax* also solving the water problem
- 4) reorganizing the sewers for the storm water runoffs using innovative decentralised solutions for each specific area



**Figure 2.10** Plan view of Waterplaza

Source: DE URBANISTEN 2016

The example of the innovative storm water management design is the water square which designed to be both public spaces with 1 metres sunken from the surrounding ground sports field and playground, as during the heavy rainfall, this area

can be function as water storage up to one thousand cubic metres and will be slowly discharge to the sewer system. Thus, Waterplan 2 has fully follow an integrative approach, generating high influences on public perception as it is possible to create an alternative solution towards mitigation and prevention for the climate change impacts (Rotterdam municipality, 2015).



### 2.7.3 Kokkedal Climate Adaptation Community, Denmark

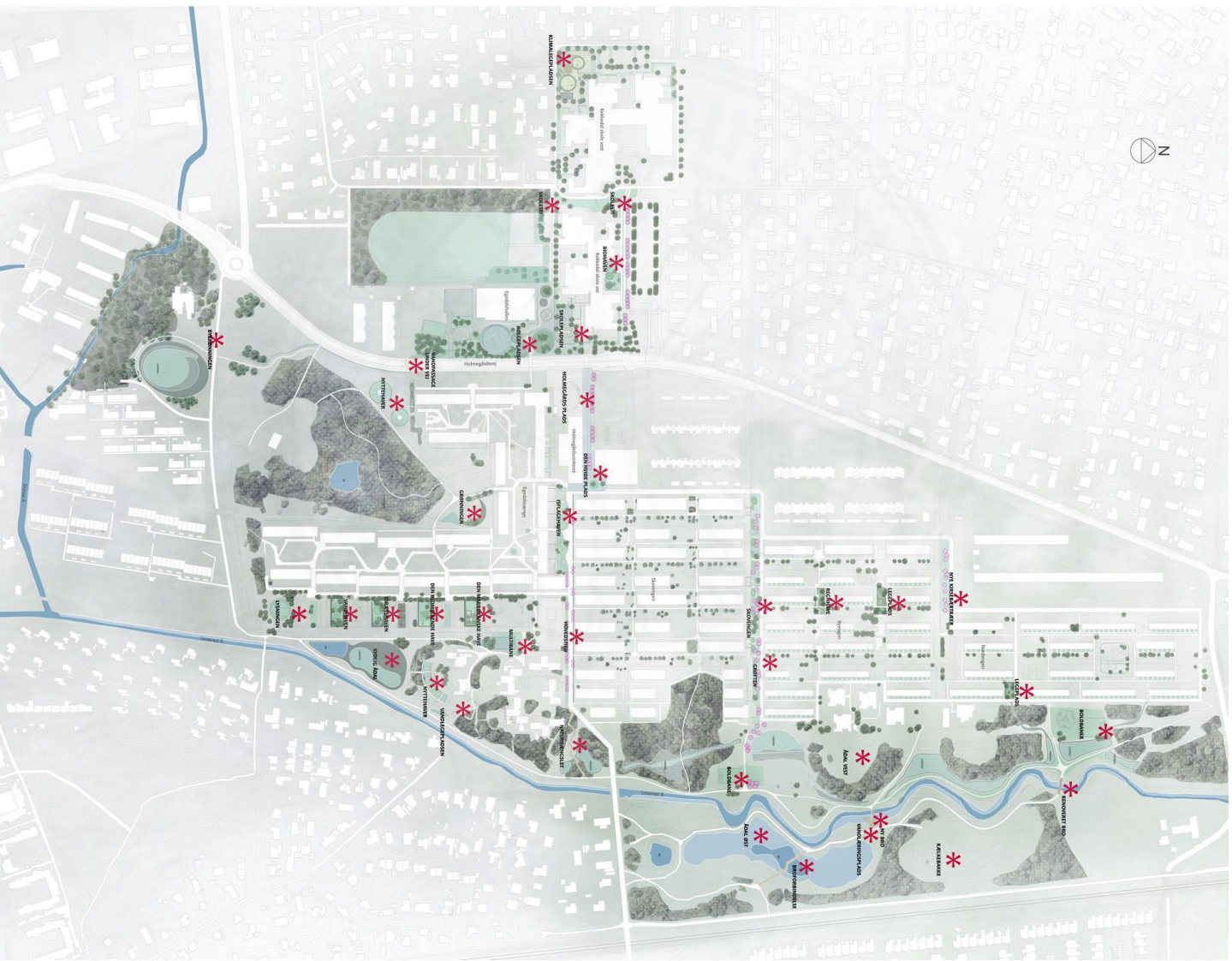


Figure 2.11 Project masterplan

Source: Landezine, 2018



A) adaptive playground with variety of functions focusing on children users with an ability to retain water after heavy rainfalls.

B) raingarden providing infiltration of rainwater together with alternative exercise trails.



C) wetland exercising trails with green retention basins providing more water capacity and greenery for the users.

D) family pocket park with community farming encouraging community interaction between different age groups.

**Figure 2.12** Examples of adaptive landscape intervention

Source: Landezine, 2018

An adaptive community project by Schønherr landscape architects, Denmark focusing on stormwater management by implementing varieties of interactive landscape interventions aiming to both develop a climate adaption concept along with promoting a better urban life quality, bringing nature closer to the residents. The design concept came after the severe flooding event during 2011, in order to promote urban life along with adaptive climate design the designer has to design mechanisms where it can provide sense of security along with rainwater management function underground. Moreover, there are an integration of different programs for different users as this is a big community with the area of 60 hectors or 375 rai with different user groups ranging from children to elder, so the recreational spaces design is driven by the shifts of different activities. Moreover, this project consists of 35 individual projects such as gardens, exercising trails, nature playground and green retainment basins aiming for an effective dual function as mentioned above, generating an interactive urban life within the community.

#### 2.7.4 Strategic Urban Flood Masterplan, Denmark

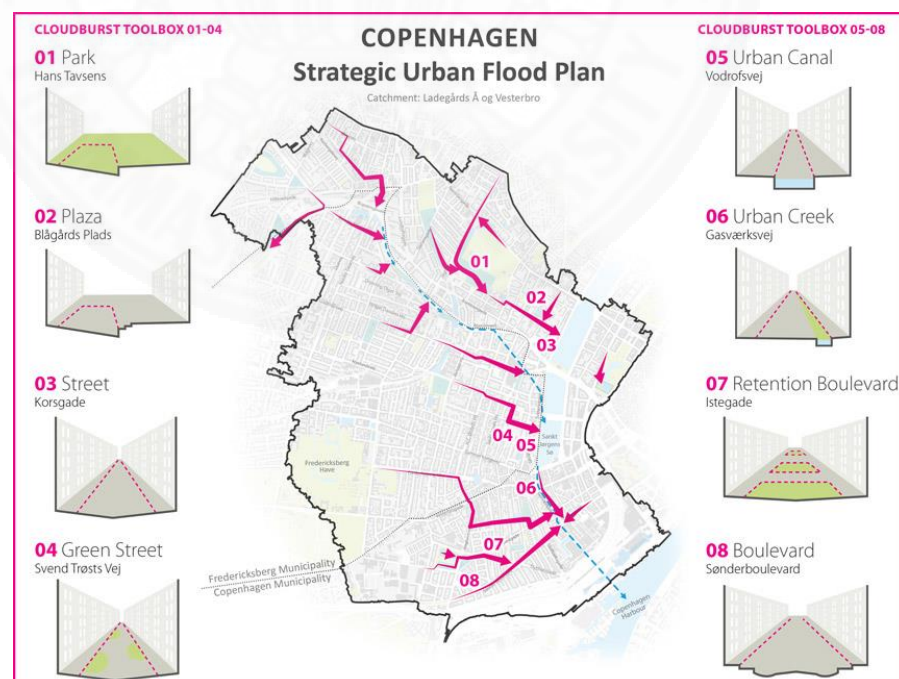


Figure 2.13 Project masterplan

Source: Landezine, 2015

A project designed by Ramboll Studio Dreiseitl, Denmark, as in 2011, there is a cloudburst or an extreme amount of rainfall in short amount of time occurred in Copenhagen, creating flood incident (rainfall is higher than 150 millimetres within 2 hours). This triggers the city to design an adaptive mechanism towards climate change impact by implementing new design approach of 'blue-green' onto the existing urban spaces. In addition, the approach is a product from a collaborative effort between public and private partnership, for example, planners, engineers, politicians and private investor aiming for a synthetic relationship by integrating adaptation solutions, existing urban spaces and feedbacks from participatory sessions in order to encourage and raise awareness on citizen's needs and interests. After project implementation, higher retention capacity within the urban grounds, public spaces and parks increased property value by 10-15% and the citizens tend to be happier and more active due to the greener environment.

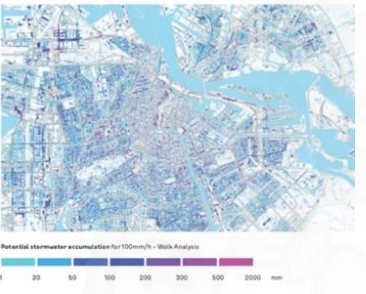


### **2.7.5 Amsterdam Rainproof, The Netherlands**

This project inspired by '*Strategic urban flood masterplan*' in Copenhagen, Denmark. The design concept and implementation are very similar to the mentioned case above which it aims to raise the direction and awareness of selecting different measures for implementation, Thus, stress testing method of this project is very effective tool using to identify precisely measurable risks and level of risks exposure on Amsterdam map, this also illustrates the interconnection of rainwater and cityscapes means that rainproofness has to be viewed in holistic picture including both interconnection and it on per area units. In addition, there are 57 rainproof measures in total with 5 strategic solutions ranging from: (1) stormwater detention, (2) retention to discharge, (3) infiltration, (4) stormwater resistant construction and (5) water harvesting method implementing on variety of neighborhood characters categorised by physical, technical and social characteristic of the area.

### 2.7.5.1 Stress Testing Method

This stress test (WOLK analysis) based on rainfall scenario of 100 mm/hour to perform the testing aiming to determine level and area of risks precisely through 3 stages of stress testing below:

**Table 2.2** Stages of stress testing

Initial stress test	Second stress test	Determine level of urgent area
 <p>Potential stormwater accumulation for 100mm/hr - Walk Analysis</p> <p>1 20 50 100 200 300 500 2000 mm</p>	 <p>Stormwater depth in public spaces 100 mm in 5 days</p> <p>Streets with stormwater depth &gt; 200 mm</p>	 <p>Potential stormwater accumulation for 100mm in 2 hours in bottleneck analysis</p> <p>1 20 50 100 200 300 500 2000 mm</p> <p>Extremely urgent: Risk of serious damage and disruption of accessibility</p> <p>Very urgent: Risk of damage and disruption of traffic</p> <p>Urgent: Risk of property damage</p>
<p>This mapping illustrates how stormwater spreads across the urban surface, revealing different depth of water on both public and private grounds. However, this stress test does not include sewer system capacity into accurate account.</p>	<p>This progress conducted by running 3Di-simulation of Amsterdam, performing hydrodynamic integration between 3 important datasets: surface water, sewage system and subsoil providing a realistic data on stormwater depth, determining each area's ability to withstand rainwater 60mm/hour and 120 mm/hour</p>	<p>After 2 stress tests, this mapping illustrates precise risks impact with 2 dimensions of (1)potential stormwater accumulation and (2)priority of areas with level of urgent, means that they can evaluate and conduct right method to manage the risks in different scale and level of impact from stormwater based on 60mm/hr.</p>

Source: Amsterdam Rainproof, 2016

### 2.7.5.2 Strategic Plan



**Figure 2.14** Strategic plan

Source: Waternet's Amsterdam Rainproof magazine, 2018

This map illustrates the solution possibility by implementing different strategy onto map with different level of risk exposure, managing the city of Amsterdam in a holistic picture, identifying which potential ways (capture, detained, directed or infiltrated) of managing water should be implemented on each district. Moreover, the function of each interventions and plan design is generated by the collaboration between both public and private stakeholders of the city, including the people of Amsterdam, creating a people co-owner of the solution (Waternet's Amsterdam Rainproof magazine, page 26).

## 2.8 Site Background

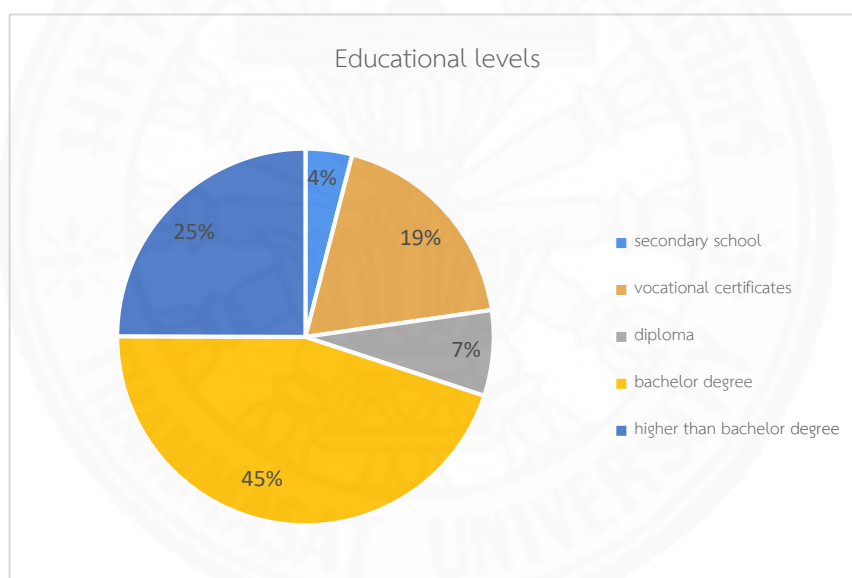
Prachanivate 2 community consists of 280 Rai or 0.448 square kilometres with a population of 1919 person, 622 households with 49 abandoned and 573 living units. The concept of building the community has been distributed around 1962-1963, during that time, Thailand has policy on development of informal settlements in Bangkok due to the rapid urbanisation. NHA is the governmental unit that assigned to provide new communities, Prachanivate 2 is also included in the plan. The construction of the community started in 1968 and finished around 1972 and started to allow people to move in at the end of 1973 until present. Moreover, community has been organized only the land allocation at first, then developed into pilot gated community with all the utilities and services such as community common spaces, playgrounds, footpaths, etc. Each houses' plot area is approximately 300 square metres (Community annual plan, 2019).

