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Flood Prevention by Open Space plan : Spatial Planning integration at local level in Bangkok city, Thailand

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Content

Chapter 1

Introduction

Floods are the most destructive, most frequent and most costly natural disasters on Earth. Flood damages have soared in recent decades, despite the expenditure of hundreds of billions of dollars on flood control structures. Climate change is expected to dramatically increase flood risk. Structural flood control is based on the assumption of a fictional static climate. The inflexibility of hard flood control is a major weakness. (International Rivers People Water Life, 2017).

Flood risk management has multiple goals relating to multiple time and space scales. Achieving these relies on the development and implementation of appropriate strategy. Flood prevention is one of the possible approaches. The main idea of prevention is to identify the areas which are the most at risk and to elaborate management plans to reduce as much as possible the potential damages. Within flood prevention, an important part of flood hazard and risk mapping is necessary to identify vulnerable places areas where there are infrastructures and people at risk within the areas where flood hazard exists before creating management plans. At the same time, open space and green infrastructures are becoming more and more used in city's plans for flood prevention by providing space to storage water for periodic time and increasing infiltration in areas that are dominated by impervious cover.

Despite facing important floods every year during the monsoon season, Thailand is still lacking of efficient flood management policy. More specifically, floods submerge on recurrent period the economic heart of the country, Bangkok city, thus impacting activities, infrastructures and people. In the very dense urban area, these floods have two main causes : the overflow of the Chao Phraya River, which is running from North to the South of the city, and the stormwater. Open spaces and green infrastructure can form part of critical flood risk management systems by providing space for managed flooding, protecting built up areas. It can be used as a counter-measure to urbanisation, which has significant effects on rainwater interception, storage and infiltration processes (CIRIA open space, 2017).

The overall purpose of this research study is to show how open space plan can be connected with flood prevention in urban areas, establishing a guided model of open space plan use. It will try to integrate the spatial planning policy, thus providing a case study on Bangkok city in Thailand. This study will try to answer the research question " what kind of conceptual model of flood prevention can be established in Bangkok city, based on open space approach in Don Mueang district and focused on stormwater management ? "

This research will be divided in three part. Firstly, it will provide a literature review which presents the key terms and ideas of the topic, relating to (1) flood prevention: Preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices (European Environment Information and Observation Network, 2017). (2) open space : Key attributes of green open spaces that have implications for flood management and mitigation include their potential capacity to prevent disturbance caused by floods through flood regulation (Millennium Ecosystem Assessment, 2005). Green open spaces can also provide storage capacity for floodwaters in urbanized areas (De Groot et al., 2010). (3) urban area : the first generic form of the city is the physical expanse, or area of continuously built up urbanization. The urban area is simply the extension of urbanization. Urban area is not defined by jurisdictional boundaries, though where national statistical authorities define it is necessary to rely on building blocks such as census tracts and municipalities (Demographia, 2002). (4) spatial planning policy Spatial planning is a nonstructural activity that governments and communities use to influence the extent of development of floodplains through zoning and other regulations (Ward 2013). Spatial planning determines the key factors that influence flood risk, such as the location of certain activities, type of land use, scale of development, and design of existing and proposed physical structures (White and Richards 2007). Secondly, the study will provide an analysis of secondary research data about the theory and concept of open spaces critical flood risk management systems, using it as a grid to adapt local area "Don Mueang district", the case study of this research, to protect built up areas. Located in the northern part of the city, within a residential area of low density, Don Mueang district provided the conditions to address the study issue on flood prevention by using open space plan approach. Finally, the study will provide a conceptual model and study of a master plan for flood prevention by open space plan in local area.

Chapter 2

literature reviews

This chapter provides the literature review; the most important topics are related to the context of flood prevention, flood and risk management and open space. The process of issues have a general review in context of definition of flood prevention, flood and risk management, urban stormwater and open space in urban context.

So, this section will focus on 4 main issues (1) flood prevention : Prevention measures aim to decrease the consequences of flooding by decreasing the exposure of people/property, etc., via methods that prohibit or discourage development in areas at risk of flooding (e.g., spatial planning, expropriation policy, etc.). The main focus of the strategy is on “keeping people away from water” by building only outside flood-prone areas. (adopted from Hegger et al. 2014). (2) open space : open space protection has long been used as a land use strategy to maintain various natural amenities within local communities. Zoning provisions, land acquisition, and other regulatory mechanisms are traditionally implemented to ensure the protection of multiple values, including recreation, wildlife habitat, water quality, aesthetics, etc. (Bengston et al., 2004). (3) urban area: the Physical City (Urban Area): The first generic form of the city is the physical expanse, or area of continuously built-up urbanization. (Demographia, 2002). (4) spatial planning policy : Spatial planning is a nonstructural activity that governments and communities use to influence the extent of development of flood- plains through zoning and other regulations (Ward, 2013).

2.1 Flood situation to flood risk management and multi-approach system to solve a complex issue

Flood runoff results from short-duration highly intense rainfall, long-duration low-intensity rainfall, snowmelt, failure of dam or levee systems, or combinations of these conditions. Events such as earthquakes, landslides, ice blockages or releases, and high tides or storm surges can worsen flood conditions.

The best information on flood magnitudes that are likely to occur in the future is obtained from observed flow records-what has occurred in the past. The nature of the flood-producing system-the interaction of atmosphere, land geology and geomorphology, vegetation and soil, and the activities- of people -is so complex that

sole use of theoretical or modelling approaches can provide only generalised estimates of the flood regime of a stream or a region. Local information on observed floods is essential to calibrate model for valid application to particular drainage basin or regions. A valuable supplement to recorded streamflow data can be provided by historic flood information from old newspaper report , long-term residents, local municipal bodies, and from road and railway authorities which usually keep records of damage to the installations. Information on more recent flood runoff events can be obtained from debris of flood mark on riverbank and floodplains. Considerable work has also been carried out in recent years on the assessment of *paleofloods.* These are major floods that have occurred outside the historical record, but which are evidenced by geological, geomorphological, or botanical information.

The need to utilise available local data for calibration cannot be overemphasized. A given storm may produce a large flood in one region, bit in an apparently is similar region, the same storm may produce little or no runoff. (David H. Pilgrim and Ian Cordery, 1992)

2.1.1 Floods, an overflow from various origin

Floods occur as a result from 2 main reasons : natural and man-made reasons. Natural origin can be events such as storms, cyclones or melting of snow or ice or, for instance, a rapid rise in discharge of a river due to intense rainfall. Man-made reasons take an important path in urban areas where the continuous impervious cover has accelerated the water cycle and increased flood occurrence in these areas.

These events lead to a rise in the water level of major riverbeds or to an accumulation of flow water, to the resurgence of underground rivers or to thaws in low-lying areas adjoining stream banks or river estuaries. In mountainous areas, landslides, earthquakes, and avalanches can cause the overflowing or rupture of hydraulic dams or cause unstable blockages at certain points on rivers, and thus threaten or destroy people and the infrastructure located in the lower parts of valleys.

All types of floods have grave consequences, mainly because of their secondary effects. Localised flood, or one involving a small rise in water level can lead to large-scale damage, to the interruption or destruction of communication routes (road, rail, etc.) or the loss of infrastructure and damage to the environment (economy, supplies, crops).
(International Civil Defence Organisation, 2017)

However, the important reason of flood is man-made focusing on urban context ; many cities are affected by flood since the water cannot flow to the river or sea easy because they have a barrier of flowing like the water blocked by concrete in city area or the water do not have the space fort drain into the natural floodway. So, that way the construction by man-made become a important reason of flooding nowadays.

Four Types of Floods

Floods are merely an extreme manifestation of normal peak flows. It is helpful to categorise floods according to their genesis, as an aid to understanding. Zinke (1965) has provided such a classification, considering floods to fall into four types:

1. Floods with all storage element full, but without snow storage.
2. Floods with all storage elements full, and with snowmelt
3. Floods with storage elements not full.
4. Floods with no precipitation, but sudden release of storage element.

Type 1: floods emerge from a completely-saturated landscape, subjected to high precipitation for considerable periods. Land use has relatively little effect on such floods.

Type 2: floods result from snowmelt, or from warm rain falling upon a pre-existent snowpack. Land use may have important effects on snowmelt, since forest cover affects the amount of radiation and advected heat reaching snowpack. Clearcutting over large areas may result in accelerated runoff. Soil-freezing differences may also affect the rate of runoff.

Type 3: flood result from high-intensity rainfall whose rate of delivery exceeds the soil-infiltration rate. land use has the largest influence upon this type, by adversely affecting infiltration capacity through soil compaction and litter removal.

Type 4: floods may result from extremely-rapid snowmelt occurring without coincident precipitation. Presence or absence of forest cover may be influential in this flood type, in the same way as Type 2 floods are affected.

This type may also result from a sudden release of water impounded by temporary barriers. Where land use creates landslides which temporarily block stream channels and subsequently fail, it is influential upon Types 4 floods also, but this is relatively uncommon. (Donald M. Gray, 1973)

2.1.2 The governance challenge of flood context with Flood Risk Management Strategies (FRMSs)

Vulnerable regions can be protected against flooding by decreasing the probability or the consequences of flooding and by preparing for a recovery after a flood has struck (Oosterberg et al. 2005; Klijn et al. 2009; Djordjevic et al. 2011). Based on this chain of responses (Hegger et al., 2014) have made an analytical distinction between flood risk prevention, flood defence, flood risk mitigation, flood preparation and flood recovery. Following this definition we argue that a diversification may result in actor, discourse, rules or resource related challenges.

Five types of Flood Risk Management Strategies (FRMSs)

1. Flood risk prevention : Prevention measures aim to decrease the consequences of flooding by decreasing the exposure of people/property etc. via methods that prohibit or discourage development in areas at risk of flooding (e.g. spatial planning, re-allotment policy, expropriation policy etc.). The main focus of the strategy is on keeping people away from water.
2. Flood defence : Flood defence measures aim to decrease the probability of flooding areas through infrastructural works, such as dikes, dams, embankments and weirs (so called structural measures^), through measures that increase the capacity of existing channels for water conveyance or the creation of new spaces for water retention outside of the area to be defended. The focus is on keeping water away from people.
3. Flood risk mitigation : focuses on decreasing the consequences of floods through measures inside the vulnerable area. Consequences can be mitigated by a smart design of the flood-prone area. Measures include constructing flood compartments, or (regulations for) flood-proof building as well as measures to retain or store water in or under the flood-prone area (e.g. rain water retention).
4. Flood preparation : Consequences of floods can also be mitigated by preparing for a flood event. Measures include developing flood warning systems, preparing disaster management and evacuation plans and managing a flood when it occurs.
5. Flood recovery : This strategy facilitates a good and fast recovery after a flood event. Measures include reconstruction or rebuilding plans as well as compensation or insurance systems.

Implementing Flood Risk Prevention

Flood risk prevention focuses on reducing the consequences of floods through land use and spatial planning measures. These can focus on forbidding or discouraging the location of vulnerable societal functions (e.g. housing, power plants) in flood-prone areas, the establish ment of building requirements or the disincentivising of urban development in vulnerable areas. Flood risk prevention is claimed to be the potentially most effective FRMS (Hooijer et al. 2004; Beucher 2009; Penning-Rowsell and Pardoe 2014). (Dieperink C,et al., 2016).

2.1.3 Flood risk management and different strategies aiming at a convergent purpose.

Spatial planning or land use measures aim to minimize the impacts of a flood (Hall et al. 2003, Pottier et al. 2005). They typically consist of a range of regulatory and pricing policies that fall within the scope of two “flood risk management strategies” outlined by (Hegger et al. 2014) flood prevention and flood mitigation. In terms of flood prevention, spatial planning measures, for example, include the widening and deepening of rivers, and restrictions on building activities in high-risk areas to create more space for water. In terms of flood mitigation, examples of spatial-planning measures are the designation of emergency water retention areas, and the use of regulatory or pricing instruments that incentives the development of flood- proof building structures (e.g., by elevating buildings, using water- resistant building materials, and applying flood-proof construction modes) to mitigate flood damage. (Bergsma, 2016)

In this section, it was showed that floods have complex and often multi-based origins, for which local authorities develop different approaches to deal with. The following 2.2 part will focus on one aspect of flood origin, stormwater, introducing the choice of Bangkok for suitable case study regarding the research topic.