### 2.8.1 Community Future Development Plan

The community annual plan for 2016 focusing on 6 important aspects which aimed to achieve by 2019. There are 2 aspects focuses on responding towards flooding problems and rapid growth of elder population consists of (1) improvement of drainage infrastructure where the community aims to dredge the sewer pipeline in every alleys including the maintenance of public drainage infrastructures and (2) the physical implementation of universal design to accommodate the rapid growth of aging population of the community by implementing ramps for every entrances of each community playgrounds. According to the community 2016's annual development plan means that the community committee already see the needs of moving towards being a flood resilient and creating a suitable environment accommodating active aging population.

### 2.8.2 Community Social Structure

Educational levels of the community residents are the distinctive measure for evaluating the social structure, the chart below illustrates percentages of educational level ranging from secondary school to higher than bachelor's degree. The majority of the population in the community are in bachelor's degree level (45%) and above (25%), means that the residents are having a high educational background and can expected to be understand the changes occurring with future perception of future. Moreover, referring to the educational level, this can be used to determine the job occupation and annual family salary which can expected to be classified as middle to middle-high income (Community Database, 2016).



**Figure 2.15** Community educational background

Source: Community database, 2016

### 2.8.3 Past Flood Events

(i) Around the year 1975, there are a flooding incident in Bangkok and Metropolitan Regions (BMR) including where the community locates, huge amount of water as flushed in from the canal into Prachachuen road causing the area had been flooded under 3 metres high water for 2 full months. However, this area has not yet

exposed to this huge flooding incident before for the past 30 years means there are no proper mitigation process and mechanisms towards the problem. Also, shared the money to buy their own community pumping machine, planed for the machine to be accommodate higher amount of water in the future.

However, after the flood event in 1976, the community committee and local government held a meeting discussed based on the possibility of upcoming floods in the future. During that time, the meteorological department of weather forecast stated that this severe flood event only has the possibility to be happening once every 30 years. However, in 1978 there are similar flooding event happening.

(ii) in 1978, flood incident happened due to the immerse flood from the northern Thailand together with sea level rises causes huge amount of water to be flushed into Bangkok and metropolitan regions. During that that period of time, the flood map is not planned to cover the area surrounding Bangkok means the community has to face this problem on their own. However, as the community has faced huge flood incident before in 1975, the residents are well aware and prepared as the community committee hosted a meeting on preventing the community to be flooded by built dykes surrounding the community area, together with implementing numbers of pumping machines. Moreover, the supportive fees on implementing each flood prevention actions especially for dykes are from the community residents' shares; 500 baht per houses, as for the pumping machines are both from the community themselves and local government supports. Furthermore, there is a major support for both physically and economically from mr. Jumlong Srimuang on soldier's GMC vehicle for better accessibilities. Thus, the community managed to prevent 70% - 80% amount of water from flooding, calculating approximately 60 centimetres high on 280 Rais (0.448 square kilometres) or 280,000 cubic meters (Prachanivate 2 in my dream, 1980s).

## CHAPTER 3

### RESEARCH METHODOLOGY

The methodology of this research topic “Designing Flood Resilient and Inclusive Urban Community: A Case of Ageless Lifestyle in 1960s Prachanivate 2 Housing” consisted as follows:

- 3.1 Research Process
- 3.2 Research Conceptual Framework
- 3.3 Source of Data
  - 3.3.1 Primary Data
  - 3.3.2 Secondary Data
- 3.4 Sample Selection and Tool
  - 3.4.1 Sample Selection
  - 3.4.2 Tool
- 3.5 Data Analysis
- 3.6 Risk and Design Proxy Diagram

**Table 3.1** Research Process table showing the overall steps from start until the end.

RESEARCH TOPIC	RESEARCH OBJECTIVES	RELATED THEORIES/CONCEPT	STUDYING FACTORS	RESEARCH METHODOLOGY	DATA ANALYSIS AND DISCUSSION	CONCLUSION AND RECOMMENDATION
Designing Flood Resilient and Inclusive Urban Community: A Case of Ageless Lifestyle in 1960s Prachanivate 2 Housing	<ol style="list-style-type: none"> <li>1) To study social and physical changes and how these exacerbate risk from flooding in the past; 30 years period</li> <li>2) To study existing mechanism to find possible ways of designing them to be an adaptive mechanism towards more frequent and heavier rainfalls</li> <li>3) To find possibility of designing spatial design strategies which limit the uncertainty and accommodate the changes of user group</li> </ol>	<p><u>Social</u></p> <ol style="list-style-type: none"> <li>1) Theory and concept of impacts of demographic changes</li> <li>2) Theory and concept of ageless lifestyle</li> <li>3) Theory and concept of participatory approaches</li> </ol> <p><u>Physical</u></p> <ol style="list-style-type: none"> <li>1) Theory and concept of climate change</li> <li>2) Theory and concept of participatory architectural design</li> <li>3) Theory and concept of inclusive design</li> <li>4) Theory and concept of urban flood management</li> <li>5) Theory and concept of Water Sensitive Urban Design</li> </ol>	<ol style="list-style-type: none"> <li>1) Site background and physical development surroundings</li> <li>2) Autonomous adaptation in 2 scales:               <ol style="list-style-type: none"> <li>2.1 community</li> <li>2.2 individual</li> </ol> </li> <li>3) Climate change impacts on precipitation magnitude and frequency</li> <li>4) Social and household structure changes Thailand and Nonthaburi</li> </ol>	<p><u>Research tools:</u></p> <ol style="list-style-type: none"> <li>1) Collections of physical data</li> <li>2) Map of the site in different years: past and present</li> <li>3) In depth interview questions for key informants</li> </ol> <p><u>Data collection:</u></p> <ol style="list-style-type: none"> <li>1) site survey to collect existing physical data on water management facilities and autonomous adaptation</li> <li>2) Quantitative and qualitative data on demographic and physical surroundings change</li> </ol> <p><u>Sample selection:</u></p> <ol style="list-style-type: none"> <li>1) Community committee</li> <li>2) residents with age 50 and above who lives in the community for 10 years or longer</li> </ol>	<ol style="list-style-type: none"> <li>1) Analysing data from theories and concept for interview questions</li> <li>2) Analysing data on existing water management mechanisms as well as the site contexts and how they correspond</li> <li>3) Cross analysing the data to see the relationship for further physical and social spatial design strategies</li> </ol>	<ol style="list-style-type: none"> <li>1) Conclusion on the existing mechanisms condition and adaptation of the community</li> <li>2) Conclusion on the risks and problems that the community is facing towards climate change</li> <li>3) Provide spatial design strategy on prevention and mitigation of rainfall flooding</li> </ol>

Source: Researcher, 2019

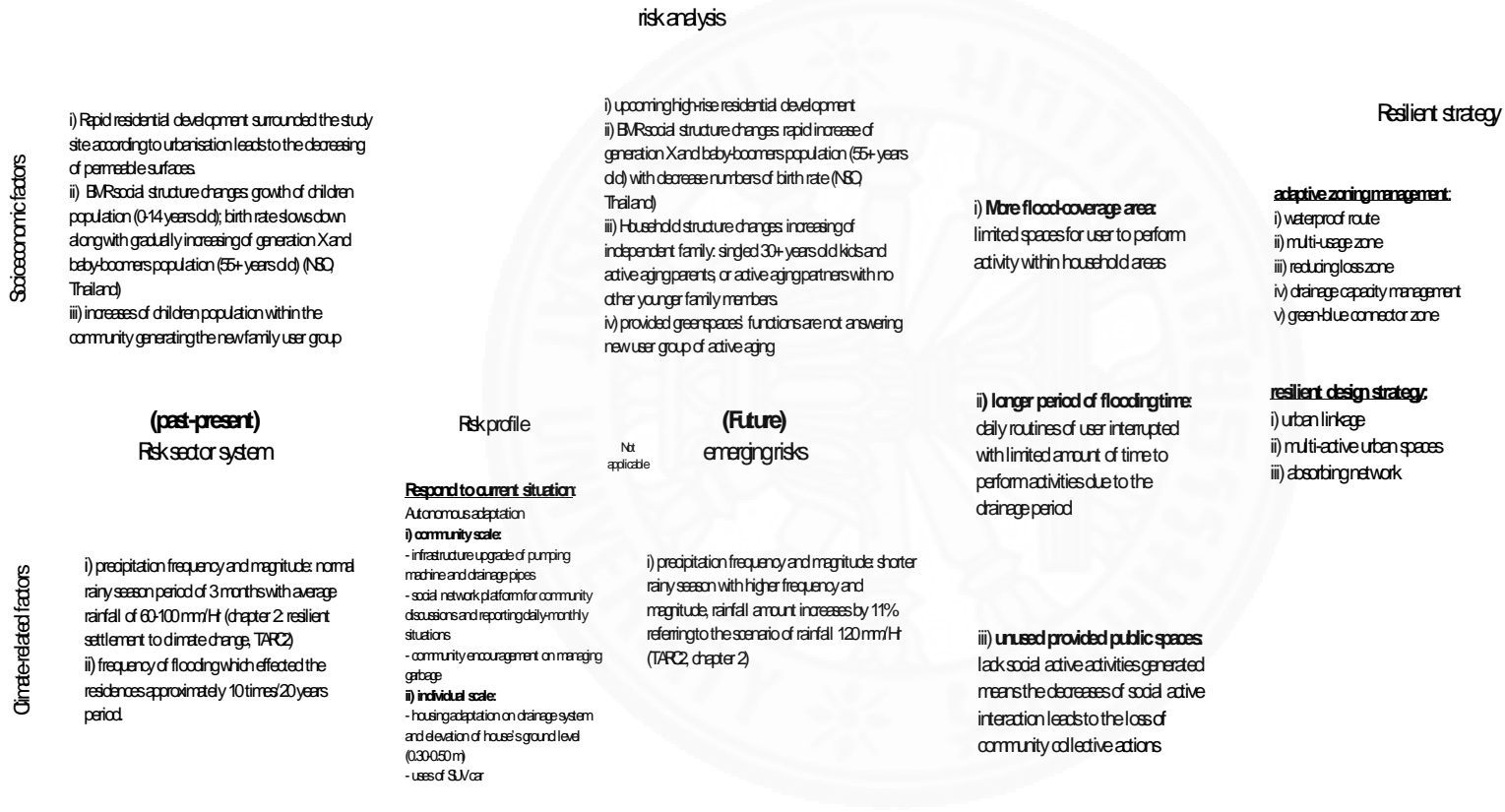


Figure 3.1 Research framework

### 3.3 Source of Data

The data that has been use in this research topic “Designing Flood Resilient and Inclusive Urban Community: A Case of Ageless Lifestyle in 1960s Prachanivate 2 Housing” divided into 2 types which are 1) Primary Data and 2) Secondary Data

#### 3.3.1 Primary Data

Primary data is the data which researcher collects by themselves focusing on the research topic that determines what data to be collect first-handed from the original source. This can be uses to conduct on further analysis (Institute of Work and Health, 2015). The primary data of this research divided into 2 sets which are:

##### 3.3.1.1 Site Survey

Surveying the existing water management mechanisms and physical autonomous adaptation such as the draining pipelines, water pumping stations, elevated ground level and individual houses’ pumping facility representing the relationship between the site and how they cope/adapt physically towards flooding also, how the study site relates to the surrounding contexts; new housing development and draining canal surrounding.

##### 3.3.1.2 Key Informant Interview

Focusing on 3 groups of the residents who 50 years old, living in this community for 10 years or longer on how the rainfall flooding affect them and how do they prevent and mitigate the impact among themselves, using which kind of adaptation or measures.

### 3.3.2 Secondary Data

Secondary data is administrative data which collected by agency or governmental units on statistical numbers such as annual precipitation, demographic changes over a long period of time (IWH, 2015).

(1) Quantitative data such as demographic changes of the province on the age group and the internal migration, annual rainfall and statistical data on flooding

(2) Qualitative data such as comprehensive plan and floodway plan of the province where the site is locates, also the data on draining system: capacity of the pumping station and the pipelines

## 3.4 Sample Selection and Tools

### 3.4.1 Sample Selection

Sample group of this research is the residence who has been living in the community of Prachanivate 2 for 10 years and over with the age 50+ (Generation X or the Baby Boomer). This will be categorised into 3 groups which are the independent living, dependent living and living within the community since born:

(1) Independent living group are the group of people who has been living by their own or with their partners but not the children.

(2) Dependent living group are the group of people who has been living with their family members ranging from parents on to their children and grandchild.

(3) Population group who has live in this community since born and has parents who will become an active aging population within 5 years period.

### 3.4.2 Tool

(1) Key informant interview questions which provide questions based on the condition of the houses, individual autonomous adaptation, problems they are facing during rainfall and flooding, so this can be used to develop into strategy design development.

(2) Map of Prachanivate 2 community with existing identification of water drainage system and high-risk area. Also, for further survey on physical condition and details of the community, moreover on the social mapping of the key informant interviewer's locations.

### **3.5 Data Analysis**

The existing map of the community will be displayed using AutoCad 2017. Following by the survey data which will be plotted using Adobe Photoshop CC to specify the updated household condition and location, existing drainage mechanisms together with infrastructure upgrade location of the community, high flood risk area, physical autonomous adaptation and the key informant interviewer's location categorised in mentioned group. Moreover, the data from the key informant interview will also be decoded and displays on physical mapping to see the relationship between socioeconomic feedbacks and physical data collection. This will later on be use as a main tool designing adaptive and resilient strategies.

## CHAPTER 4

### RESULTS AND DISCUSSION

This chapter will illustrate secondary data of the study area: Prachanivate 2 community, Nonthaburi with physical data collections within the community using the criteria which related to flooding and ageless lifestyle of the focal user groups as mentioned in sample selection section. Moreover, the result of in-depth interview will also be displayed along with the physical data collection to be tools for integrated analysis further. The provided data collection and analysis are aimed to meet objective 1 and 2, also to use as tool to generate product to meet objective 3 which will be clarify further remotely in this chapter. The data collection and analysis of study area will be consisted as follow:

#### 4.1 Secondary Background Data of Study Site

##### 4.1.1 Community Flood Mitigation Process: Autonomous Adaptation

##### 4.1.2 Physical Development Timeline

#### 4.2 Physical Data Collection Results from Study Site

##### 4.2.1 Study Area Context and Transportation Network

##### 4.2.2 Autonomous Adaptation within the Community Area

##### 4.2.3 Permeability and Accessibility of Community Urban Spaces

##### 4.2.4 Time-Related Activity Map

#### 4.3 In-depth Interview Results

##### 4.3.1 Summary of Interview Session 1 (without Community Map)

##### 4.3.2 Summary of Interview Session 2 (with Community Map)

#### 4.4 Integrated Analysis between Physical Data Collection and In-Depth Interview Results

##### 4.4.1 Flood Hazard Map

4.4.1.1 Past-Present Flood Hazard Map: 60 mm/Hour Rainfall

4.4.1.2 Future Flood Hazard Map: 120 mm/Hour Rainfall

##### 4.4.2 Integrated Analysis

4.4.2.1 Integrated Analysis: Socioeconomic Zoning

4.4.2.2 Integrated Analysis: Longer Flooding Period and

Coverage Area

4.4.2.3 Integrated Analysis: Public Space Usage

4.4.2.4 Integrated Analysis: Zoning Management Strategy

4.4.2.5 Integrated Analysis: Resilient Design Strategy

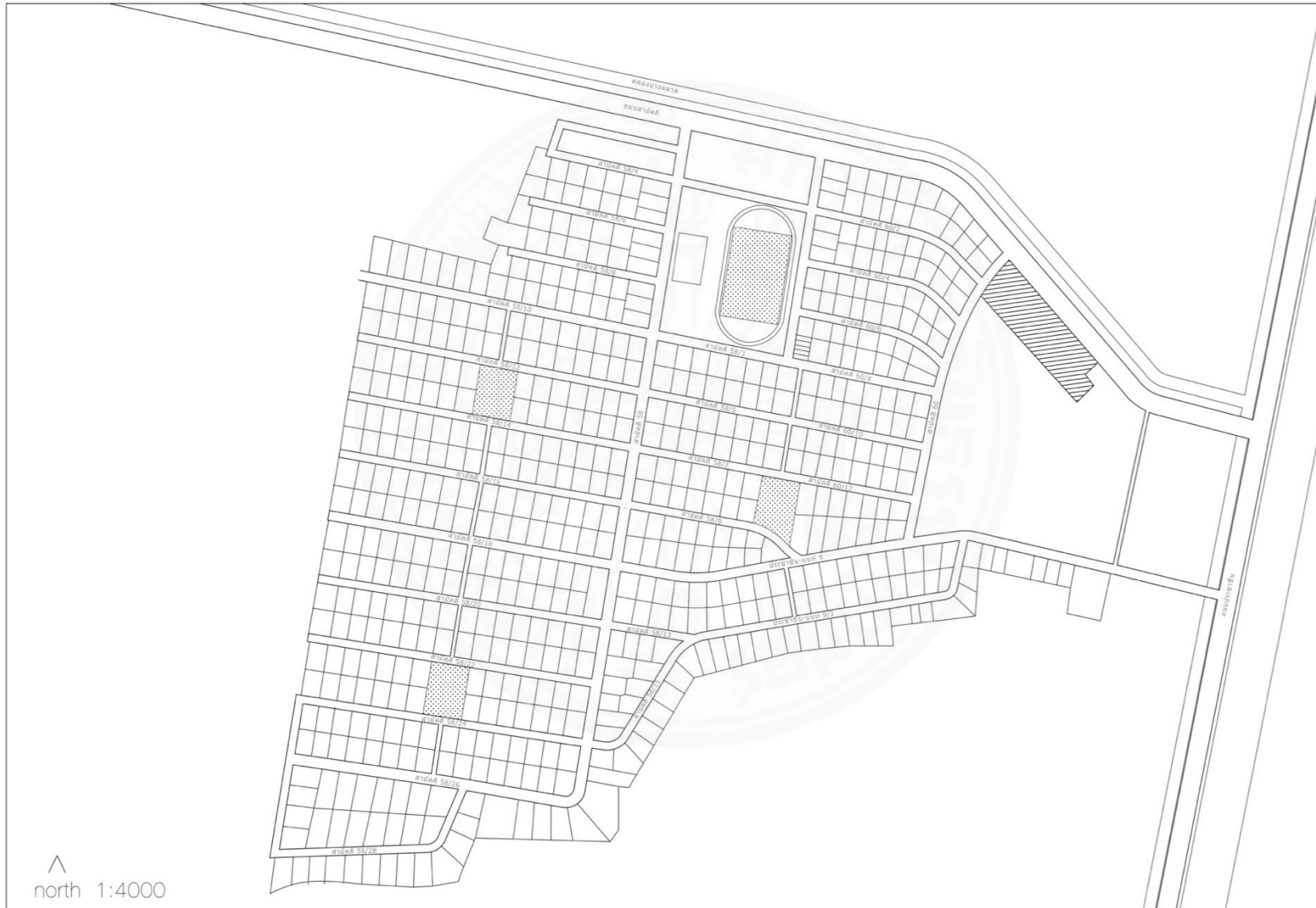
4.4.2.6 Integrated Analysis: Hazard Map After

Design Implementation

4.5 Data Analysis Reflection on Research Objectives

#### 4.1 Secondary Background Data of Study Site

Prachanivate 2 community consists of 280 Rai or 0.448 square kilometres with a population of 1919 person, 622 households with 49 abandoned and 573 living units. The concept of building the community has been distributed around 1962-1963, during that time, Thailand has policy on development of informal settlements in Bangkok due to the rapid urbanisation. NHA is the governmental unit that assigned to provide new communities, Prachanivate 2 is also included in the plan. The construction of the community started in 1968 and finished around 1972 and started to allow people to move in at the end of 1973 until present. Moreover, community has been organized only the land allocation at first, then developed into pilot gated community with all the utilities and services such as community common spaces, playgrounds, footpaths, etc. Each houses' plot area is approximately 300 square metres (community database, 2016).



**Figure 4.1** Overall community plan

Source: Researcher, 2019

#### 4.1.1 Community Flood Mitigation Process: Autonomous Adaptation

After the flooding incident, the community tend to be flood after heavy rainfalls, together with the rapid development surrounding, increasing the impervious grounds with higher surface runoff water means that the existing drainage systems and mechanisms are not enough to accommodate the rapid changes. In order to continue living in the area, the community has to adapt themselves towards flooding that occurs more often. This self-governed adaptation called autonomous adaptation.

Autonomous adaptation defined as the ability to have freedom to govern itself or control its own affair; or performing adaptation decisions reflecting your own needs (Cambridge, 2018). In climate change context, autonomous adaptation is a spontaneous act aiming to reduces risks from climate changes in every aspect including flooding from higher frequency and magnitude rainfalls. For the study area method, it categorised into 2 scale consists of (1) community scale: social network group, infrastructure upgrade and encouraging on management of garbage, (2) individual scale: uses of SUV car and houses modification on drainage system and houses level to be higher than ground level.




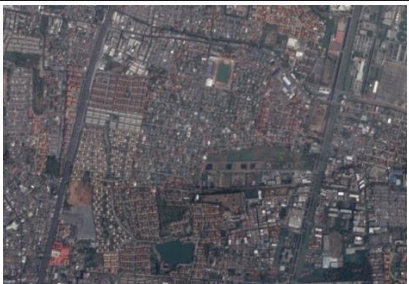
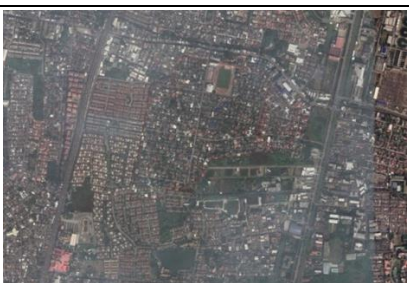
The table below illustrating the examples of existing conditions of the community consists of existing autonomous adaptation and condition of connecting alleys and public spaces.

#### 4.1.2 Physical Development Timeline

The table below illustrates the development timeline through a series of satellite maps ranging from 2004 to 2019 displaying how new housing development from rapid urbanisation occupied the area surrounding of the community, causes the rapid loss of open-green spaces reflecting the increased drainage capacity that the existing facilities has to manage.



**Table 4.1** Physical Development

year	Development satellite map	description
2004		Majority of the area surrounding the community are open and green with no further development, as you can see from the north of the map where new residential development just started to construct. Means that there still spaces which can be utilised to retain water.
2008		In 2008, the open spaces surround the community started to be occupied by new residential developments meaning there will be less space for water retention, higher impervious grounds causing higher surface runoff.
2012		There is a rapid development of gated community around the community in 2012, from the map, majority of the green open spaces area in 2008 are already occupied by mainly new housing developments. This illustrates the rapid loss of impermeable area.
2016		The map illustrating present contexts of the community and surrounding area, Majority of the area are occupied by new housing developments and the green open spaces are left with small patch adjacent to Prachachuen road, south-east of the community.
2019		The present condition of the study area and the developments surrounding, comparing to satellite image of 2004, with only 15 years period, the developments have already taken the majority of the open-green spaces in the area along with increased population density.

Source: Researcher Adjusted from Google Earth, 2019

## 4.2 Physical Data Collection from Study Site

The physical data collection criteria will be based on the important elements and factors which can be use as scenario-based assessment tool on past to present days flooding in order to develop further on categorising area into adaptive zonings and design resilient design strategy afterwards. The data will be categorised into 4 main parts as follow:

### 1) Study area context and transportation network

Providing surrounding context around the study area focusing on transportation networks, connectors and transit nodes with bus numbers, given the sense of direction and location of the study area (as shown in figure 4.2.1).

### 2) Autonomous adaptation within the community area

Autonomous adaptation level categorised of into 2 scale: (1) community scale, exploring through community physical applications of infrastructure upgrading and social encouragement on social networking group, reporting current situation based on flooding events and community encouragement on managing garbage within public grounds and (2) individual scale, this consists of 3 main autonomous adaptation methods consist of: (2.1) house renovation to be more elevated, (2.2) drainage system from the house into public grounds (community streets) and (2.3) SUV car users in the community area. Furthermore, the collected data can be used to illustrates the percentage of each autonomous adaptation applications (as shown in figure 4.2.2).

### 3) Permeability and accessibility of community urban spaces

The possible existing physical elements such as the condition and permeability of small public playgrounds and parks, footpaths, connecting alleys each small block or even the streets themselves can be uses as a designing tools in strategic scenario design afterwards. This collection will consist as follows: location of water pumping machine, (1) condition and permeability of pedestrian alleys and footpaths,

(2) vacant land, (3) public greenspaces usage, condition and maintenance, (4) condition, location and accessibility of connecting alleys. The mentioned data can also be transformed into percentages, illustrating the level of accessibility and permeability of the study area (as shown in figure 4.2.3).

The photos of existing condition from study area will be displayed after the map with annotations on map (ii) autonomous adaptation within the community area and (iii) permeability and accessibility of community urban spaces

#### 4) Time-related activity map

The data set illustrates the relationship of users, urban spaces and usage hours within the community to see the overlapping area of usage space to evaluation tool to find the possibility of implementing suitable design and adjusting programs of each urban spaces (as shown in figure 4.2.4).

#### 5) Building usage and characteristics

The map displays the uses, program and characteristics of each area within study area, categorising into zoning consists of: (1) commercial usage, (2) residential clusters, (3) residential usage and (4) apartment building which will be use as a tool for socioeconomic zoning afterwards (as shown in figure 4.2.5).

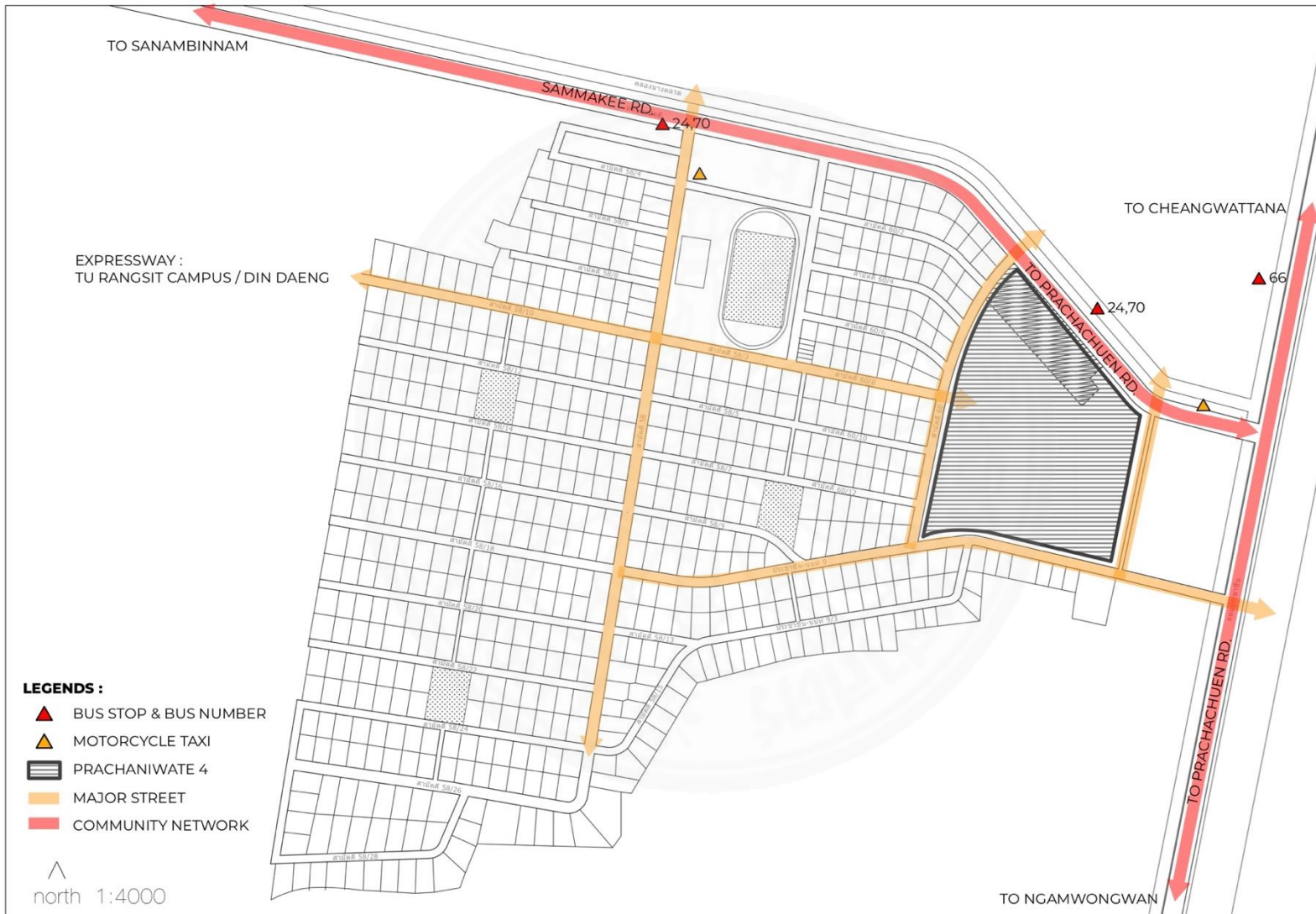


Figure 4.2 Study area context and transportation networks

Source: Researcher, 2019



Figure 4.3 Autonomous adaptation within the community area

Source: Researcher, 2019



Figure 4.4 Permeability and accessibility of community urban spaces

Source: Researcher, 2019



- A)** How each individual housing implement their own drainage line towards the public grounds.
- B)** Displaying the level that majority of each houses will be elevated (30-50 centimetres)



- C)** Existing accessible connecting alley which can connects people towards the existing public parks.
- D)** Connecting alleys which is under-maintenance and cannot be accessed.