2.2 Urban stormwater as an environmental flow problem and an unrealized water resources

Stormwater is taking an increasing concern for urban planners in many cities. Indeed, more and more cities face stormwater based floods for which different solutions are being proposed. This section will present the main ideas about stormwater (origin, water cycle related effects, differences with other floods in urban areas...) and link this issue to the current situation in Bangkok city.

Most environmental flow problems arise from water being extracted for human use: the challenge for environmental flow researchers and practitioners in such situations is how to distribute the remainder for maximum environmental benefit (Arthington AH et al., 2010). This focus on extraction of water from aquatic ecosystems, compounded with the tendency for water resource managers to prefer centralized systems (Harremoes P, 1997), (Mitchell VG, 2006) , leads to a tendency of urban water managers to first consider extraction from urban rivers and drains when identifying urban stormwater harvesting projects (e.g. (Anon, 2007) , (Newton D, Ewert J, 2009)). Such a conception of stormwater harvesting has led to a misconception that urban stormwater runoff has some environmental flow benefit (Victorian Government: Department of Sustainability and Environment, 2006) . Studies showing consistent degradation in the face of increasing urban stormwater drainage (Walsh CJ et al., 2005) , (Wenger SJ et al. 2009) indicate that the reverse is true. Urban stormwater runoff, delivered through conventional drainage systems, is a complex environmental flow problem that can, in large part, be solved by harvesting stormwater before it reaches aquatic ecosystems.

The protection and restoration of urban streams has thus been hampered by a lack of understanding of the unique nature of urban stormwater runoff as an environmental flow problem that could be solved by using stormwater as a water resource. Stormwater harvesting defies the dominant conception of water resource management that extraction of water from ecosystems must result in a monotonic decline in the ecological condition of that ecosystem (Gleick and Palaniappan, 2010) (Figure 2.1).

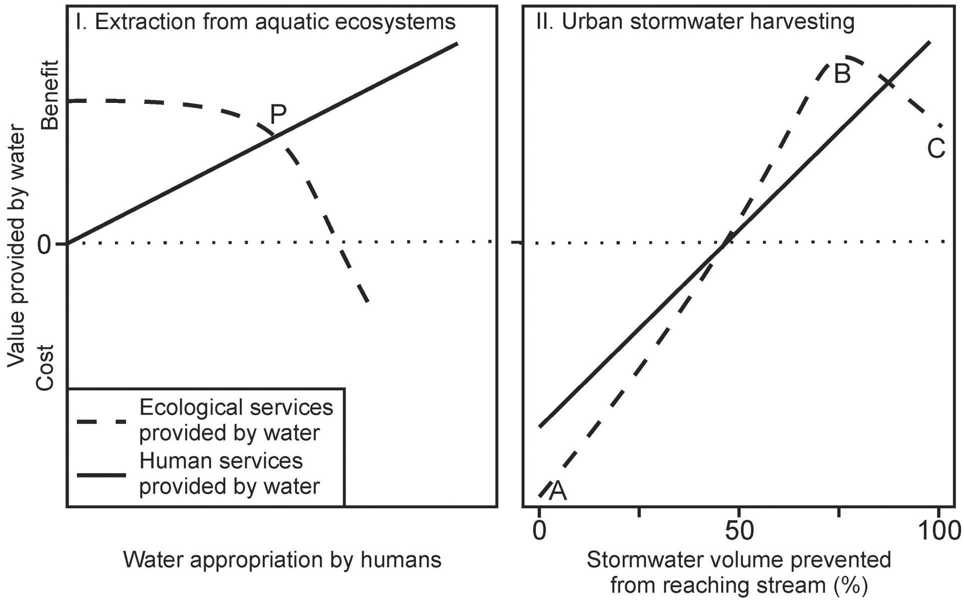


Figure 2.1: Conceptual graphs of ecological and human value of water.

The model proposed by Gleick and Palaniappan (2010) assumes that any extraction from aquatic ecosystems has a negative ecological impact, predicting a monotonic decline of increasing gradient with greater extraction. The benefits accrued by the human population rise linearly with the volume extracted. Beyond peak ecological water (P) (Gleick, Palaniappan, 2010), any increase in human benefit is outweighed by reduced ecological benefit. II. illustrates different trends in ecological and human cost and benefit with increasing retention and use of stormwater before it reaches aquatic ecosystems. No stormwater use (A) results in ecological degradation of receiving waters. It also presents greater costs in urban microclimate control and flood mitigation than if stormwater was harvested. Using a volume of stormwater equivalent to the volume lost to evapotranspiration in the pre-urban state (B), if coupled with infiltration systems to restore lost sub-surface flows, provides maximum environmental benefit. Using all available stormwater runoff (C) has an environmental cost by reducing subsurface flow delivery to stream.

2.2.1 Rainfall-Runoff Relationship and Runoff Process

Flood runoff has often been considered to consist of surface runoff produced at the ground surface when the rainfall intensity exceeds the infiltration capacity. While this process, known as Hortonian overland flow, occurs in many situations, two other general storm runoff processes are now recognized, as a result of observations on natural basin during storm periods and many detailed studies of instrumented plots and small areas.

Saturated overland flow occurs when, on part of the drainage basin, the surface horizon of the soil become saturated as a result of either the buildup of saturated zone above a soil horizon of lower hydraulic conductivity of the rise of a shallow water table to the surface. While this usually occurs in valley bottoms, in some regions saturated areas first occur on ridge tops where the surface soil horizon is thin.

Throughflow is water that infiltrates into the soil and percolates rapidly, largely through micropores such as cracks and root and animal holes, and then moves laterally in a temporarily saturated zone, often above a layer of low hydraulic conductivity. It reaches the stream channel quickly and differs from other subsurface flow by the rapidity of its response and its relatively large magnitude.

Runoff process operating at any location very from time to time. Large variation in hydrologic characteristics, and therefore in runoff processes discussed above may occur during a single storm event. Associated with the recognition of several processes producing storm runoff has been the concept that storm runoff may be generated from only a small part of many drainage basin. In addition, this source area may very in extent in different seasons and during the progress of a storm.

The type of runoff process and the location of source areas, whether close to the outlet and adjacent to stream channels or on ridges remote from the channels, has considerable influence on the resulting hydrography. However, practice methods for estimating storm losses and runoff have not yet been developed to explicitly account for these differences. Uniform or average conditions, at least over subareas, are generally assumed. These new insights into physical processes do, however, give some guidance in assessing the validity and applicability of the practical methods. (Pilgrim and Cordery, 1992)

2.2.2 Bangkok city situation regarding flood origins and various trends among a major origin

Flooding in Bangkok is mainly caused by large upstream runoff (causing river flooding), and heavy local rainfall (leading to pluvial flooding), but is also affected by the tidal effect. Following months of heavy downpours in the rainy season in the Chao Phraya River Basin, the River draining the northern part of the country flows through the center of Bangkok on its way to the Gulf of Thailand. At the same time, since the city is close to the sea, the direction of flow of the Chao Phraya River at high tides can be reversed, and in the process the river can overflow its banks when tidal surges meet the heavy run-off from upstream. Land subsidence due to pumping of a large amount of underground water is another factor, although the pace of subsidence has significantly reduced in recent years (World Bank, 2012a). (Norio Saito, 2014).

Bangkok flooding is chronic problem

The Bangkok Metropolitan Administration (BMA) is organized in accordance with the Bangkok Metropolitan Administration Act 1985, to be responsible for the management of the city of Bangkok. officials admit they cannot cope with heavy rains as experts blame infrastructure and lack of preparedness. Bangkok will continue to experience flooding after heavy rains unless water-drainage problems including roads and canals are solved, water-management experts have said.

The heavy rains turned many streets of the city into canals and seriously worsened rush-hour traffic, causing many commuters to arrive late at work or school. One of the worst flooded areas was the Lat Phrao intersection at Ratchadaphisek Road, where the floodwaters reached about 30 centimetres and seriously disrupted traffic. BMA drainage and sewerage director Sompong Wiangkaew said the heavy rains were more than the city's drainage system could cope with. "We are trying our best to save our city from flooding, but the rain was far too heavy for our drainage system, which can accept around 100 to 120 millimetres. Last night, total rainfall was about 170 millimetres," Sompong said. "Moreover, we could not drain the floodwater out of the street properly, because the canals were already full of water from the rains, even though we had decreased the water levels in the canals in advance." Sitang Pilailar, a lecturer at the Water Resources Engineering Department at Kasetsart University, said the reasons the BMA cited were chronic problems for the city. "Bangkok will still flood every time after heavy rain, if the water cannot drain from the roads to the drainage pipes and to the canals properly," Sitang said. (Rujivanarom, *The Nation*, 2017) Thus, stormwater, also

defined as runoff water, especially in a urban area which has to deal with intense rainfall during a short period in the year, has played a significant increasing role in the flood disasters in city, such as Bangkok city. Indeed, the capital city of Thailand is settled on an area with intense seasonal rainfall and where widespread impervious cover leads to major stormwater runoff. Identifying the causes of floods in an area is a first but necessary step in flood prevention policy. Though the policy also needs to address what specific tool can be used. The next section will present one of the possible approach on flood prevention : open spaces.

2.3 Open space protection as a flood mitigation tool

Open space approach has been used in many countries across the globe, not only in countries dealing with monsoon seasons such as Thailand. Indeed, open space protection has long been for instance a cornerstone of land use planning and policy across the U.S. This designation is ubiquitously embedded within local land use or comprehensive plans and often implemented through zoning ordinances. Open space is employed as a land use strategy for multiple purposes, including establishing public parks and recreation areas, separating conflicting land uses, protecting naturally occurring wetlands and riparian corridors, and providing water retention/detention (Bengston et al., 2004).

It was not until the 1990s that local policy makers began using open space protection explicitly for flood mitigation purposes (Randolph, 2004). Protecting floodplains, particularly riparian areas, can help maintain natural storage capacity and reduce the severity of inundation (Freitag et al., 2009; Opperman et al., 2009). Greenways are especially effective in establishing a buffer between waterways and developed areas while still allowing public access and recreational use.

In general, open space protection in the floodplain (where there is a one percent chance of inundation every year) is considered a key element of an “avoidance” strategy of flood mitigation (Beatley, 2009) for several reasons. First, open space land use designations remove people and structures (aside from some recreational buildings) from the most flood-prone areas. Thus, the opportunity for property loss and economic disruption is eliminated. In particular, setbacks from or buffers around riparian areas make space for natural fluctuations of riverine systems and reduces adverse impacts to structures that would otherwise be placed in harm’s way. Linear protected areas associated with rivers and streams can be considered the horizontal equivalent of freeboard (elevation about base flood) in that it spatially extricates development from floodplain areas (Medlock, 2008). While elevation of structures takes an engineering approach to flood mitigation, establishment of

protected areas addresses the problem through land use planning and growth management. (Samuel D. Brody and Wesley E. Highfield, 2013)

The short case study presented above with open space use in United States was chosen as an introductive example of the widespread use of open spaces in flood risk management policies. It doesn't not aim to be a comparative base for the Bangkok situation though it can be used for an integrated reflexion of the utility and aims of open spaces and use of open space planning in urban planning. The following section will develop in deeper details the main ideas relating with open space management approach for flood prevention.

2.3.1 Open space based management, mimicking river flood functionality

Open spaces and green infrastructures can make a valuable contribution to managing surface water run off. This is a particular concern associated with the effects of climate change, notably the anticipated increased frequency of heavy rain events. Open spaces and green infrastructure can form part of critical flood risk management systems by providing space for managed flooding, protecting built up areas.