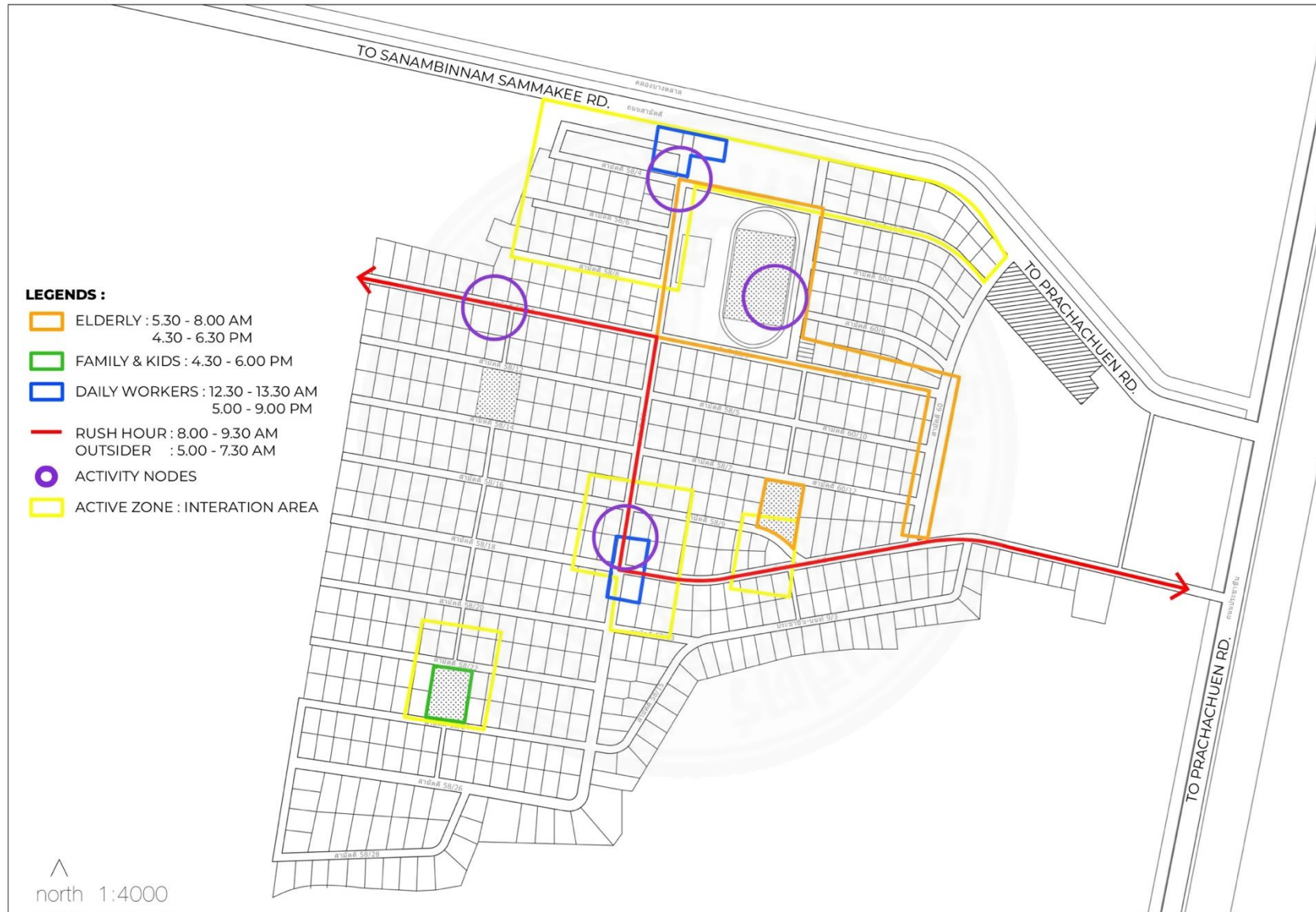


E) The existing public space with good maintenances and actively used by the community.

F) Existing public space with no maintenances and not used by the community residents.

**Figure 4.5** Conditions of existing study area

Source: Researcher, 2019



**Figure 4.6** Time-related activity map

Source: Researcher, 2019

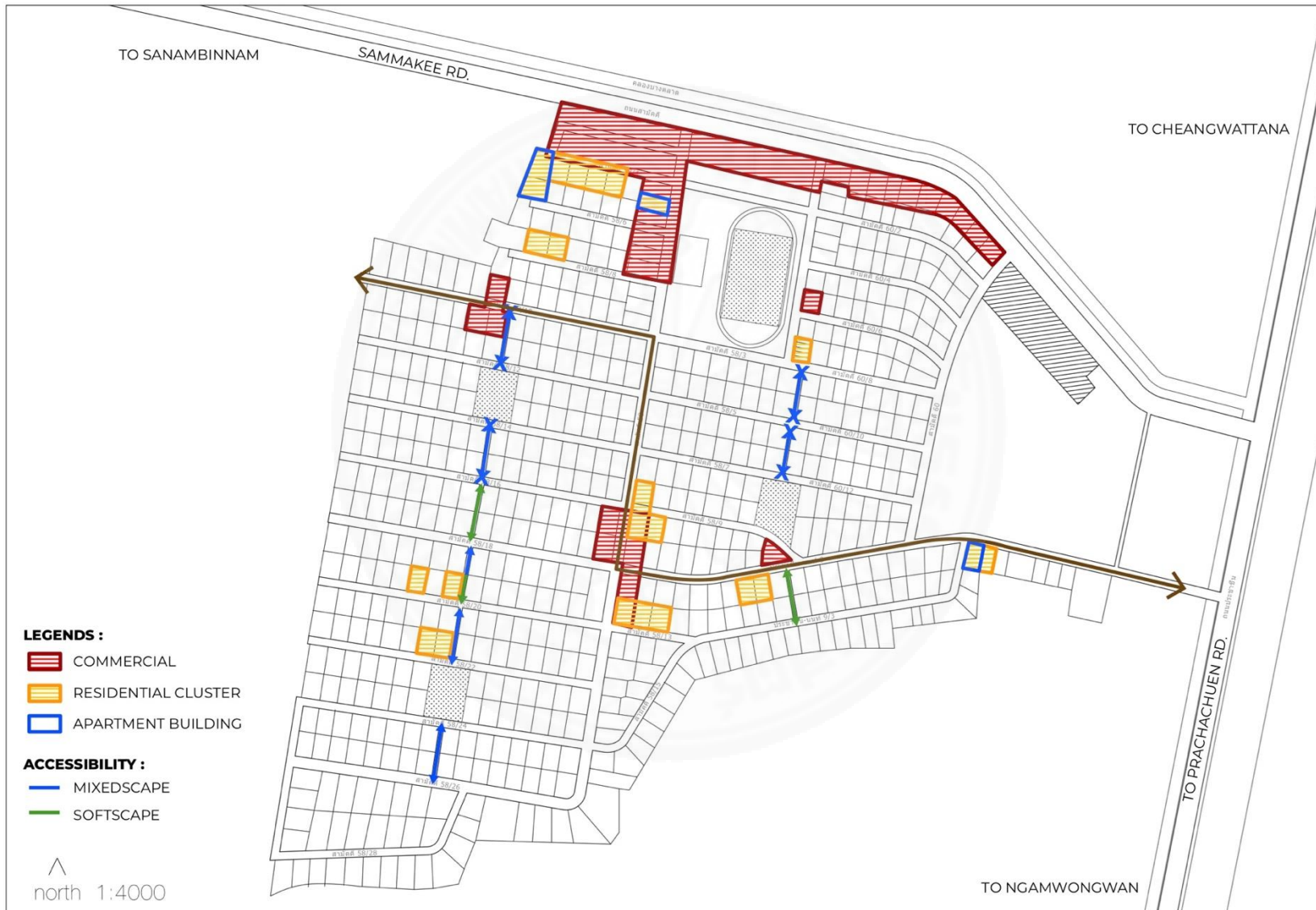


Figure 4.7 Building usage and characteristics

Source: Researcher, 2019

### 4.3 In-Depth Interview Results

For this section, it will display the result from an in-depth interview session (40 minutes to 1 hour) from 12 key informant person using purposive sampling to pick the interviewees together with the criteria from chapter 3 in 3.4.1 sample selection section which consists of 3 main group as stated:

1) Independent living group are the group of people who has been living by their own or with their partners but not the children, this group consists of 3 persons.

2) Dependent living group are the group of people who has been living with their family members ranging from parents on to their children and grandchild, this group consists of 6 persons.

3) Population group who has live in this community since born and has parents who will become an active aging population within 5 years period, this group consists of 3 persons.

The interview questions will be divided into 2 parts: Interview questions only and interview questions with tool (blank community map) so there will be a tangible data on both physical and social aspects which illustrates each user groups' perception towards flooding and their differences in lifestyle. The summary of interview questions will be displays below.

### 4.3.1 Interview Questions Without Community Mapping

#### (figure 4.3.2: interviewees location)

(1) Questions based on point of view, experiences and adaptation towards flooding

From the interview, community's perception on the definition of flooding is when the water level has gone further than the footpath height and will be affects their daily life routine. However, the issue of flooding after heavy rainfall is not a factor that influence people in the community to move out of the area as they mentioned on their acknowledgement of how community adaptation towards the flooding situation by upgrading drainage infrastructure; both pipes and water pumping stations, after the upgrading, the flood water after heavy rainfall takes much shorter time to drain from whole day to only 2-3 hours so it does not concern the people in the community as much as before. Moreover, there is also adaptation in the scale single household as the majority of the houses are elevated for 20-50 cm with draining system within the house towards the public grounds. Even though the majority of the population are familiar with commuting and dealing with flooding and the impacts are decreasing according to the community adaptation, but flooding is still one of the important factors choosing higher cars (SUV) to use within the community.

(2) Questions based on lifestyle and demographical data of the interviewees

This section will be focusing on the lifestyle, daily routine which can be affected by flooding incidents and demographical data such as age, family members and years that the interviewees had been living in the community. From the interview, the average age of overall interviewees from 3 main focal groups is 52 years old, the majority of the population over 60 years old has been living in the community from the year of 1979-1983 means that people started to move into the area 10 years after the community was constructed. Furthermore, the first generation who has been living in the area mostly are retired and having a variety of hobbies such as karaoke singing with friends, doing stock markets, playing cards, social volunteering and exercising. The mentioned activities are performed by commuting in and out of the community using cars, bicycle and motorcycle. Furthermore, the majority of the population over 50

years old are still staying with 2 or more family member. For example, staying with their partner and their child, the average of their child's age are 30-40 years old. Also, this group of population are planning to live here during the retirement as it is very convenience to access varieties of city utilities and services e.g. hospital and shopping mall. As well as the location of the area is very safe, quiet and peaceful with enough facilities within the community e.g. public playground and park, also the plot size is quite big, so the level of privacy is also quite high.





Figure 4.8 Interviewee location categorised by groups

Source: Researcher, 2019

### 4.3.2 Interview Questions with Community Mapping

This section will be displays using community map as a medium illustrating the community's perception such as the chosen route when they face flooding or the area in their opinion that takes shortest and longest time to drain. Also, the results based on their knowledge on flooding impacts, adaptation within community ground by explaining their opinion on the factors that causes flooding and the potential location which can retain water in the future. (as shown in figure 4.3.4) Provided interview questions (appendix C) are as follow (question i) and ii) the interviewees will be asked to draw on blank community map):

(1) when flooding occurs, what is your preferable mode of transportation and which route in the community you choose in order to avoid flooding?

(2) please specified the location of pumping machine and pumping station that you know, also how long will it take for the community to be dry or commutable and which area will dry first?

(3) please list and explain the factors causing the community to be flooded.



Figure 4.9 Community map displays the result from interview session with community mapping

Source: Researcher, 2019

### 4.3.3 Community Condition During Flood Period



**Figure 4.10** Condition of the community after heavy rainfall during the night time causing the community and the road surrounding flooded, causing traffic jam problems.

Source: Instagram accounts @lovemeloveyd and @napaphanoi



**Figure 4.11** Condition inside the house after heavy rainfall for 2-3 hours, causing it to be impossible to access in and out the community.

Source: Researcher, 2019

#### 4.4 Integrated Analysis Between Physical Data Collection and Interview Results

Integrated analysis will combine and overlay the layers of physical data collection and reflection from in-depth interview results in order to generate a systematic integrated analysis which can be used to create a strategic plan with different scenarios., categorising into different data layers as follow:

##### 4.4.1 Flood Hazard Maps

###### 4.4.1.1 Past-Present Flood Hazard Map: 60 mm/Hour Rainfall

Stress test in this research is the progress of evaluating level of risks using rainfall scenario: 60-100 mm/hour and interviewing feedbacks as tool to determine different impacts of risks on the physical map, illustrating the range of flooding impact with 2 factors: (1) flooding time and (2) drainage time. This leads towards designing a zone management strategy afterwards (figure 4.12).

###### 4.4.1.2 Future Flood Hazard Map: 120 mm/Hour Rainfall

For future risk map, using the increased amount of rainfall: 120 mm/hour (Wijitbusaba, TARC 2016) reflecting the development of impacts on community fabric with 2 mentioned factors: (1) flooding time and (2) drainage time, illustrating the increased possible impacts on the physical fabric of the community (figure 4.13).

##### 4.4.2 Integrated Analysis

###### 4.4.2.1 Socioeconomic Zoning

Displaying the zoning of user groups on the study area determining by building usage and characteristics together with time-related activities data set which will be categorised into 4 main zones consists of: (1) new family with children, (2) daily workers, (3) independent elder family and (4) generation X and baby boomers. This can be use as design tool for resilient design strategy for more precise program and design implementation onto each urban space (figure 4.14).

###### 4.4.2.2 Longer Flooding Period and Coverage Area

Referring to climate change scale, the rainfall increases from 60mm/hour to 120 mm/hour (Wijitbusaba, TARC2 2016) together with the layers of physical data collection: autonomous adaptation, permeability and accessibility of

footpaths and connecting alleys, physical development surrounding, flood hazard map and existing mechanisms displaying how the flood coverage area and time period has increases in the community as there are higher amount of rainfall, causing higher amount of flood water from the surrounding developments to flows and trapped in the area. The existing mechanisms are not enough managing the increased flood water within the area (figure 4.15).

#### 4.4.2.3 Public Space Usage

The map displays the integration between time related activity, interview reflections and building usage together to present how the existing public spaces within the community are used by different user group and different time period, also which area are not actively used by the residents. This map can be use as tool leads towards implementing resilient design strategy with higher precision of programming of each public space (figure 4.16).

#### 4.4.2.4 Adaptive Zoning Management Strategy

This integrated analysis map generated the first layer of strategic design and implementation of adaptive zoning, aiming to provide solid boundary within the study area defining priority and scale of uncertainty management which the area needed, minimising risks also, providing clear guidance for resilient design strategy implementation afterwards (figure 4.17).

#### 4.4.2.5 Resilient Design Strategy

The application of resilient design strategy will be taken place according to the adaptive zoning strategy as a tool for managing the uncertainty, the zoning strategy will provide a management scale, means that, the implementation of each design strategy will aimed to manage different scales of uncertainty as the adaptive zoning criteria (figure 4.18).

#### 4.4.2.6 Integrated Analysis: Hazard Map After Design Implementation

The map illustrates the future possibility on how the community changed after the adaptive zoning management and resilient design strategy implementation using future rainfalls of 120 mm/hour as justification factor on evaluating risks that decreased. Also, specify how the future risks will be managed (figure 4.19).

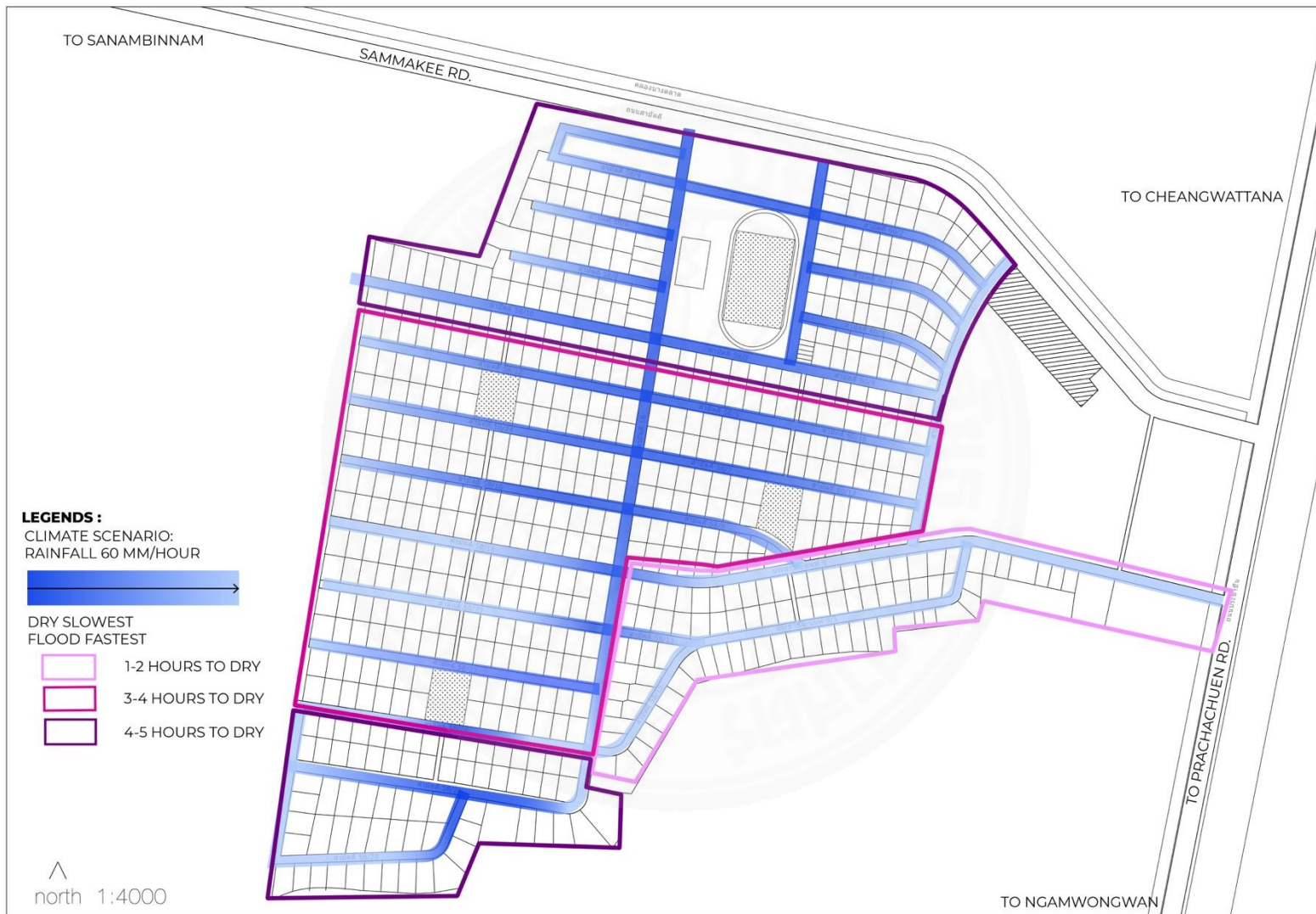


Figure 4.12 Past-present flood hazard map (60 mm/hour)

Source: Researcher, 2019

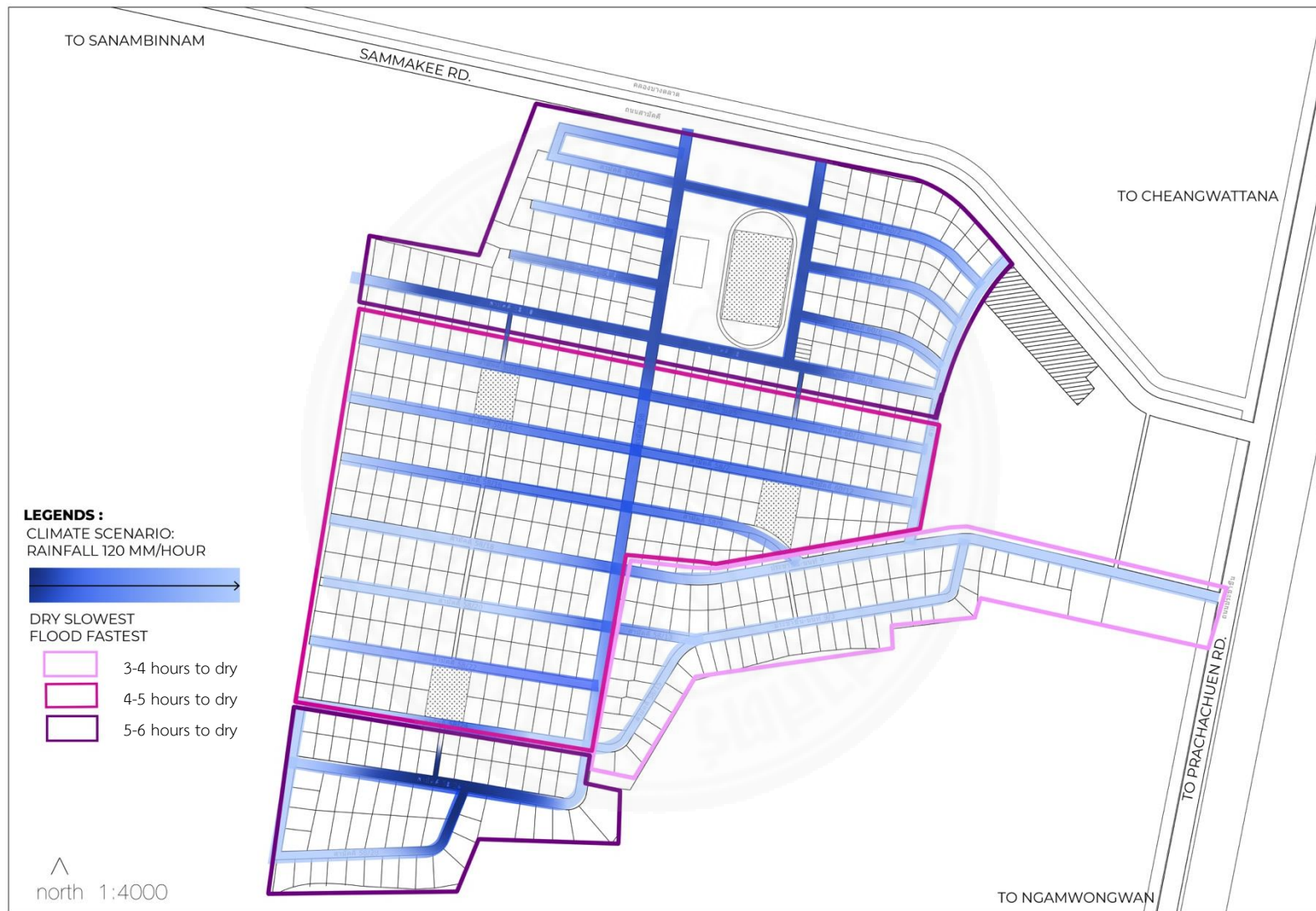


Figure 4.13 Future flood hazard map (120 mm/hour)