Urbanisation has significant effects on rainwater interception, storage and infiltration processes. Alteration of these hydrological processes can lead to increased surface runoff and greater vulnerability to flooding, with its associated physical and psychological effects.

Proper utilisation of green infrastructure and Sustainable Drainage Systems (SuDS) can reduce the impacts caused by flooding. The primary benefits of SuDS to flood management are rainfall interception, increased soil infiltration, water uptake, water storage and the delay of peak flows, all of which reduce the quantity of water requiring management. Soil infiltration is a key method of managing flood waters and root penetration aids the process of infiltration. In addition, increased evapotranspiration releases water vapour to the atmosphere, increasing the storage potential of the ground.

While it is obvious that blue infrastructure such as ponds, lakes and rivers store water, green areas such as parks and fields within the flood plain also have the potential to temporarily store storm water and aid with infiltration. Surface attenuation is a key benefit of green infrastructure and it has been shown that trees and pastureland can decrease peak flows by up to 60%.

SuDS have been developed to improve urban drainage and therefore reduce the amount of surface runoff. Swales, infiltration trenches and retention basins capture water where needed and encourage infiltration into the ground.

One of the difficulties regarding storm water management appears to be that the function of green and blue infrastructure is not properly understood and engineers tend to lean towards engineered solutions when assessing the options for managing excess surface water. This is due to the ease of calculating the capacity and efficiency of engineered solutions, yet the benefits of SuDS are often less clear. The implementation of SuDS requires multidisciplinary working and the integration of urban design, landscaping and engineering considerations. The challenge can be overcome when urban design is at the heart of the design process.(Ciria Open space, 2017) (Figure 2.2)

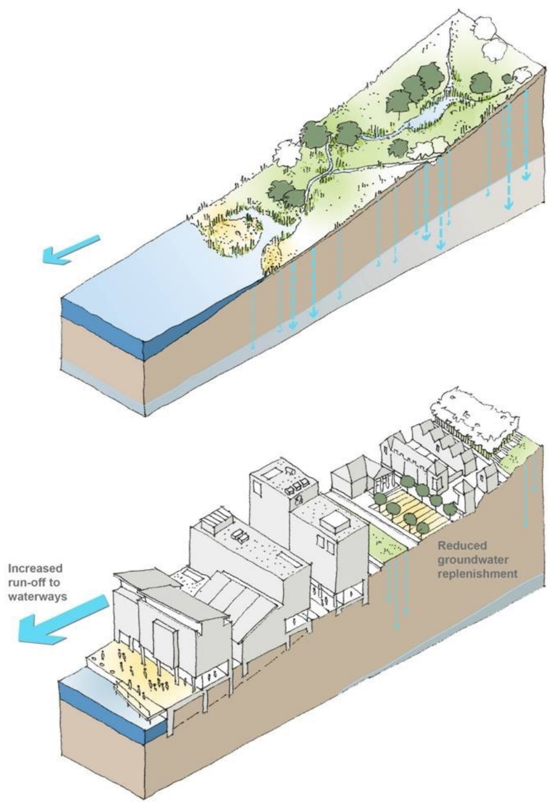


Figure 2.2: Open space for floods risk management
Source: http://www.opengreenspace.com

2.3.2 open space for multiple benefits

Development and land use change in flood-prone areas have greatly increased the impacts of flooding in the United States. Never before in our nation's history have the effects from both surge and rainfall-based storm events been so damaging to the economic vitality of local communities. Losses from both acute and chronic flood events are especially problematic in low-lying coastal areas, where development has accelerated in recent decades. From 2003 to 2013 alone, property owners in the U.S. claimed over $3.5 billion per year in insured flood losses. Strategic land protection, where undeveloped open spaces are protected in perpetuity, is a viable nonstructural solution for reducing flood risk. Protecting open space is also imperative for wildlife and the habitats they depend upon. Yet while open space protection is effective for reducing flood risk and conserving biodiversity, until now there have been no guidelines for determining where to target open space protection efforts to provide these multiple benefits. Scientists at The Nature Conservancy and Texas A&M University partnered to provide that guidance. Together we identified 421 watersheds, out of approximately 2,600 across the Gulf of Mexico (GOM) that are the best targets for strategic land conservation to both reduce flood risk and conserve biodiversity.

To identify the most effective watersheds for land conservation, we took the following approach:

- Identified watersheds with a high probability of future flood damages, using a statistical classification model, and a suite of physical-based predictor variables.
- Identified high conservation opportunity watersheds using the Partnership for Gulf Coast Land Conservation vision footprint and the Protected Areas Database.
- Mapped priority multi-objective watersheds with high likelihood of future flood damage and high conservation opportunity.

(Shepard, 2016)

Beyond the use of open spaces for flood prevention, many different benefits can exist, depending on the design of the open space : **recreational use** for the citizens living nearby; **biodiversity reservoir**, which can enhance the city biodiversity, especially when the open space is connected with other reservoirs with blue or green corridors; **economical value**, when the proximity of open spaces can rise the value of the land properties and attract some activities in the surroundings; finally, a **regulating value**, since open spaces can reduce the pollution and the temperature of the city.

2.3.3 The integration of flood and stormwater management into open space

Key attributes of green open spaces that have implications for flood management and mitigation include their potential capacity to prevent disturbance caused by floods through flood regulation (Millennium Ecosystem Assessment, 2005). Green open spaces can also provide storage capacity for floodwaters in urbanized areas (De Groot *et al.*, 2010). In addition to these flood regulating attributes, water sensitive urban design (WSUD) structures (such as rainwater tanks, bio-retention swales and basins, constructed wetlands, and stormwater harvesting and storage) in green open spaces can reduce stormwater runoff volumes and peak flows at site level (Barton and Argue,2007; Coombes, 2009; Walsh *et al.*, 2012) Finally, there have been calls for planning for interconnected and strategically planned networks of green open spaces to occur early in land use planning and design processes, with consideration of ecosystem values and water-related landscape functions (Benedict and McMahon, 2002; Carmon and Shamir, 2010). In particular, it is argued that such early planning could facilitate the development of networks of multi-functional green open spaces in concert with land development, growth management and physical infrastructure planning (Benedict and McMahon, 2002; Carmon and Shamir, 2010).

Hence, there is substantial evidence that green open spaces can provide ecosystem services to support flood management and that land use planning has a key role to play in implementation of green open space strategies within urban areas. Nonetheless, there is limited evidence of green open spaces being considered within planning as a key part of flood mitigation. Additionally, while planning for multi-functional green open spaces is a relatively new concept yet to be tested in its full potential, this consideration should permeate land use planning and design processes; especially as an attempt to revert some of the negative effects borne from past land use planning and water resource management decisions. This multi-functionality needs to be integrated with water resource management along with other planning considerations, such as grey infrastructure planning and community facilities, to protect hydrologically sensitive areas and water-related ecosystem services. The development of water sensitive green open space networks and concepts of green infrastructure and ecosystem services as an ally to flood management requires application-oriented frame-works that are suitable to be mainstreamed into planning practice in a holistic way. (Schuch *et al.*, 2017)

Objectives of Public Open Space & Water Sensitive Urban Design

There are different types of open space, each with different purposes and needs. This paper confines the discussion to public open space — that is, open space in public ownership and accessible to many. Public open space is commonly separated into four categories: active public open space, passive public open space, conservation public open space, or operational public open space. These are defined in (Figure 2.3).(Water by Design, 2011)

Table 1: Types of Public Open Space

Type of public open space	Definition	Characterised by
Active public open space	Primarily designed for users to participate in physical and social activity. It has a focus on activation of the body.	Sporting fields, playgrounds, dog exercise areas, sports courts and practice walls, wide, high-use walking and cycling tracks, large clusters of picnic and BBQ shelters, sport playing amenities including ablutions and lighting
Passive public open space	Primarily designed for its natural or created amenity and views. It has a focus on activation of the senses such as the mind and the eyes. It can also allow for social gathering and interaction.	Gardens (whether exotic or natural), viewscapes, informal lawn areas, narrow informal walking and cycling tracks, small-scale seating and picnic facilities
Conservation public open space	Primarily natural areas with conservation values (not designed).	Natural, largely unmodified bushland areas
Operational public open space	Primarily retained for infrastructure purposes. It is often viewed as wasteland, without regard for other open space attributes. There are few opportunities for shared uses.	Land under power line easements, buffers to adjacent land uses, constructed drainage lines such as concrete-lined channels

Figure 2.3: Type of Public Open space
Source: Water by Design, 2011

2.3.4 The relation between flooding and open space

Specifically, open spaces (Not Public Open Space) "Public open spaces such as parks and green spaces are key built environment elements within neighbourhoods for encouraging a variety of physical activity behaviours. Over the past decade, there has been a burgeoning number of active living research studies examining the influence of public open space on physical activity. (Koohsari et al., 2015)" are increasingly being used for flood mitigation, to reduce the damage caused by floods and to protect the flood prone areas from land encroachment and to control the future development is keeping flood-prone areas for open space purposes (Brody

and Highfield, 2013),(White and Richards, 2007) and (Burby and French, 1981). Within this view, most of the local authorities protect these open spaces as an important land use planning tool focusing flood mitigation. However, most of these discussions and strategies merely recommend to preserve the hazard prone lands as open spaces and lack of consideration is given to understand the practical implementation of this strategy to cities. As a solution, these flood- prone areas can be converted to Public Open Space (POS) with designated uses. Valuing this approach, the literature studies such as Woolley (2004), Kubal, Haase, Meyer, and Scheuer (2009) emphasize that these preserved open spaces as flood prone areas can be potentially converted to POS promoting wildlife habitat and recreational activities. Specially, in the urban context where the land is a scarce resource, this can be considered as a vital solution to get the highest and best use of land in rapidly urbanizing areas and at the same time, as a strategy for disaster resilience. Accordingly, it can be summarized that existing literature suggest the use of POS for disaster resilience contributing three main stages of disaster cycle; emergency response, recovery and mitigation. Nevertheless, currently less attempts have been made to harness the above mentioned potentials when planning and design POS for sustainable and resilience cities. Addressing this need, the next section is focused on how to harness these potentials through planning and designing POS in urban context.

In this section, it was demonstrated that open space have many benefit for flood prevention and can provide the implications for flood management and mitigation include their potential also many function of open space managing surface water run off. This potential can adapted to the spatial planning for flood prevention it will show in the next section.

2.4 Open space for flood prevention in term of urban context

Definition of Urban Terms

Regarding cities, there are two generic forms of the city, the urban area (the physical form) and the metropolitan area (the functional or economic form). The first generic form of the city is the physical expanse, or area of continuously built-up urbanization. The urban area is generally observable on a clear night from a high flying airplane. The urban area is simply the extension of urbanization. The urban area is not defined by jurisdictional boundaries, though where national statistical authorities define it is necessary to rely on building blocks such as census tracts and

municipalities. Like metropolitan areas, urban areas can extend across sub – national jurisdictional lines (such as state, provincial or regional boundaries), or in special cases, international boundaries.

Various terms are used by national statistical authorities in the United Nations (Table: Urban Area Terminology). An urban area will never be the same as a municipality. Usually it will include many municipalities, though in the case of many geographically large municipalities, such as Anchorage or Shanghai, the urban area will be smaller than the core municipality. The Chicago urban area (population over 8,000,000) includes the city of Chicago and many other cities. An urban area might be thought of as defined by the lights seen from an airplane on a clear night. Some nations formally designate urban areas, which are called “urbanized areas” in the United States, “unites urbaines” in France, urban areas in the United Kingdom and Canada, “urban centers” in Australia and “urban agglomerations” in India. An urban area is also an *agglomeration*. A *conurbation* is an urban area that forms when two or more urban areas grow together, as has occurred in Osaka-Kobe-Kyoto, Essen-Dusseldorf (the “Rhine-Ruhr-Wupper”) or Katowice-Gliwice (Poland).