Source: Researcher, 2019

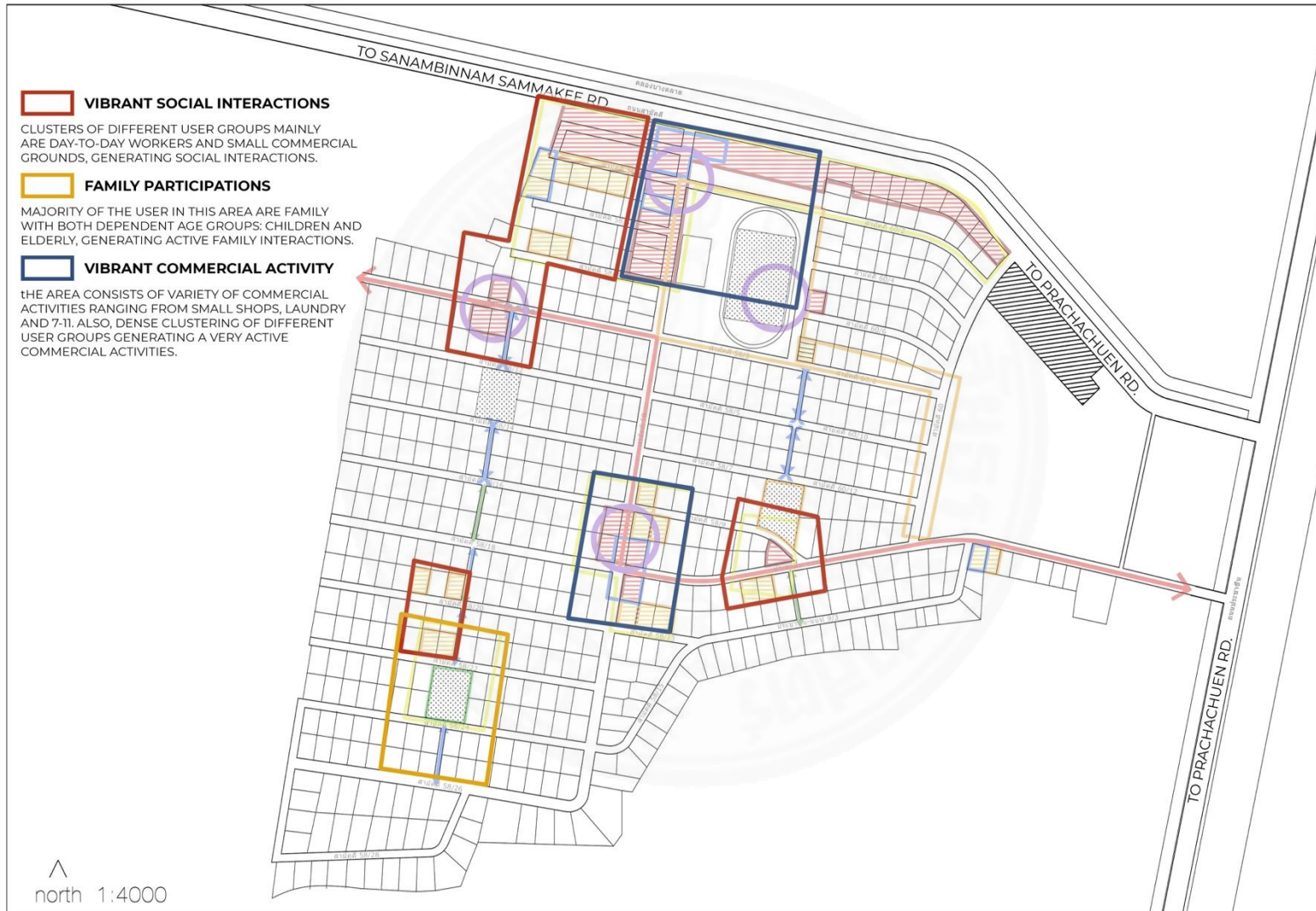


Figure 4.14 Integrated analysis: socioeconomic zoning

Source: Researcher, 2019

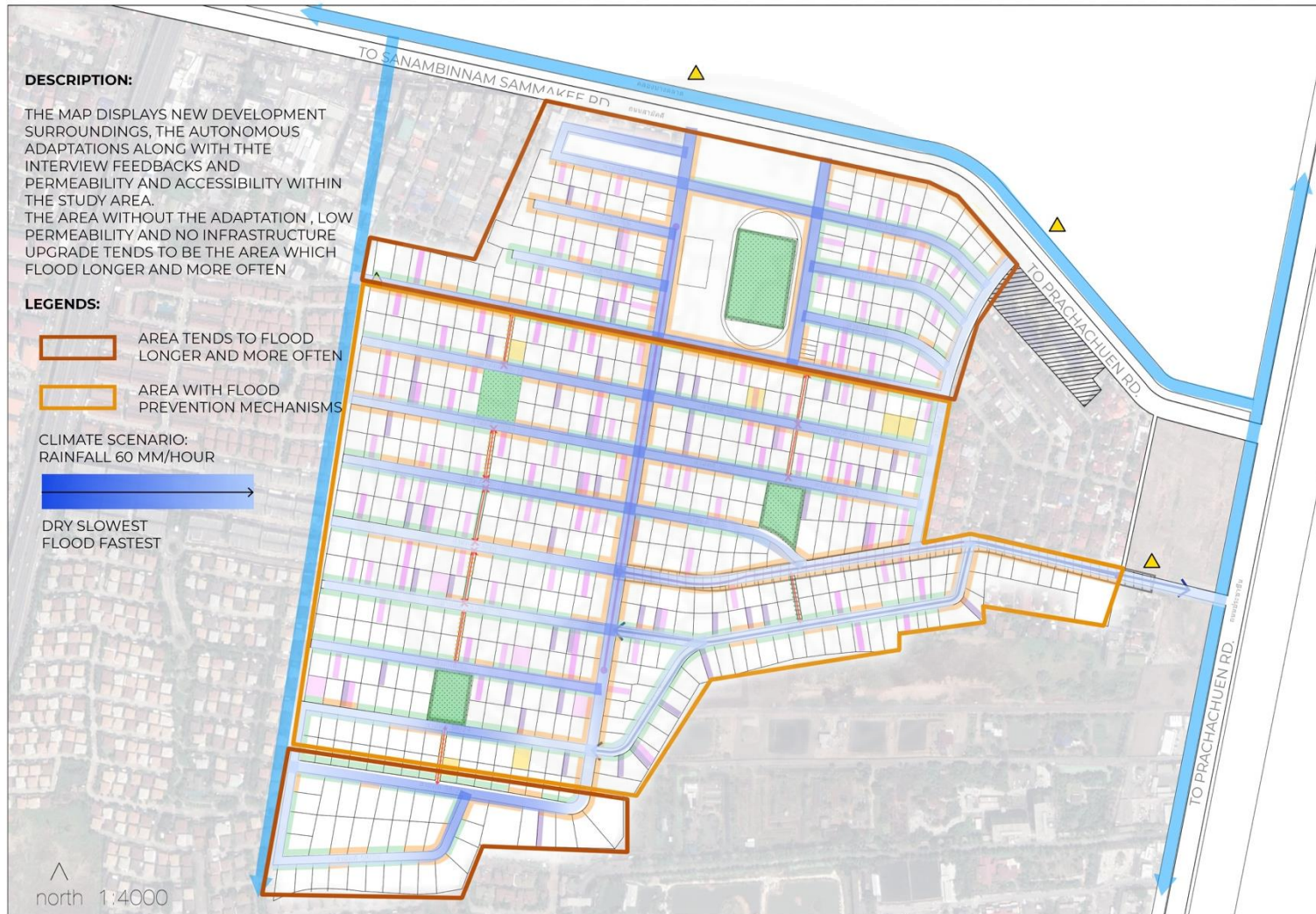


Figure 4.15 Integrated analysis: longer flooding period and coverage area

Source: Researcher, 2019



Figure 4.16 Integrated analysis: public space usage

Source: Researcher, 2019

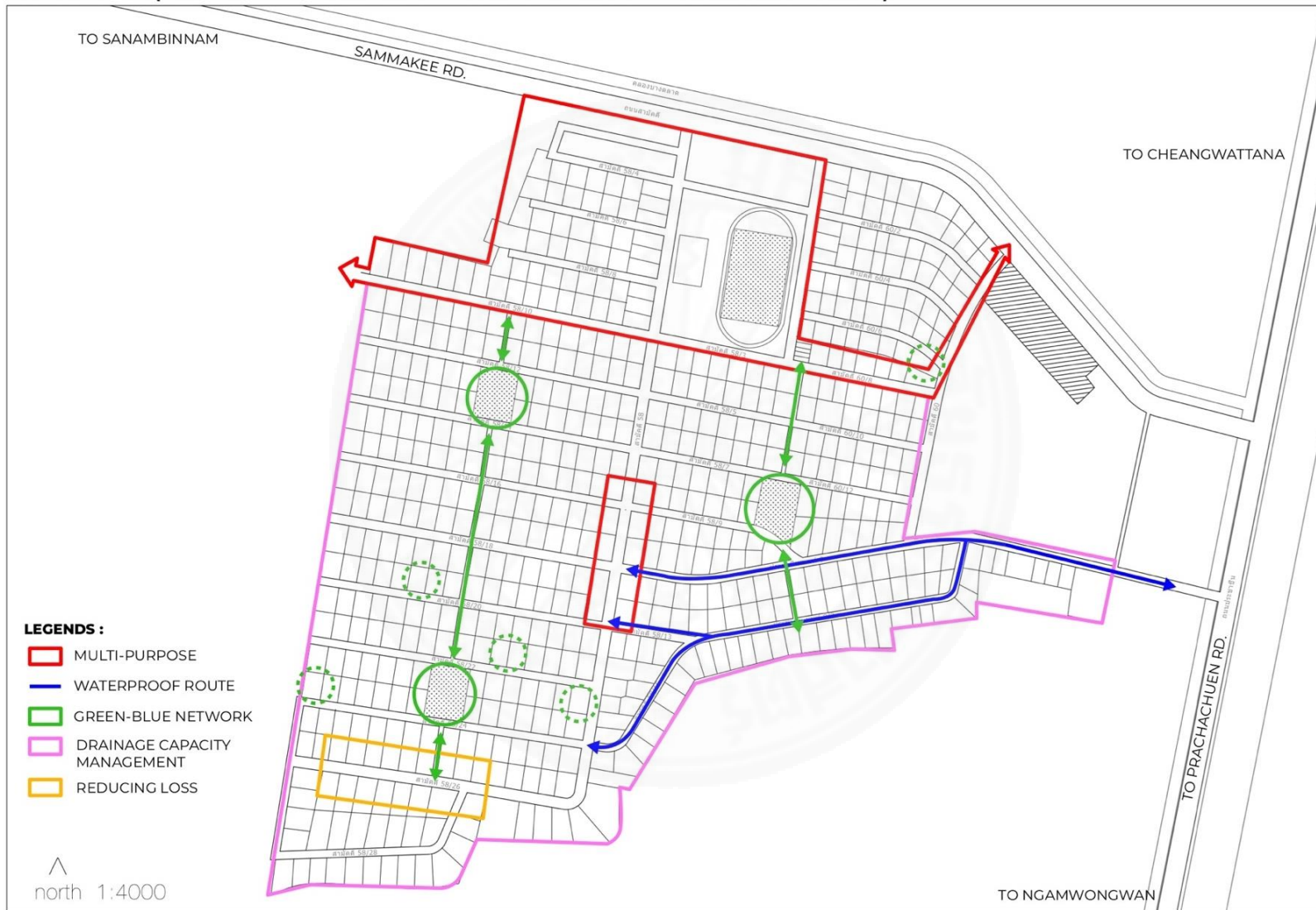


Figure 4.17 Integrated analysis: zoning management strategy

Source: Researcher, 2019



Figure 4.18 Integrated analysis: resilient design strategy

Source: Researcher, 2019



Figure 4.19 Future flood map with design implementation (120 mm/hour)

Source: Researcher, 2019

## CHAPTER 5

### CONCLUSIONS AND RECOMMENDATIONS

From data collection on both physical and socioeconomic aspects leading towards integrated analysis process towards designing an adaptive and resilient design strategy which will be use as tool to generate a flood resilient and inclusive strategic masterplan which can be justify and evaluate by these criteria:

- 5.1 Design Assumption Towards Research Objectives
- 5.2 Design Assumptions and Its Proxy
- 5.3 Design Dynamics
- 5.4 Design Effectiveness: Percentage of Change
- 5.5 Community Masterplan and Design Perspectives
- 5.6 Conclusion and Recommendations

## 5.1 Design assumption towards research objectives

This research paper has 3 main objectives to achieve in order to design a flood resilient and inclusive urban community. From the data collection and analysis in chapter 4 can be reflected into each objective on how each stage of analysis and data collection completed the aim of each objectives.

### **5.1.1 Objective 1: To study social and physical changes and how these exacerbate risk from flooding in the past; 30 years periods.**

To study the changes, The physical development timeline, data collection on autonomous adaptation and interview reflection is the main materials in order to study the social and physical changes as the data provides how the community adapted towards risks using both physical and social adaptation, including the acknowledgement of individuals on community changes towards the risks for the past 30 years.

### **5.1.2 Objective 2: To study existing mechanism to find possible ways of designing them to be an adaptive mechanism towards rainfall with higher frequency and magnitude.**

From the data analyzing for objective 1, it can be use further on studying the existing mechanisms managing present risks from flooding as there are both physical mechanism in community scale which is drainage infrastructure upgraded onto how the people react towards the risk in order for them to perform daily routine on flooding days. Moreover, measurement of extreme rainfall frequency and magnitude can be assess using stress-test map, by overlaying mentioned data layers, the existing mechanisms with the potential of developing to be adaptive mechanisms will be visible and use as a tool to design the strategy afterwards.

**5.1.3 Objective 3: To find suggest design strategies which can manage changes and support inclusive community.**

There are 2 scale of design strategy generated by series of data and integrated analysis, the design strategy consists of: (1) Adaptive zoning strategy and (2) resilient design strategy aiming for the community to be resilient in the future. Furthermore, the application of inclusive design qualities such as universal design, park design with distinctive programs for variety of user groups and good transportation linkage facilities e.g. principle of walkability will be implemented to increase inclusiveness of the study area.



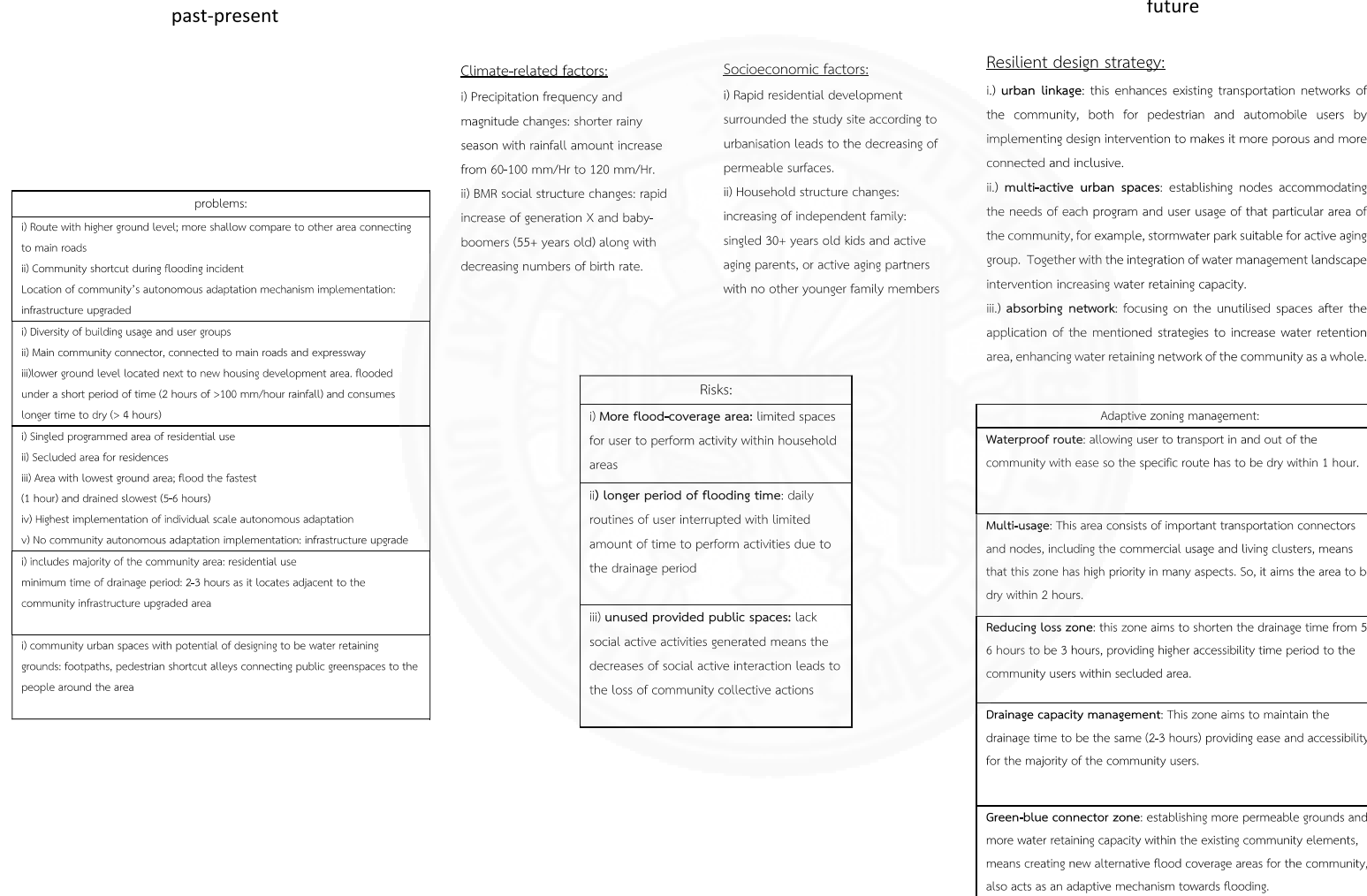


Figure 5.1 Design Assumption and Proxy, Researcher 2019

## 5.2 Design Dynamics

In order to prove the resiliencies and inclusiveness of this research's design concept, the design needs to have dynamics on both social and physical aspects. Starting with social aspect, the design needs to be able to accommodate the upcoming active ageing population with the shift of lifestyle towards being an ageless society. Moreover, the community public spaces have to provide a good quality of accessibility and space design so, the user can perform active social interactions between each other. Furthermore, in the terms of physical measures, the design needs to be justified by using the management within spaces as criteria. Each adaptive zoning and resilient design strategy have to be able to justify by how each of them can manage the future risks.

**Table 5.1** Design Dynamics

zoning	Strategy			Interpretation					
	Urban linkage	Multi-active urban spaces	Absorbing network	Uncertainty management			Inclusiveness		
				1	2	3	1	2	3
Waterproof route	/		/			/	/		
Multi-usage	/		/		/			/	
Reducing loss	/	/	/	/			/		
Drainage capacity management	/	/	/		/			/	
Green-blue connector		/	/		/				/

**Interpretation criteria**

Uncertainty management level:  
 1 – minimum management of uncertainty impacts: draining time (<4-5 hours)  
 2 – moderate management of uncertainty impacts: draining time (<3-4 hours)  
 3 – maximum management of uncertainty impacts: draining time (<2 hours)

inclusiveness:  
 1 – minimum implementation of inclusive design: universal design and simple walkability environment e.g. plantation, good quality footpaths  
 2 – moderate implementation of inclusive design: universal design, small transit nodes for bicycle and pedestrian users, walkable environment  
 3 – maximum implementation of inclusive design: Universal design, small transit nodes for bicycle and pedestrian users, walkable environment and specific programs and services based on user group

Source: Researcher, 2019

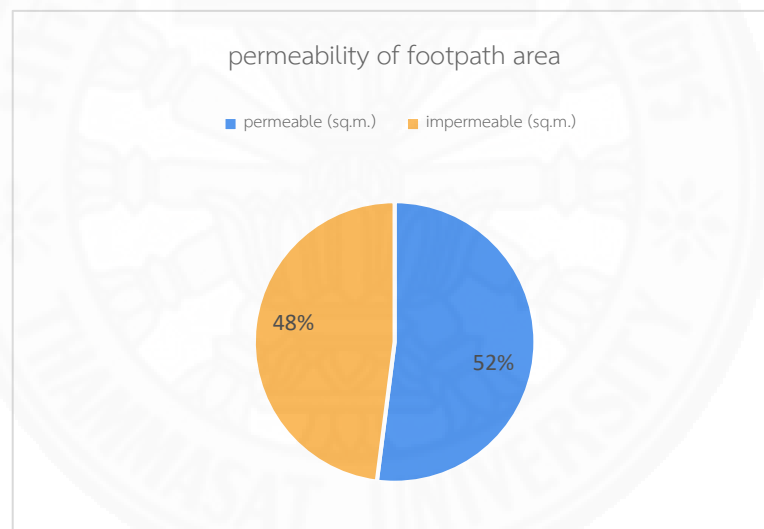
The table illustrates the relationship between two levels of design strategy consists of (1) adaptive zoning strategy and (2) resilient design strategy. The connection between the two level of design strategy is first, adaptive zoning strategy will be working as a frame for resilient design strategy implementation aiming to meet the

goals and purpose focusing on managing risks of each distinctive zones. Secondly, to evaluate which resilient design strategy is efficient and effective towards meeting the goals of each zoning, achieving the maximum potential of managing risks on each distinctive area, meeting the needs of users. Moreover, for the community to be both flood resilient and inclusive for everyone, the concept of inclusive design has to be implemented along with the flood resilient design strategy. In this research, the concept of inclusive design has to be interpreted into urban design quality which is suitable for everyone, the chosen qualities are: walkability principle and universal design with an urban spaces program design to meet the needs of every user group not only the active aging population. The criteria and indicator for measuring the level of risks management and inclusiveness is provided as results from design implementation, illustrating overall relationships of each design implementation and quality. This means that, after the implementation of both adaptive zoning management and resilient design strategy will increase the dynamics on both social and physical aspects of the study area, managing upcoming future risks, resiliencies and inclusiveness.

(past-present)	(future)
Before zoning and strategy implementation	after zoning and strategy implementation
<p>i.) drainage pipe on main community streets from 0.80 metres to 1.20 and 1.50 metres starting from sports complex towards new pumping machine and the start of soi 2</p> <p>ii.) total of 4 pumping machines around the community with one machine automatically works 24/7</p> <p><u>permeability of footpaths</u>  <b>total area of footpaths: 8657.5+7085 = 15,742 sq.m.</b>                      i.) impermeable footpath:  <math>2.5(40 \times 20) + 1.5(226 \times 15) = 7085</math> sq.m.                      ii.) permeable footpath:  <math>2.5(17 \times 20) + 1.5(347 \times 15) = 8657.5</math> sq.m.</p> <p><u>Permeability and accessibility of connecting alleys</u>  <b>total number of connecting alleys: 9</b>                      i.) permeability:                      - total number of permeable connecting alleys: 2                      ii.) accessibility:                      - total number of accessible connecting alleys: 3</p> <p><u>Public open and greenspaces</u>                      (-30% circulation = buildable area)                      i.) community park 1 area:  <math>2,430</math> sq.m. - 30% = <math>1,701</math> sq.m.                      ii.) community park 2 area:  <math>2,990</math> sq.m. - 30% = <math>2,093</math> sq.m.                      iii.) community park 3 area:  <math>2,200</math> sq.m. - 30% = <math>1,540</math> sq.m.  <b>maximum area for design implementation: 5,334 sq.m.</b></p>	<p>i.) extensions of area implementing drainage pipe (0.80 metres to 1.20 metres): the minor connecting community street, connecting to the west and east of the community and extension from existing upgraded drainage pipeline from the start of soi 2 towards the secluded area inside.</p> <p><u>Footpath water retention capacity:</u>  <b>total area of footpaths: 15,742 sq.m.</b>                      i.) available area for intervention implementation:  <math>15742 - 30\% = 4722</math> sq.m.  <b>Only implement design strategy on main community streets footpath</b>                      ii.) maximum water retention capacity:                      - Main alley footpath: <math>798 \times 1.25(0.15)</math> m = <b>150 m<sup>3</sup></b></p> <p><u>Connecting alleys water retention capacity:</u>  <b>total area of connecting alleys: 9(4x60) = 2160 sq.m.</b>                      ii.) available area for intervention implementation:  <math>2160 - 30\% (648) = 1512</math> sq.m.                      iii.) maximum water retention capacity:  <math>1512 \times 0.30</math> m = <b>453.6 m<sup>3</sup></b></p> <p><u>Public open and greenspaces</u>  <u>water retention capacity:</u>  <b>maximum area for design implementation: 5,334 sq.m.</b>                      i.) maximum water retention capacity:                      - community park 1: <math>1701 \times 2.00</math> m = <math>3,402</math> m<sup>3</sup>                      - community park 2: <math>2093 \times 2.00</math> m = <math>4,186</math> m<sup>3</sup>                      - community park 3: <math>1540 \times 2.00</math> m = <math>3,080</math> m<sup>3</sup>  <b>Total of maximum water retention area: 3,402+4,186+3,080= 10,668 m<sup>3</sup></b></p>
<p><u>Total community area: 448,000 sq.m. (0.448 sq.km.)</u>  <math>622 \text{ households} \times 300 \text{ sq.m.} = 186,600 \text{ sq.m.}</math>  <math>= 0.186 \text{ sq.km.}</math>                      area which can be implemented publicly:  <math>448,000 - 186,600 = \underline{261,400 \text{ sq.m.}}</math></p>	<p style="text-align: center;">Flood resilient community</p>

Figure 5.2 Design Effectiveness: Percentage of Change, Researcher 2019

The flowchart above illustrating the existing quality of community urban elements which can be adapted into resilient design strategy, provided with the possibility of design applications on each existing urban spaces together with maximum water retainment capacity that each quality can maintained, this reflected back to the effectiveness measurements of each resilient design strategy, and how its comprehend to achieve each adaptive zoning criteria. Moreover, permeability and accessibility are important quality in order to implement an efficient, effective and connected adaptive zoning and resilient design strategy. The following charts displaying the differences in percentage of each important qualities, starting with permeability of footpath area (figure 5.3):

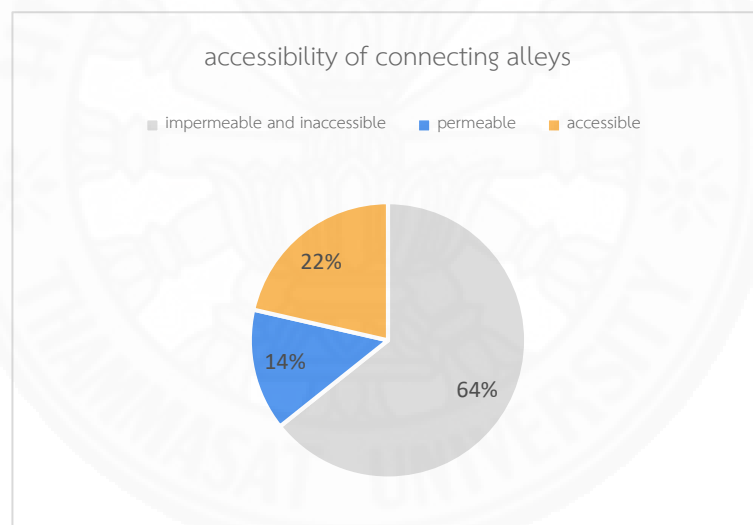


**Figure 5.3** Permeability of footpath area

Source: Researcher adjusted from Physical Data Collection, 2019

From the chart, there are no dramatic differences between permeable and impermeable, however, it is in positive stage as the percentage of permeable grounds (52%) is higher comparing to impermeable grounds (48%), this means that it is highly possible to implement the resilient design strategy on footpath area to increase the percentage of permeability and also design the existing footpath to be more walkable

and connected. Next will be focusing on the accessibility of the connecting alleys within the community area, this urban space contains high potential of implementing resilient design strategy, enhancing internal connection of pedestrian networks along with creating new green-blue network as stormwater management spaces, connecting every zone together. However, according to the chart below (figure 5.3.2), majority of the connecting alleys are impermeable and inaccessible (64%) but there are possibility of develop the condition of the connecting alleys as the percentage of the alleys with permeability (14%) and the ability to access (22%) combined together is 36% in total, even though it is only half of the impermeable and inaccessible spaces but it can be implies as there are an community effort on creating green and accessible connecting alleys.

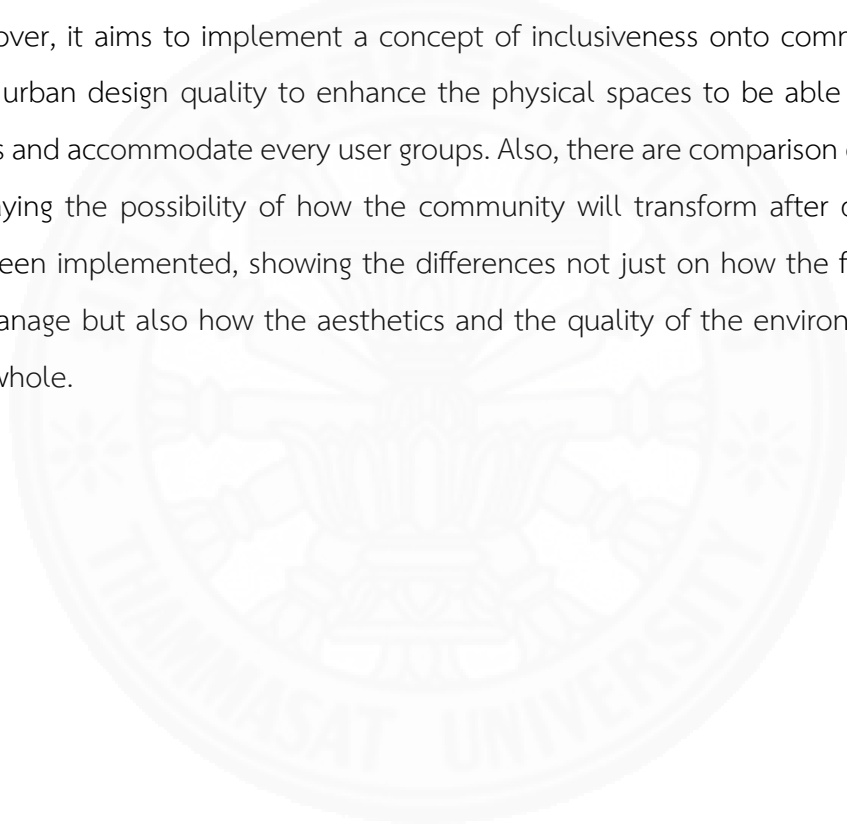


**Figure 5.4** Accessibility of connecting alleys, researcher 2019

Source: Researcher adjusted from Physical Data Collection, 2019

## 5.5 Community Masterplan and Design Perspectives

This masterplan provides reflections from integrated analysis between the community ground using stress testing, data collection and in-depth interview as tools to design distinctive zoning and design strategy to be most suitable for users. Furthermore, it illustrates the guideline towards designing and implementing physical design on to existing community fabrics, so the networks are displayed clearly. Moreover, it aims to implement a concept of inclusiveness onto community area by using urban design quality to enhance the physical spaces to be able to answer the needs and accommodate every user groups. Also, there are comparison collage photos displaying the possibility of how the community will transform after design strategy has been implemented, showing the differences not just on how the floodwater will be manage but also how the aesthetics and the quality of the environment improve as a whole.