The second generic form of the city is the functional expanse, which is also the economic expanse. The metropolitan area includes the built-up urban area and the economically connected territory to the outside. The economic relationship is generally defined by patterns of commuting to work into the urban area. Thus, metropolitan areas constitute labor market areas. Metropolitan areas can extend over sub-national boundaries, except in rare cases where there is not free movement of labor (such as between Hong Kong and Shenzhen in China). Further, where free movement of labor is permitted by international agreements, metropolitan areas may cross national boundaries (such as in the European Union or between Switzerland and France, in the Basel and Geneva urban areas). (Demographia, 2002).

2.4.1 Planning Approaches to Reduce Natural Hazards

Flooding is a natural process that, in the absence of human settlements, is of relatively little concern. However, when human settlements are introduced in to an area where flooding occurs, hazards to life and property from rising flood waters become challenges that must be addressed. Effective floodplain management requires communities to identify and understand which areas in their community are at risk from flooding, create planning and zoning schemes that keep people and infrastructure out of harm’s way, and establish regulations that promote flood-safe decision making.

With effectively mapped floodplains and flood risks, planning and zoning are powerful tools that, when used effectively, can set communities on the path to resilience. As a part of a floodplain management strategy, this can allow for the reduction or prevention of current and future flood problems and creates a means of protecting natural habitats that provide hazard reduction and other benefits. What follows is a presentation of some of the more common planning tools that may have a role to play in promoting more flood hazard-resilient communities. It is important to consider that these tools, while presented as separate, are most effective when they are integrated with one another and carry a consistent message and set of actions that promote resilient decision making.

The first tool is the comprehensive plan. Much as its name implies, it establishes a comprehensive set of goals for a community to pursue. It is a forward-looking, at times aspirational effort that sets the stage for other plans, regulations, policies, and programs that implement the comprehensive plan's goals. Comprehensive plans are often used to establish a vision for future land uses, which can be used to promote a more resilient community. Directing development away from current and future areas that are vulnerable to flood impacts can promote greater community resilience. Similarly, open space acquisition plans and conservation plans can be used to target valuable natural habitats that can reduce flood and erosion risks if they are protected from development impacts.

A second tool, Risk Assessment, relies on Planning and floodplain management efforts built on a description of the hazard and its impact on development (and the impact of development on natural floodplain functions). While some communities rely solely on their Flood Insurance Rate Map (FIRMs) to determine what their risk is or react to the impacts of the most recent disaster, communities that have invested in enhanced floodplain mapping should look to those mapping efforts to guide the assessment of their disaster risk. It is important to account for not only current risk from a variety of hazards but also to look at how that risk may change over time as flooding and erosion impacts change with changes to sea level and precipitation patterns.

The last tool, Hazard mitigation plans, focus on actions that are intended to reduce flood losses in a community, such as identifying areas where buy-outs of flood prone structures may occur. A local hazard mitigation required for local governments to be eligible to receive hazard mitigation assistance from the federal government. These plans and the process used to develop them generally provide a good opportunity to work with community members to identify real and perceived vulnerabilities and to map out strategies to reduce or eliminate those vulnerabilities.

While the process can be onerous, it is well worth the time to invest in the development of a highly localized hazard mitigation plan and to integrate that planning work into land use plans and building codes. **(**Naturally Resilient Communities, 2017)

2.4.2 Land use tool : Park and Open space plan

Integrating Hazard Mitigation into the Plan

Much like any other planning document, parks and open space plans vary widely in terms of format, organization, and level of detail, based on the goals of the jurisdiction and the resources available to support the planning effort. Most parks and open space plans contain **3 components**, or some variation: the first one consists in an **Inventory of assets**. It provides a list of the overall existing structures, addressing the following : What is the current total amount of parks, open spaces, trails, and recreation areas and facilities? Where are they located? Where are there gaps in the system? Are assets located in hazard areas?

One of the major component of open space plans is the part presenting the **Policies**. This part deals with the existing state of the parks and open spaces, presenting global trends to address also their maintenance : How should the community address issues related to parks and open space? Should additional investments and land acquisitions occur outside of hazard areas? Is increased maintenance a priority? Should the community consider sharing resources? Finally, the 3rd component of parks and open spaces deals with the future of it with **Priorities and recommendations.** It provides a guideline to answer the actions to do in the following years : What are the specific steps a community can take to address a stated issue? Are there gaps in the system that should be treated as priorities? Should areas outside known hazard areas be given higher priority than others? The next paragraph will explain in details the main ideas which can deal with the choice of **policies** and the establishment of priorities and **recommendations**.

Policies

Parks and open space plans use the inventory of assets and identification of issues and gaps in service to develop **policies** to help achieve the goals of the plan. Those policies can include statements related to reducing risk and hazard mitigation. Some examples of policies that address hazard areas include:

- Encourage the use of floodplains and major drainage facilities for recreational use, open space, and other appropriate uses that preserve the natural environment and minimize the potential for property damage.
- Work with experts to ensure there is an adequate buffer between development and natural areas, water bodies, wetlands, and floodplains.
- Maintain adequate buffers through open space preservation to allow high-hazard landscapes to function in a natural way with minimal human intervention and modification.
- Strengthen safety and security in the community's parks, open space, and recreation areas by addressing flood, fire, drought, and other hazard issues.
- Design park facilities to preserve natural features that help control stormwater, and minimize the introduction of new structural features and impervious surfaces.

Priorities and Recommendations

Much like a comprehensive plan, the parks and open space plan typically establishes recommendations and strategies to achieve the stated policies and goals of the plan, such as:

- Review floodplain regulations and revise, as appropriate, to encourage recreational and open space uses within floodplains.
- Review floodplain regulations to ensure they sufficiently limit the amount a floodplain can be modified when considering current and future parks, open spaces, and recreation areas.
- Prioritize acquisition of riparian corridors for open space preservation to achieve multiple benefits (e.g., trail connectivity, stormwater management, habitat preservation, and recreation).
- For [specific park or open space], provide a trail surface that can stand up to intermittent flooding during high water events in an effort to reduce ongoing maintenance requirements.
- For steep slopes, allow adequate separation from developed landscapes.
- For fire zones, provide demarcation or buffer zones between development landscapes and natural forests.
- Land not suitable for development or passive recreation within new development proposals due to steep slopes, poor soils, floodplain areas, or other hazards should be maintained as deedrestricted private open space and not accepted as publicly dedicated open space.

- Landscape conditions caused by natural hazards (flooding, erosion, or wildfires) may be modified for habitat restoration, public safety, or the reconstruction of public facilities such as trails or cultural resources.

(Planning for Hazard Land use Solution for Colorado, 2017)

2.4.3 Planning for green open spaces to aid flood management

The role of green open spaces in aiding flood management

Floods can be naturally occurring phenomena that benefit ecosystem health (Mirza et al., 2005). However, human activities can reduce the capacity of ecosystems and soils to absorb excess water and attenuate floods (Bravo de Guenni et al., 2005), (Vorosmarty et al., 2005), (Coombes and Roso, 2015). Population growth and settlement preferences also strongly influence the regulation of floods, the expansion of human settlements onto floodplain areas being a common cause for increased vulnerability to flood impacts in human settlements (Bravo de Guenni et al., 2005), (Mirza et al., 2005). Efficient transport of runoff from impervious surfaces in urban settlements by piped stormwater drainage systems have generally resulted in urban streams that exhibit a flashy hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness (Meyer et al., 2005), (Walsh et al., 2005), (Haase and Nuissl, 2007). The accompanied decreased infiltration, increase in surface runoff, and reduced baseflow discharge in urban streams often leads to increased risks of flash flooding (Haase and Nuissl, 2007) and reduced potential for groundwater recharge (Hough, 1995), (Paul and Meyer, 2001), (Walsh et al., 2005).

These consequences are especially likely where impervious surfaces are directly connected to urban streams (Walsh et al., 2005) and are related to a range of other factors such as the spatial pattern of land conversion, and the previous quality of converted land (Haase and Nuissl, 2007). In this paper, green open space is defined as space that is dominated by a ‘natural’ environment and characterised by ecosystem and landscape values, as opposed to a built-up environment with a higher degree of intervention in ecosystem and landscape processes (Maruani and Amit-Cohen, 2007). This definition includes a range of different land uses such as agricultural and conservation areas through to greenways and green belts or corridors, and constructed and natural wetlands (Bengston et al., 2004), (Bomans et al., 2010).

This section concentrated on the role of green open spaces and inherent ecosystem services in aiding flood management and mitigation. Key attributes of green open spaces that have implications for flood management and mitigation include their potential capacity to prevent disturbance caused by floods through to flood regulation (Millennium Ecosystem Assessment, 2005). Green open spaces can

contribute to flood regulation through increased soil permeability, which leads to reduced surface runoff and peak stream flows (Bravo de Guennietal., 2005), (Gilletal., 2007), (Kaz´mierczakand Cavan, 2011), (Ellis, 2013). Green open spaces can also provide storage capacity for floodwaters in urbanised areas (De Groot et al., 2010) while riparian vegetation helps to reduce stream bank erosion during flood events (Tubman and Price, 1999). These functions are also performed by corridors and networks of green open spaces that incorporate stormwater infrastructure alongside or adjacent to water bodies (Gill et al., 2007), (Handley, 2007), (Wheater and Evans, 2009) (Ellis, 2013), which can be used as surface flow path- ways, providing water storage and retention areas at times of high water flow. Site vegetation and neighbourhood riparian corridors can also reduce runoff from low intensity, short duration rainfall events (Ellis, 2013).

Green open spaces retained in upstream catchment areas help maintain streamflow and reduce peak streamflow in lower parts of the catchment (Sinai et al., 2006 in Carmon), (Shamir, 2010). Inland water components such as natural and constructed wet- lands, floodplains, lakes and reservoirs can assist flood attenuation through increasing residence time of rivers, reservoirs and soils (Bravo de Guenni et al., 2005), (World Resources Institute, 2005), (Demuzere et al., 2014). These flood regulating services clearly justify attention paid to green open space planning in the context of ecosystem services that contribute to flood management.

In choosing to focus on the planning of green open spaces and ecosystem services for flooding, we acknowledge that this is one aspect of a range of different actions that may relate to water sensitive planning and integrated urban water management, and that due to the connected dynamic movements of water through urban regions specific water management issues (such as flood management and planning for green open spaces) are intrinsically connected and difficult to separate from a range of other water management issues and actions. Nonetheless, green open spaces (Benedict and McMahon, 2002), (Keeley et al., 2013), flood management (Godden and Kung, 2011) and ecosystem services (Liu et al., 2013) are crucial aspects in the shift to total water cycle management that need to be mainstream in policy (and planning initiatives) (Ellis, 2013). These are concepts and ideas that have received significant attention in applied science (Lennon et al.,2014) and some practice internationally (Ashley et al., 2011), but potentially remain experimental and limited within policy.

Enabling the implementation of green open spaces

Accompanying the rising interest in the role of carefully planned green open spaces to achieve flood regulation and other ecosystem services, are a number of planning measures and concepts that seek to accommodate surface water rather than exclude it. There is increasing evidence that such measures, often proposed under

headings of green infrastructure, WSUD, and/or low impact development (LID), can contribute to flood regulation (Fletcher *et al.*, 2015) through the maintenance of ecosystem services in green open spaces (Demuzere *et al.*, 2014).

In response, a number of urban planning approaches seeking careful placement of green open spaces in accordance with the natural hydro-geographic layout have emerged over the last decade (Carmon and Shamir, 2010), (Porse, 2013). These approaches can alleviate pressures on underground drainage networks and reduce risks of sewer and stormwater flooding through capturing and infiltrating urban runoff in consideration with the natural stream system (Carmon and Shamir, 2010). However, the capacity of green open spaces to regulate flooding may be limited in severe meteorological events (Depietri et al., 2012). In addition, it is important to acknowledge that simplistic panaceas or blueprints will be insufficient to address the complex issues associated with ecosystems services relating to flood management that are derived from green open space, and planning has to be suitable for specific localities (Ferguson et al., 2013).

One of the emerging urban planning approaches seeks to avoid development of urban settlements in floodplains, leaving them as green open spaces with designated land uses (such as agriculture and recreational areas) that may be temporarily suspended during flood periods with acceptable losses (Carmon and Shamir, 2010). A second approach relates to the placement of green open spaces alongside, or close to urban streams, with multi-functional attributes such as providing active transport corridors, recreational areas, amenity, and habitat (Flink, 2002), (Gill et al., 2007), (Carmon and Shamir, 2010).

Finally, there have been calls for planning for interconnected and strategically planned networks of green open spaces to occur early in land use planning and design processes, with consideration of ecosystem values and water-related landscape functions (Benedict and McMahon, 2002), (Carmon and Shamir, 2010). In particular, it is argued that such early planning could facilitate the development of networks of multi-functional green open spaces in concert with land development, growth management and physical infrastructure planning (Benedict and McMahon, 2002), (Carmon and Shamir, 2010). Planning approaches that address the whole water cycle and landscape scale in a holistic manner (McCallum and Boulot, 2015), and that integrate land use planning (including green open space planning) and water resource management are sought to facilitate the aims described above (Brown et al., 2009), (Gain et al., 2013), as fragmented and piecemeal approaches have been cited as common challenges in achieving water resource management goals (McCallum and Boulot, 2015).

Hence, there is substantial evidence that green open spaces can provide ecosystem services to support flood management and that land use planning has a key role to play in implementation of green open space strategies within urban areas. Nonetheless, there is limited evidence of green open spaces being considered within planning as a key part of flood mitigation. This study applies a case study approach to investigate how green open space is currently incorporated into land use planning, how flood management ecosystem services are considered and what opportunities and limitations there are to implementing green open space as a flood strategy. (Gemma Schuch et al., 2017)

Open Space plan related to Flood Prevention

Open spaces are increasingly being used for flood mitigation, to reduce the damage caused by floods and to protect the flood prone areas from land encroachment and to control the future development is keeping flood-prone areas for open space purposes (S. D. Brody and W. E. Highfield, 2013), (I. White and J. Richards, 2007), and (R. J. Burby and S. P. French, 1981) . Within this view, most of the local authorities protect these open spaces as an important land use planning tool focusing flood mitigation. However, most of these discussions and strategies merely recommend to preserve the hazard prone lands as open spaces and lack of consideration is given to understand the practical implementation of this strategy to cities. As a solution, these flood-prone areas can be converted to Public Open Space with designated uses. Valuing this approach, the literature studies such as (Woolley H. H. E. Woolley, 2004), (Kubal et al., 2009), emphasize that these preserved open spaces as flood prone areas can be potentially converted to Public Open Space promoting wildlife habitat and recreational activities. Specially, in the urban context where the land is a scares resource, this can be considered as a vital solution to get the highest and best use of land in rapidly urbanizing areas and at the same time, as a strategy for disaster resilience.

Accordingly, it can be summarized that existing literature suggest the use of Public Open Space for disaster resilience contributing three main stages of disaster cycle; emergency response, recovery and mitigation. Nevertheless, currently less attempts have been made to harness the above mentioned potentials when planning and design Public Open Space for sustainable and resilience cities. Addressing this need, the next section is focused on how to harness these potentials through planning and designing Public Open Space in urban context. (R.R.J.C Jayakody, D. Amarathunga, and R. Haigh, 2018)

2.4.4 Integration of Spatial Planning and Flood Risk Management

This section represents a visual way area of interest of this thesis the gap between comprehensive plan and flood risk management planning. The study will try to link both data to our case study, Don Mueang, which will tackle our first hypothesis.

Spatial planning is a nonstructural activity that governments and communities use to influence the extent of development of floodplains through zoning and other regulations (Ward 2013). Spatial planning determines the key factors that influence flood risk, such as the location of certain activities, type of land use, scale of development, and design of existing and proposed physical structures (White and Richards 2007).

Noticing the important role of spatial planning in flood mitigation, scholars suggested that integration of spatial planning and flood risk management is a promising approach for addressing flooding problems (Miguez et al. 2015; Khailani and Perera 2013; Neuvel and Van Der Knaap 2010; Howe and White 2004). Integration is frequently reflected in statements such as (1) coordinating strategies and policies, (2) encompassing a new issue, (3) connecting policy and action, and (4) linking actors together (Vigar 2009). In practice, integration requires actions to strengthen the linkages between places, interconnections among policies, and cooperation between sectors (Kidd 2007). These actions improve the degree of integration in the territorial, policy, and institutional dimensions.

Difficulties in achieving integration in territorial and institutional dimensions have been identified. In the territorial dimension, difficulties lie in the mismatch of the jurisdiction boundaries between planning authorities and flood risk management authorities. The jurisdictions of planning authorities, which are often defined according to human activities, rarely correspond to the jurisdictions of flood risk management authorities, which are often natural geographic districts (Howe and White 2004; White and Richards 2007). In the institutional dimension, difficulties are caused by the disagreement regarding the role of spatial planning in flood mitigation. Planning authorities propose ways to arrange physical space and suggest future activities within the planning jurisdiction based on a variety of planning interests, feasibilities, and accepted principles (Kidd 2007; Larsson 2006). Planning authorities generally do not consider spatial planning as a flood risk management tool (Dawson et al. 2011). For example, Neuvel and Van Den Brink (2009) found that planning authorities in Netherlands rarely considered spatial planning as a flood mitigation measure. Thus, planners and flood risk managers tend to have different views of the role that spatial planning has in flood risk management. These differences may lead to inappropriate expectations and inefficient practices. For example, Howe and White's (2004) study in the United Kingdom concluded that the value that spatial

planning added to flood risk management was limited.

In the policy dimension, it is unclear that what barriers and factors prohibit the policy integration in the field of spatial planning and flood risk management. Stead and Meijers (2009) suggested that policy integration requires a variety of facilitators from the political, financial, organizational, management, and cultural sectors. Ran and Nedovic-Budic (2016) underlined the absence of easy access to integrated and high-quality information, and the lack of technologies and tools to use information to support policy integration. (Jing Ran, 2017)

Consequently, this part summarised all of the theory and article that can describe above the concepts and ideas of this research. Firstly, it focused on flood definition. This disaster can happen in many areas around the world but there are different cases so it is very efficient to understand the case of flooding to find the suitable solutions in each area. In this case, this research concerns on flooding from stormwater in urban areas. On this purpose, the concept of Rainfall-Runoff Relationship can help to understand this situation. Also, in this chapter, it was tried to present the concept of green infrastructure for flood prevention focusing on open space to understand the process of exploiting the open space plan to the benefits of flood protection. Therefore, the researcher will be able to link ideas and theories to data analysis in the next chapter.

Policy Implementation: Legislation, Policy, and Development

Policy implementation is a central concern to policymakers. Studies of policy implementation try to discover and understand the inconsistency between government policies at one level and policies at another level, or the incompliance of policy in specific actions (Lowry 1985; McLaughlin 1987). Policy implementation studies apply top–down or bottom–up approaches. The top–down approach utilizes careful analysis of official government decisions and the extent of attainment of formal objectives (Sabatier and Mazmanian 1979, 1980). The bottom–up approach focuses on the linkage between actors and public behavior (Benny 1982). In a research of dominant public policies or the effectiveness of public programs, the top–down approach is more useful. In the policy areas where individual actors and public behaviors play the dominant role, the bottom–up approach is more useful (Sabatier 1986).

Two main concepts raised from this chapter. First, the description of the different causes and patterns of floods settled the issue at stake in the research. Also, on a second part, stormwater was developed in the light of open spaces, one of the key tool to assess flood risk prevention. These ideas introduced the situation of Bangkok city where stormwater is on global concern and for which the local planning document, the Comprehensive Plan takes open space into account for flood protection in order to protect the city center area. The methods that will lead to the implementation and research methods will be presented in the next chapter.

Chapter 3

Theoretical framework and Research approach

The aim of this chapter is to allow the main purpose of this research, to provide a response on flood prevention with open space planning, thus providing a case study on Bangkok city in Thailand. There are gaps in the existing open space plan for flood prevention in Bangkok city concerning the process of spatial planning instruments and the relationship between policy instruments and the tools of flood prevention. To help address this gap this research attempt to fill the gap of 4 mains issue are (1) flood prevention (2) open space (3) urban area (4) the spatial planning policy by literature review is analytical tools to study empirical facts.This research will try to demonstrate how open space plan can be connected with flood prevention policy in urban areas. It will try to integrate the spatial planning policy with the result of research to improve the terrible situation and suggest the solution of this problem. It is not a main objective to understand the flood situation in Bangkok city. The study will try to provide a guided view of open space planning based flood prevention which could be used later on a flood guideline to develop overall flood risk management policy in Bangkok city in the future.

In this thesis, it is acknowledge that : flood prevention policy is on vital consideration in Bangkok city due to the overall damage caused by flood every year in the city on people, infrastructures and activities. Also, within the comprehension plan of Bangkok, which is the planning plan of the city, open space plan, one of its documents, is not efficiently taken into account. The Master Plan for Water Resources Management, which includes the city flood management strategy, has not yet taken into account open space based approach. This is why this thesis will try to fill the gap between flood management policy and urban planning policy (Bangkok comprehensive plan) by providing a new approach on flood prevention using open space.

The objectives are: to protect city centre of Bangkok city by using open space plan and to examine the efficiency of non-structural flood countermeasure by open space include in Thai master plan for water resource management, namely land use regulation, Bangkok comprehensive plan. It is not a main objective to understand the flood situation in Bangkok city.

Research Question:

What kind of conceptual model of flood prevention can be established in Bangkok city, based on open space approach in Don Mueang district and focused on stormwater management ?

The hypothesis in this thesis are :

1 : The efficiency of non-structural flood countermeasure by open space, which can protect from flooding, has not been considered much yet in Bangkok's master plan for water resource management by land use regulation.

2 : Open space areas can be added into the local comprehensive plan to support an overall flood prevention strategy.

3.1 Methodology

The process attempts in three parts. Firstly, it will expose the structure of urban planning system in Thailand and focus on a presentation of a local area in Bangkok city, Don Mueang district, which is one of the 50 districts (khet) of the city, suitable case study to become an area to protect the city center of Bangkok city using open space plan tool. Secondly, the study will provide an analysis of secondary research data about the theory and concept of open space critical flood risk management systems, using it as a grid to adapt to Don Mueang district to protect built up areas. Also, analysis of the Bangkok comprehensive plan and concerning in open space plan will be discussed. Finally, the study will provide a conceptual model and study of a master plan for flood prevention by open space in local area.