**Figure 5.5** Community Masterplan

Source: Researcher, 2019

### 5.5.1 Community Masterplan Design Implementation

#### 1) Adaptive Playground

The adaptive playground is designed with different depths of terrains ranging from 0.30 metres to 1.00 metres creating a manmade scape which can generate active activities between children, also increasing flood water retainment capacity within the existing public park after heavy rainfalls. Moreover, the program of this park is focuses on family and young children user group according to the integrated analysis of socioeconomic where it displays the cluster of different user group within the community.

#### 2) Adaptive Community Retaining Pond

As from the socioeconomics integrated analysis, it reflects that this park has not been utilised and active as there are no cluster of distinct user group using the public park. So, the new design implementation of the park will be focusing on being a floodwater retaining area as its major program, thus, the park can also be use during the dry time and will be flooded in the main sunken area in the middle. This adaptive park provides the highest capacity of water retainment compared to the other 2 flood-adaptive designed public parks.

#### 3) Adaptive Ageless Park

The park locates near the main sports complex of the community, this means that the activities are flow from there, causing this park to be very active in the evening. According to the socioeconomic integrated analysis where it displays the time related activities and the reflection from interviewees determined that this park is used mainly by active elderly so the program of the public park will be focus mainly on providing suitable environment to accommodate active elderly group. Moreover, there will be an interactive station such as small community farming, generating activities between the community.

#### 4) Permeable Connecting Alleys

The adaptive design strategy of blue-green networks is implemented on the existing 9 connecting alleys which connects sub alleys to the community's public parks to be impermeable with the ability to retain floodwater by applying a raingarden alongside with pedestrian walkway with inclusiveness quality. Moreover, this also enhances the network of both pedestrian walkway and how the floodwater will be stored and connected from adaptive nodes to another adaptive nodes. Also, the paving and the level of the street that connecting between each connecting alleys are needed to be elevated to the same level as the footpath with the same paving as (5) to enhance the connectivity of pedestrian networks of the area.

#### 5) Redesigned Community Main Street

The community main street will be redesigned with the implementation of raingarden on both sides of footpaths along with the elevated to the same level as the existing footpath. Also, the changes of pavements of the main alleys locating on both multi-purpose and waterproof route zones to highlight the importance of the route. This makes the mentioned alleys dry faster as it needs to act as main connector connecting the study area to the surrounding areas. Furthermore, the raingarden implementation increases the capacity of water retaining from the road surfaces as it needs to be dry the fastest.

#### 6) Active Community Crossing Junction

The active community junctions are the area with vibrant social activities between different group of users within the community, referring to the time related activity map. This will enhance the connectivity of pedestrian networks and inclusiveness as there are an implementation of zebra crossing together with pavement changes to raise awareness of the automobile users. Moreover, the ramps and small transportation nodes such as bicycle parking stop are provided aiming to increase accessibility and generates more social activity within the area.



**Figure 5.6** Adaptive Park

Source: Researcher, 2019

Figure above displays the comparison of how the resilient design strategy implemented on the existing fabric which is the public park within the community perimeter. The collage photo illustrates how the park will be designed, as there are permeable grounds which will be adapted by applying raingarden design to increase the capacity to retain flood water, waiting for the flood water on the road surfaces to drained down first. Moreover, the park can still be active while it floods as the trail are elevated.



**Figure 5.7** Connecting Alley Design

Source: Researcher, 2019

The photos above illustrate the comparison between the existing accessible connecting alley and how will the design strategy be implemented on the area. Pedestrian walkways are implemented along with rain garden on both sides to increase the capacity of retaining floodwater, channelling excess amount of water which can be flows on to road surface. This allows the road surfaces to be drained first, improving community connectivity and accessibility within the area and the surroundings.



**Figure 5.8** Adaptive Playground

Source: Researcher, 2019

The adaptive playground will be implemented on one of the existing public parks where there are a cluster of family and children user group, refers from socioeconomic mapping. From the collage above, the design includes manmade terrains with different depths for retaining water while flooding which can be use as creative playground during the dry time. This means, the programming of this park aims to retain water along with the ability to generate active social interactions.

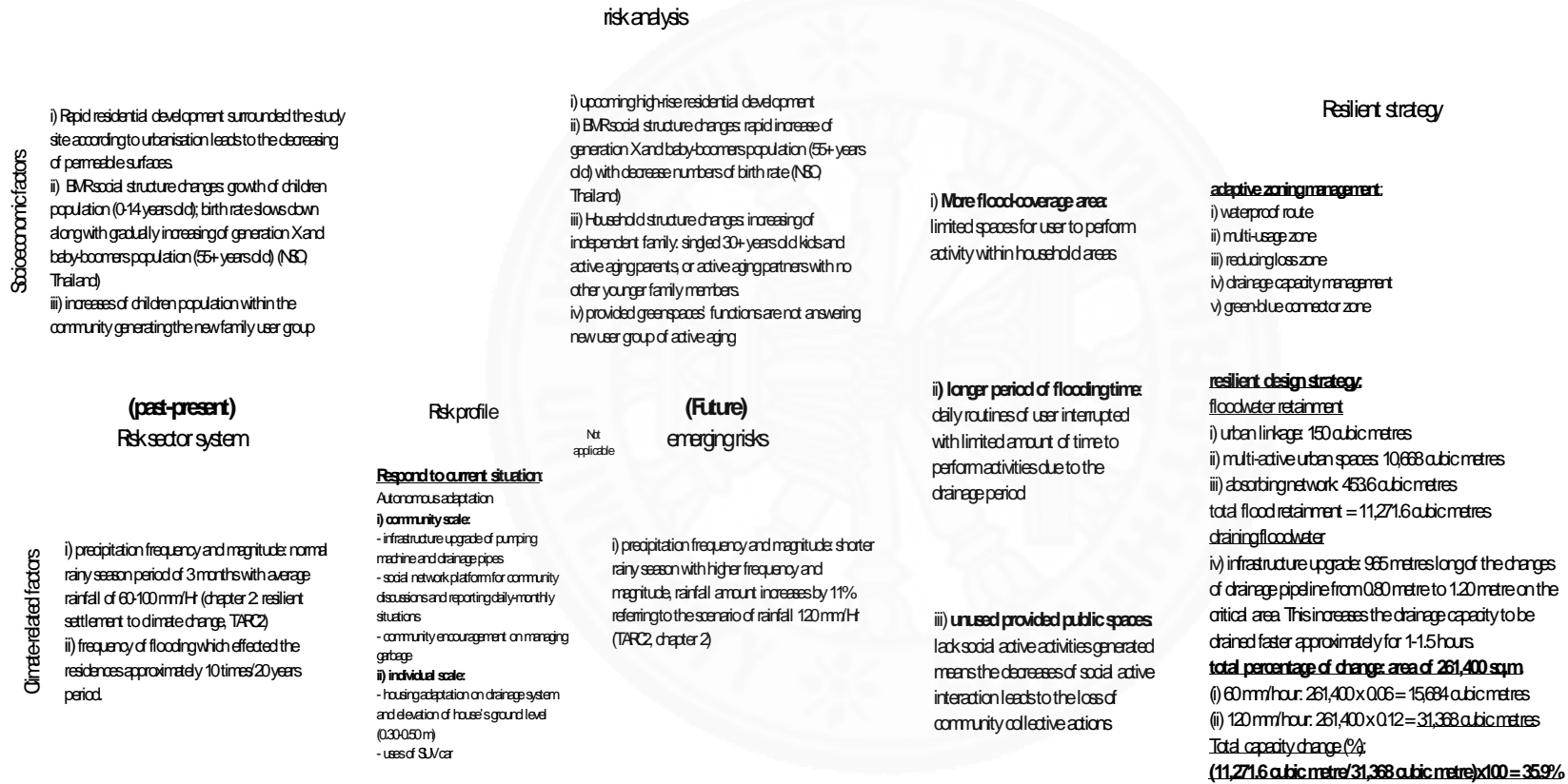


Figure 5.9 Conclusion on Percentage of Changes, Researcher 2019

Concluding from the research framework, this displays how the resilient design strategy contributing towards changing the flood resilient community in the future by using the percentages of manageable floodwater after implementation. For this, the maximum amount of floodwater that can be retained is 35.9% using future rainfall scale of 120 mm/hour. Moreover, this has not combined with the floodwater which will be drained faster according to the extension of infrastructure upgrade as this will help the community to drain faster for approximately 1-1.5 hours. In addition, as these two methods of resilient design strategy results combined, it aimed to help the community to be more efficient and effective towards managing floodwater and its impacts, transforming this community to be flood resilient community in the future.

### **5.5 Future research recommendation**

Design recommendation to develop masterplan further is to develop stormwater management into next level by looking at the water as reusable resources of the community, the design implementation could be inspired by Waterplan 2 in Rotterdam, the Netherlands where they designed plaza with multipurpose functions of social gathering spaces and also as an water retainment ground where the activities will shifts due to rainfalls. Moreover, the retained water can be utilise for public community usage afterwards such as watering plants within community's public spaces.

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## APPENDICES

## APPENDIX A

### Climate Change

#### 1. Resilient

Resilience can be defined as the ability of the system and its components to anticipate, absorb, accommodate or recover from the hazardous events' effect in a timely and efficient ways. Also, it needs to ensure the preservation, restoration or improvement of its state after got affected by the event.

#### 2. Adaptive

Adaptation has been defined as the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. For example, human interventions can be mechanisms to facilitate adjustment towards expected climate change activities.

#### 3. Climate Change

Climate change is the state of climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, creating impacts in many forms including disasters (a severe change from the normal functioning of a community or society due to the hazardous physical events causing vulnerable social conditions, leading to unfortunate events on human, economic and environmental effects requiring urgent respond in order to satisfy human needs towards recovery, Intergovernmental Panel on Climate Change (IPCC)).

## APPENDIX B

### Inclusive Design

#### 1. Inclusive Design

Inclusive design is a concept that emphasized on including everyone in the users, understanding the differences and diversity in many groups of users as possible. This is to include variations in aspirations, capabilities and needs as much as possible. Referring to British Standards Institute (2005), inclusive design defined as ‘the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible ... without the need for special adaptation or specialized design’ to stated simply, it’s the design of one product that aimed to address the needs of the entire population.

#### 2. Universal Design

Universal design is a composition of physical architectural or environmental design, finding solutions which can be fixed physically by design, also can be access and used in many ways and many groups of users possible without the users adaptation means it needs to achieve the needs of all people who wish to use it.

#### 3. Walkability Principle

Walkability index is a tool uses to measure the scale of walkability level in the neighbourhood, later on it was adapted to fit an urban design context by Bradshaw, 1993. This aims for the walkability index to be able to implement physically using urban design, creating a walkable environment. However, it has no clear definition of walkability as most of the indexes are intangible characteristics, the term walkability was defined by Abley, 2005 as ‘... the extent to which the built environment is walking friendly and as ‘... a useful way to assess the characteristics of an area or a route, although it can be subjective.’

## APPENDIX C

### Ageless Lifestyle

#### 1. Active Aging

a new term defined and adopted by the World Health Organisation in the late 1990s, was developed from the term of healthy aging by inputting more inclusive perimeter. It is the progress of optimising opportunities for health, participation, and security in order to enhance quality of life as people ages. Thus, the term reflects the independency of individuals to be able to live independently in both social participation in every aspect, referring to the definition of the word 'active' means the right to continue to participate in every social activities either it is cultural, spiritual or civic affair not only as labour workers.

#### 2. Ageless Lifestyle

Ageless society is an emerging term where the city with high aging population, such as Japan, use as a concept to propose policies that fits with their situation. The term of 'ageless' simply means to never be retired; achieving timeless way of being, as it is the concept that helps the seniors to generate more self-satisfaction and self-enrichment as the population of 60-65 years old and above will soon become the majority of the world population.

#### 3. Social Structure

Structure within the demographic data, displaying the different social structure using gender, age and job occupations as main criteria

## Questionnaire

### Questions without interviewing tool

1. In your opinion, what is flooding?
2. What is your daily lifestyle, and do you often have travel in-out the community?
3. How do you travel in-out of the community?
4. Do you spend much time in your hobbies, does it need to perform outside the community and how often do you need to do them?
5. What activity you enjoy doing while staying home?
6. How do you travel in-out of the community?
7. Can you please tell your previous experiences with flooding?
8. Do you ever experience flooding inside your housing property and how do you manage it?
9. can you please tell your previous experiences with flooding?
10. What time in a year that flooding occurs often?
11. Is flooding has any influence on moving out of the area, if not, why?
12. During flooding event, how is it affects you on your daily life, if yes please explain.
13. How do you prepare yourself towards flooding event?
14. Do you have any suggestions for the community in order to improve physical facilities towards solving flooding problem?
15. How many of your family members, including you?
16. How old are you and how long have you been staying in this community?

### Questions with interviewing tool

1. While flooding happens, which mode and route of transportation you chosen?
2. Please label the location of pumping machines and area which dry first-last.
3. Which area affected the most during flooding?
4. Which area within the community has potential of being water retention area?
5. Please explain physical topography of community from your understanding.

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### Publications

Yada Ponchamni, Assistant Professor Wijitbusaba Marome, Ph.D. (2019) Towards Designing Flood Resilient and Inclusive Urban Community: A Case of Ageless Lifestyle in 1960s Housing Prachanivate 2, Nonthaburi. Paper presented at the 16th Pacific Regional Sciences Conferences Organization Summer Institute, Chulalongkorn University.