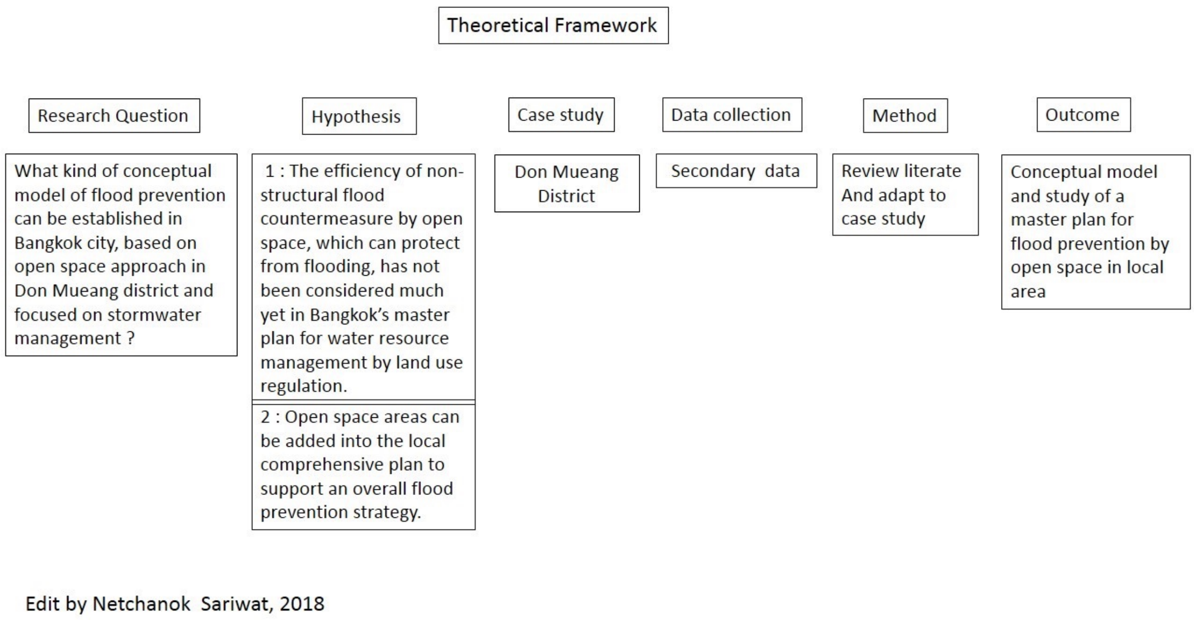


Figure 3.1: Theoretical Framework
Source: Netchanok Sariwat, 2018

Thus, the theoretical framework gave the process of this research and started with research question and hypothesis to specify the objectives of this research and also defined the case study which is suitable for the research. In addition, the researcher will use secondary data in this study. Analytical methods are used in conjunction with theory and thinking. This will lead to the results of the research that will be presented in the next chapter.

3.2 Analysis data

This part will integrate the chapter 2 (literature review part), which is the analytical tool to study empirical facts and also study the background of the case study. Moreover, it will study the law and regulation of case study, focusing on the Bangkok comprehensive plan, considering at the same time open space plan from 2006-2013. The analysis will be divided in two parts. First, the different planning documents will be presented focusing on land use, legal part. On parallel, flood management maps, plan and legal part of flood management will be discussed. On a second part, these data will be put together to provide a complete overview on how both urban planning and flood management policies are combined into the

overall land use in Bangkok city. This analysis will be used as a basic starting point to highlight the key strengths and weaknesses of the combined policies. Furthermore, improvements will be proposed on the cooperation of both policies, applied in the Don Mueang district case study. This process will help to identify further suitable open space areas which could be used as storage areas during heavy rain episodes.

3.3 Conceptual Model : Definition of Analytical Framework

After analysing the data this research will try to provide a conceptual model as a Analytical Framework by using the master plan for flood prevention by open space planning in local area (Bangkok city).It will try to demonstrate the urban context and flood prevention aligned with integrated with Bangkok comprehensive plan, the study create a conceptual model based on data and perspective of researcher. The methods used in the process of creating the concept was a theoretical analysis and connection was made between theoretical and Bangkok situation and take to implementation.

The key point of the analysis was to set objective criteria which can provide a good evaluation of the policies linking Flood risk management and land use. Evaluation was here based on :

- transparency
- compatibility
- efficiency

This criteria echoed those used in literature (Meghan Alexander et al., 2016). The goal here was to present wether actions were done within the city to address flood risk. The legitimacy question was mostly based on the use of flood risk occurrence map in Bangkok city. Societal acceptance of such policy could not be taken into account due to the lack of data even though the tool can be a useful parameter to take into account for land use and land management policies. Considering than the first land use and open space plan are from 2006, it has been possible to discuss on effectiveness and efficiency of the measures taken on an 11 year's scale. Compatibility was settled between flood risk management on one side and land use/Comprehensive Plan goals on the other hand. It was then possible to establish an overall notation of the quality of the response given by the authorities to the flood risk management issue in the city.

Hence, this chapter provided explications of the methodology of this research. The case study was chosen from the analysis of land use plan based on the Bangkok comprehensive plan and more specifically the open space plan from 2006 - 2013. Then the process of analysis data will be divided in two sections and finally the outcome of this research will come up with the conceptual model for the analytical framework.

Chapter 4

Analysis and Results

The aim of this chapter is to present the collection of secondary data with the process of analysis data and present the conceptual model for analytical framework. The process of this section is to present on one side the different data gathered regarding planning system in the country Bangkok related information, land planning, flood prevention plans and mapping before the focus on Don Mueang district. Then, on the other side, the chapter will deliver a complete analysis of such information, based on different time scales approach and typology of action to establish a lecture table which synthesises the key ideas .

Research overview

Based on the literature review of the chapter 2, stormwater was identified as the main reason for floods in Bangkok city area. Also, in this chapter, open space areas, through integrated open space plan within spatial planning policy, were identified for their valuable contribution to propose an efficient approach for flood prevention policy. These guide the main idea of the result part approach. The research start with overview the background of Bangkok city. After that, understanding to the structure of town and planning system in Thailand also specific on the system of comprehensive plan in Bangkok city. Then the study will focus on the existing maps and guiding plans concerning flood management policy. Hence, this part is followed by a study of subjects such as: review policy and land use policy plan from the past (2006) to the latest updates (2013) in Bangkok city and focusing in case study in Don Mueang district. A third part will try to link both data to our case study, Don Mueang district, which will tackle our first hypothesis. And the end of this chapter, provide a conceptual model will be established in a fourth part from the information gathered and the analysis concluded, answering our 2nd hypothesis.

4.1 Background of Bangkok city

The Bangkok city proper covers an area of 1,568.737 square kilometres (605.693 sq. mi), ranking 69th among the other 76 provinces of Thailand. Of this, about 700 square kilometres (270 sq. mi) form the built-up urban area.It is ranked 73rd in the world in terms of land area by City Mayors.The city's urban sprawl reaches into parts

of the six other provinces it borders, namely, in clockwise order from northwest: Nonthaburi, Pathum Thani, Chachoengsao, Samut Prakan, Samut Sakhon and Nakhon Pathom. With the exception of Chachoengsao, these provinces, together with Bangkok, form the greater Bangkok Metropolitan Region. (Wikipedia, 2017)

Topology

Bangkok is in the Chao Phraya River delta in Thailand's central plains. The river meanders through the city in a southward direction, emptying into the Gulf of Thailand approximately 25 kilometres (16 mi) south of the city centre. The area is flat and low-lying, with an average elevation of 1.5 metres (4 ft 11 in) above sea level. Most of the area was originally swampland, which was gradually drained and irrigated for agriculture via the construction of canals (khlong) which took place throughout the 16th to 19th centuries. The course of the river as it flows through Bangkok has been modified by the construction of several shortcut canals. Bangkok's major canals are shown in this map detailing the original course of the river and its shortcut canals. (Wikipedia, 2017)

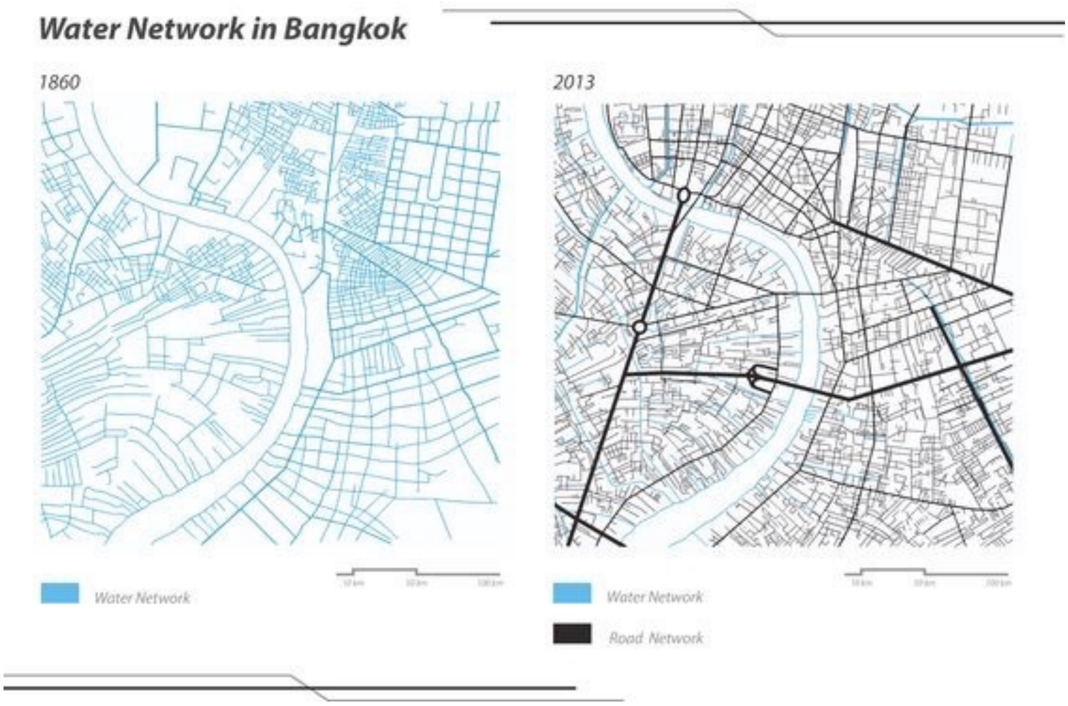


Figure 4.1: water network in Bangkok city
Source: https://www.pinterest.com/pin/308848486917784692/

This intricate waterway network served as the primary mode of transport up until the late 19th century, when modern roads began to be built. Up until then, most people lived near or on the water, leading the city to be known during the 19th century as

the "Venice of the East".Many of these canals have since been filled in or paved over, but others still criss-cross the city, serving as major drainage channels and transport routes. Most canals are now badly polluted, although the BMA has committed to the treatment and cleaning up of several canals.

The geology of the Bangkok area is characterised by a top layer of soft marine clay known as Bangkok clay, averaging 15 metres (49 ft) in thickness, which overlies an aquifer system consisting of eight known units. This feature has contributed to the effects of subsidence caused by extensive ground water pumping. First recognised in the 1970s, subsidence soon became a critical issue, reaching a rate of 120 millimetres (4.7 in) per year in 1981. Ground water management and mitigation measures have since lessened the severity of the situation, although subsidence is still occurring at a rate of 10 to 30 millimetres (0.39 to 1.18 in) per year, and parts of the city are now 1 metre (3 ft 3 in) below sea level.There are fears that the city may be submerged by 2030. Subsidence has resulted in increased flood risk, as Bangkok is already prone to flooding due to its low elevation and inadequate drainage infrastructure resulting from rapid urbanisation. The city now relies on flood barriers and augmenting drainage from canals by pumping and building drain tunnels, but parts of Bangkok and its suburbs are still regularly affected by flooding. Heavy downpours resulting in urban runoff overwhelming drainage systems, and runoff discharge from upstream areas, are major triggering factors. Severe flooding affecting much of the city occurred recently in 1995 and 2011. In the latter, most of Bangkok's northern, eastern and western districts became inundated, in some places for over two months. Coastal erosion is also an issue in the gulf coastal area, a small length of which lies within Bangkok's Bang Khun Thian District. Global warming poses further serious risks, and a study by the OECD has estimated that 5.138 million people in Bangkok may be exposed to coastal flooding by 2070, the seventh highest among the world's port cities. (Wikipedia, 2017)

4.2 Don Mueang district : case study

Don Mueang is one of the 50 districts of Bangkok, Thailand. Situated in the northern part of the city, It is bounded by (from north clockwise): Mueang Pathum Thani and Lam Luk Ka of Pathum Thani Province; Sai Mai, Bang Khen and Lak Si of Bangkok; and Pak Kret of Nonthaburi Province. The total area is 36.803 km^2 (14.210 sq mi).

Figure 4.2 : Don Mueang District location
Source: Wikipedia

4.3 The role of Comprehensive Plan

A key tool of land use planning

The New York State Court of Appeals noted in Udell v. Haas that "the comprehensive plan is the essence of zoning. Without it, there can be no rational allocation of land use." Indeed, the statutes require that all land use regulations must be made "in accordance with a comprehensive plan." Therefore, planning should precede any adoption or amendment of a land use regulation. (State of New York Local Leaders Guide to Comprehensive Planning, 2016)

New York statutes define a comprehensive plan as the "materials, written and/ or graphic, including but not limited to maps, charts, studies, resolutions, reports and other descriptive material that identify the goals, objectives, principles, guidelines, policies, standards, devices and instruments for the immediate and long range

protection, enhancement, growth and development of the [locality]." (State of New York Local Leaders Guide to Comprehensive Planning, 2016)

Comprehensive planning is an attempt to establish guidelines for the future growth of a community. As the term “comprehensive” suggests, this is an all-inclusive approach to addressing the issue of a community’s future growth. A comprehensive plan is the formal document produced through this process. The document is official in nature, meaning that it is designed to be adopted into law by some form of local government. The document should then serve as a policy guide to decisions about community development. (University of Illinois at Urbana-Champaign, 2018) The comprehensive plan creates a blueprint for the future development and preservation of a community. Often referred to as the "master plan," it is the essential foundation upon which communities are built. A good comprehensive plan guides not only the physical and economic development of the municipality, but also accommodates social, environmental and regional concerns.
(State of New York Local Leaders Guide to Comprehensive Planning, 2016)

Implementation

Good comprehensive planning begins with information gathering. Physical data should be compiled and considered including, for example, roads and transportation, wetlands, water, sewer, utilities, soils and drainage. Additionally, the community should inventory its assets including natural, historical, cultural and geographical and consider to what extent these features should be enhanced or protected. The municipality must also consider its needs; for example, is there adequate housing, parks, economic development, capital infrastructure and open space in the community? Are there areas that are particularly appropriate for growth and others in need of conservation? The plans of neighboring municipalities should also be examined as well as regional economic, environmental and social needs.
(State of New York Local Leaders Guide to Comprehensive Planning, 2016)

Limitation and Concern

As discussed above, there are many benefits and values to good comprehensive planning. It does, however, take time, cost money and require great effort. Additionally, many good plans are created, and even adopted, only to lie dormant on a shelf in the clerk’s office. This needn’t be the case. The comprehensive plan can serve as an opportunity for the community to create a shared vision for the future and a strategy to accomplish that vision. It often requires updating of the local zoning ordinance and other land use regulations, as well as incorporating new ideas and techniques to achieve the community’s objectives. Costs, however, may be

reduced through strategic use of available funds and volunteers.
(State of New York Local Leaders Guide to Comprehensive Planning, 2016)

It was showed in this section how important is a Comprehensive Plan in urban planning, in order to set up the different parts of a urban area. The next section will focus on how such comprehensive plan can slot within the Thai planning system and Thai bureaucracy system.

Thai Bureaucracy and Spatial Planning System

There are three basic levels of public administration in Thailand: central, provincial, and local administration (Figure 4.3). The central administration consists of ministries. The provincial administration comes under the concept of deconcentration, which means that the central government delegates some of its power and authority to its officers who work in provinces and districts, and the provincial administration consists of provinces, districts, minor districts, subdistricts and villages. The local administration is based upon the concept of decentralization, which allows local people to participate in local affairs under concerned laws and regulations, and there are 2 types of local administrative organization: the general type (composed of Provincial Administration Organization, Municipalities, and Subdistrict Administration Organization); and the special type (consisted of Bangkok Metropolitan Administration and the City of Pattaya).

The National Economic and Social Development Plan, which is under the purview of the Office of National Economic and Social Development Board, has been considered as the document with the highest authority in matters of national spatial policy. Spatial development policies, including region-specific programs, have traditionally been included in this document, but in recent years the policy statements on spatial development have grown weaker, and at the same time the Department of Public Works and Town & Country Planning of the Ministry of Interior has become much more involved in spatial development and planning at the national, wide-area regional, subregional, provincial, town, and specific area levels.

Table 4.1: Structure of planning system in Thailand

Stages of plan	Plans	Responsible authorities
National	Policy Plan : National Economic and Social Development Plan	National Economic and Social Development Board (NESDB)
	Spatial Plan : National Spatial Development Plan	Department of Public Works and Town & Country Planning, Ministry of Interior (DPT)
Regional	Regional Spatial Development Plan (6 regions)	Department of Public Works and Town & Country Planning, Ministry of Interior (DPT)
Subregional	Subregional Plan	Department of Public Works and Town & Country Planning, Ministry of Interior (DPT)
Provincial	Comprehensive Plan	Department of Public Works and Town & Country Planning, Ministry of Interior (DPT)
Town	Comprehensive Plan	Department of Public Works and Town & Country Planning, Ministry of Interior (DPT)
Specific area	Specific Plan	Department of Public Works and Town & Country Planning, Ministry of Interior (DPT)

Source: Department Public Works and Town & Country Planning, Ministry of Interior, Thailand (DPT) (2013).

Outline of Bangkok and its Vicinity Regional Plan

Bangkok and its Vicinity play a fundamental role in the administration and governing of the country. Regional development in the past has enabled Bangkok and its Vicinity to attract varieties of developmental activities, from the development of infrastructures, social services, and particularly the development of economic activities. The concentration of development in the region has led to inequality in income and employment opportunities compared to other regions. The subsequent development situation lies in the rapid growth of all activities, with the region being the center of settlement, industry, commerce and services including social services. The aforementioned are key factors that attract labor and populations from other regions.

The urban sprawl of the area has led to inappropriate land use, which has instigated various urban problems. There has been rapid growth within the area joining the inner city and urban fringe, creating economic, commercial, industrial, and residential centers in both vertical and horizontal directions. These types of development create problems of insufficient services and facilities, as well as the growth of urban communities along the transportation routes in both the urban fringe and suburb areas. Most of these areas are developed into residential quarters, with huge department stores and industrial clusters along the main transportation routes and the intersections between two main roads. This leads to problems in providing infrastructures, which cannot be thoroughly distributed, and influences the high price of the land. Furthermore, Bangkok and its Vicinity have become congested with overpopulation, employment sources, and traffic. Subsequent problems include: urban environment, disorganized town plan, the over-exploitation of natural resources for development and maintenance, encroachment upon efficient agricultural land, job and housing balance problems, and ensuing traffic problems. It is apparent that all of these problems, arising from unplanned development, has not only had an impact on inappropriate land use, but will lead to a chain of continuous problems as well. In order to ensure a better quality of life for people in the region, the land use problem must be alleviated.

The formulation of the Bangkok and its Vicinity Regional Plan is fundamental in defining a unified developmental framework. Opportunity, potential, and problem solving strategies for spatial management and development have been taken into account. Outside influences have also been incorporated into this study, analysis through both strategic policies and plans, as well as international collaborations at all levels. Global and national factors such as the environment, population, and energy have also been considered. In order to clearly picture the development trends and possibilities, the external as well as internal factors, such as a study in spatial constraints and potential, must be considered. This integrated analysis of information is used in the formulation and development of Bangkok and its Vicinity Regional Plan, reflecting the quality of life of the people in the region.

Sustainable Spatial plan

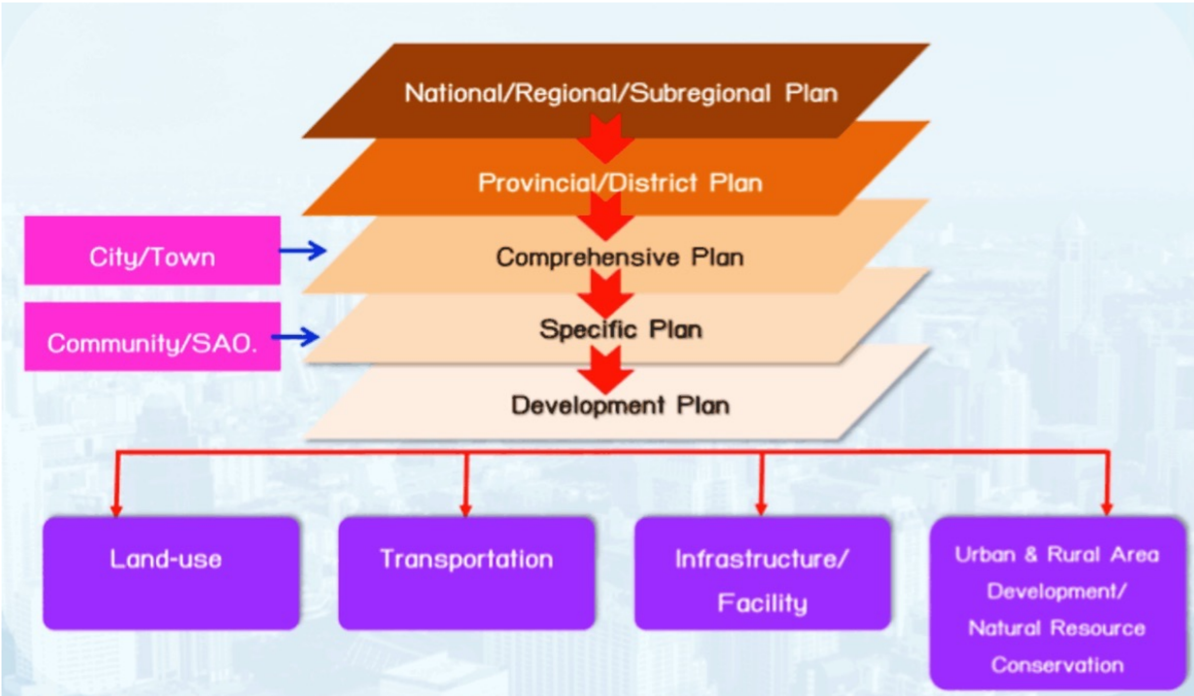


Figure 4.3: Sustainable spatial plan
Source: Department Public Works and Town & Country Planning, Ministry of Interior, Thailand (DPT) (2013).

4.4 The stormwater situation in Bangkok city : focus on Don Mueang district

สถิติปริมาณฝน ณ สถานีอุตุนิยมวิทยา กรุงเทพมหานคร พ.ศ.2546 - 2558
STATISTICS OF RAINFALL AT METEOROLOGY STATION, BANGKOK: 2003 - 2015

รายการ	2546 (2003)	2547 (2004)	2548 (2005)	2549 (2006)	2550 (2007)	2551 (2008)	2552 (2009)	2553 (2010)	2554 (2011)	2555 (2012)	2556 (2013)	2557 (2014)	2558 (2015)	Item
	สถานีอุตุนิยมวิทยากรุงเทพมหานคร (ศูนย์ประชุมแห่งชาติสิริกิติ์) Bangkok Meteorology Station (Queen Sirikit National Convention Center)													
ฝนรวม (มิลลิเมตร)	1,372	1,160.4	1,651.4	1,598.7	1,684.2	1,902.4	2,272	2,023.7	2,240.2	1,656.9	1,772.9	1,130.1	1,907.6	Total rain (millimeter)
จำนวนวันฝนตก (วัน)	108	102	124	125	139	156	139	142	161	133	148	128	113	Number of rainy days (day)
ฝนสูงสุด (มิลลิเมตร)	87.6	87.9	86.9	132.9	117.9	70.1	216.8	73.5	157.4	87.9	103.7	60.3	174.3	Daily maximum (millimeter)
	สถานีอุตุนิยมวิทยาท่าเรือคลองเตย Port Khlong Toei Meteorology Station													
ฝนรวม (มิลลิเมตร)	1,596.6	1,192.7	1,623.8	1,582	1,419	1,795.4	2,002.4	1,865	2,191.7	1,241.1	1,297.8	894.3	1,728.3	Total rain (millimeter)
จำนวนวันฝนตก (วัน)	123	113	129	123	143	142	129	126	153	118	132	100	104	Number of rainy days (day)
ฝนสูงสุด (มิลลิเมตร)	88.2	73.8	90.1	95.2	125.1	80.2	140.3	80.7	152.2	60.3	77.4	50.5	165.5	Daily maximum (millimeter)
	สถานีอุตุนิยมวิทยาสนามบินดอนเมือง Don Muang Airport Meteorology Station													
ฝนรวม (มิลลิเมตร)	1,484.5	1,100.1	1,609.5	1,433	1,543	1,553.8	2,014.2	1,902.8	1,958	1,587.2	1,430.1	1,267.8	1,221.4	Total rain (millimeter)
จำนวนวันฝนตก (วัน)	106	95	124	120	128	130	138	129	124	125	135	126	124	Number of rainy days (day)
ฝนสูงสุด (มิลลิเมตร)	82	101.5	102.9	95	89.8	118	123.3	94.9	106.9	104.6	82	76	107.7	Daily maximum (millimeter)

ที่มา: กรมอุตุนิยมวิทยา กระทรวงเทคโนโลยีสารสนเทศและการสื่อสาร
Source: Meteorological Department, Ministry of Information and Communication Technology

Figure 4.4 : Statistics of Rainfall at Meteorology station, Bangkok 2003-2015
Source: Meteorological Department, Ministry of Information and Communication Technology

In this section, the research is focusing on the stormwater situation in the city and especially Don Mueang district, stormwater which is so far the main reason of floods in the area. So, the record of rainfall is on valuable contribution to understand the flooding situation in this area. According to (The Figure 4.4) above, Don Mueang district (Case Study), like the other stations of this table, has faced important variation of annual rainfall within the years, with for instance a total nearly twice as high in 2009 compared to 2004. The average of the 13 years record is 1546.6mm/ year. Though, there is also a considerable variation of mean rainfall regarding the seasons.

Indeed, the most important rainy events occur during the monsoon season, which usually occurs between May and October. Taking the 2011 flood disaster event as example, the maximum extent of water reached 106.9mm/day. This represents more than 3.9 million cubic meters of rainfall coming in a single day. The district is mainly a low-density residential area according from the land use zoning plan mapping (Figure 4.12 and 4.14) . The lack of green spaces in the area and the important impervious cover lead by the housing properties, the pavement and the road network allow to suppose that most of the rainfall becomes stormwater since the infiltration is very low. The areas at risk in the long term are situated in the northern and eastern parts of the district according to the maps from the Department Public Works and Town & Country Planning. Though the intensity should vary, all the district will have to face stormwater based flood events during heavy rain.

4.5 Existing plans and measures of Thailand

The relevant plans and measures for managing flood risk in Thailand have been carried out by the assigned government agencies, whereas the public and private sectors in the flood risk areas are rarely involved. Working under the Ministry of Interior, the Department of Disaster Prevention and Mitigation (DDPM) is the main government agency responsible for all kinds of disasters as indicated in the current National Disaster Prevention and Mitigation Plan (NDPMP) 2015 (DDPM, 2016). Key elements of the NDPMP include (1) implementing and promoting disaster risk reduction, (2) integrating multi-sectoral cooperation in emergency management, (3) enhancing measures in recovery, re- habilitation, and reconstruction, and (4) developing and strengthening international cooperation in disaster risk management.

The NDPMP has been used as an umbrella for all relevant plans to manage flood risks at a local level. It is a master plan that contains top-down policies (i.e., one-way communication policies), emphasizes passive responses (e.g., emergency responses to an existing flood event and recovery after the flood ends), and relies mainly on structural measures (e.g., dams or dikes for controlling floods). The NDPMP lacks any aspects of community participation (communication and consultation) and progressive responses to deal with future and continuing flood risks. Consequently, few operational plans formulated under the NDPMP's umbrella could be effectively implemented at a local level and have attracted criticism, for example: too broad or general, inappropriate for applying to local conditions, and so forth.

Following the 2007 National Disaster Prevention and Mitigation Act (NDPMA) (Gazette Office, 2007), the National Disaster Prevention and Mitigation Committee (NDPMC) was set up as a national multi-sector body for policy formulation and planning for disaster preparedness, mitigation, and response. The NDPMC is chaired by the Prime Minister, and it includes representatives from line government agencies. These are the Ministry of Interior, DDPM's central Emergency Operation Center (EOC), BMA's EOC, provincial EOC, district EOC, and local EOC (i.e., the EOC of the municipalities, sub-district administration offices, and Pattaya City) located in 76 provinces across the country, excluding Pattaya City, which is a special local administration in Chonburi Province (Figure 4.5).

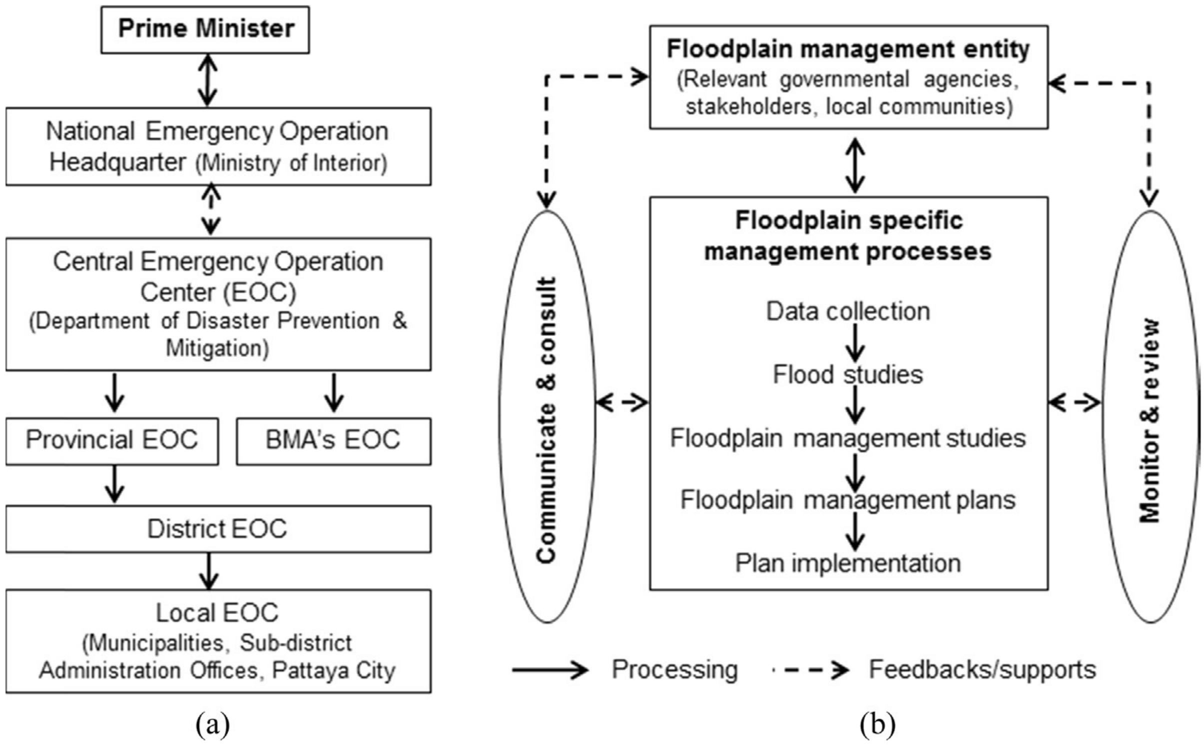


Figure 4.5 : The functional structures of the National Disaster Prevention and Mitigation Committee of Thailand (a) and the proposed flood risk management framework (b) for the Chao Phraya River Basin.
Source: (a) Thailand's national disaster prevention and mitigation plan, 2015 (b) Australian Emergency Management Institute, 2013

The functional structure of the NDPMC also lacks community participation at all levels. Similarly, the top-down policies and relevant disaster management plans were formulated by the committee without community consultation causing them to be ineffectively implemented and/or unable to receive good cooperation from local communities. For instance, the DDPM's Strategic National Action Plan on Disaster Risk Reduction 2010–2019 (M.Chanachaiwiboonwat, 2009) was ineffectively operated by local government agencies during the 2011 flood. As a result, on 21st October, the Thai Government led by Prime Minister Yingluck Shinawatra had to take full authority under Section 31 of the NDPMA for ordering all relevant government agencies to prepare flood disaster relief, undertake protection measures, and offer assistance to the affected people (Ministry of Finance and Work Bank, 2012). Additionally, the Flood Relief Operations Center (FROC) was established and chaired by the Justice Minister. These were the kinds of emergency command and extra operations used to support the existing strategic plans and line agencies that could not efficiently handle the flood situation in 2011.

The FROC comprised various experts in advising, monitoring, and setting guidelines and measures to divert water and lessen the food impacts. However, some important aspects were still overlooked in these measures, especially community participation and effective communication in flood risks. These shortcomings diminished the efficiency of flood risk management because the results of the flood risk assessment were not adequately understood by the affected people, causing them to improperly respond to the known risk (Ministry of Finance and Work Bank, 2012) . Lacking effective communication by the government agencies to deliver critical messages about flood risks to the public caused people to be frustrated, unprepared, or distrustful of the government's information (N. Jukrkorn et al., 2011) (S. Kittipongvises and T. Mino, 2011).

In addition, collaboration among line government agencies at local and national levels was ineffective and responsibilities overlapped. According to the NDPMP, confusion was unavoidable where more than ten ministries and institutions were designated as key implementing agencies for conducting flood risk assessments. The lack of coordination in flood prevention and management planning across the administrative systems at all levels brought conflicts among both the government agencies and among the communities that were located in different administrative zones. For instance, during the 2011 flood in Bangkok, the government did not get good cooperation from the governor of Bangkok. Different flood management practices from the FROC and BMA were applied, causing people to be confused about which measures they should follow or what information they should believe.

After the 2011 flood, the Thai Government's Strategic Committee for Water Resources Management (SCWRM) was set up with the responsibility for developing plans to prevent future floods. The SCWRM is under the Secretariat of the Prime Minister. The committee assigned the Japan International Cooperation Agency (JICA) to conduct a under a supervisory panel including representatives from the Royal Irrigation Department and the Department of Water Resources. Most of the sub-projects initiated as a result of the plan emphasized structural measures to prevent or mitigate floods in the Chao Phraya River Basin, but did not consider the impacts on neighboring areas. For instance, there was a project to build a water diversion route to take future floodwaters from the Sakae Krang River Basin (located to the northwest of the Chao Phraya River Basin) to the Tha Chin and Mae Klong River Basins (located to the west of the Chao Phraya River Basin). This is a type of passive response to flooding that tends to shift the problem spatially and temporarily to nearby river basins. In addition, it may adversely affect people living in those river basins and lead to public concern and disapproval of the project's development.

The strategic plan for flood management 2015–2026 (Water Resources Management and Policy Board, 2015) was later launched by the current Thai government of General Prayut Chan-o-cha (22 May 2014 – present). This plan focuses on the Chao Phraya River Basin and it still emphasizes structural measures and passive responses to flooding. The plan comprises feasibility studies and environmental impact assessments in the short-term (2015–2016) and mega-project developments (e.g., water routes or dikes) in the medium- term (2017–2021) and long-term (2022–2026). Upon the initiation of the plan, 185 flood projection systems are planned to be developed in Nakhon Sawan Province (located in the upstream portion of the river basin). The major weakness of these measures include (1) allowing development in areas with a high flood risk, (2) stimulating new developments that may increase the flood risk in these areas, (3) causing significant damage to areas with sensitive environments (R.J. Burby, L.C. Dalton, 1994), (W. Su et al., 2014) and (4) diverting flooding to, and increasing flooding in neighboring areas. These impacts need more investigation and mitigation.

Overall, various aspects of the existing plans and measures relevant to flood risk management of Thailand need to be reviewed and improved for robust flood risk management; with fewer overlapping responsibilities and more community participation.

Policy and Plan of Floods and Risk Management in Thailand

Over the past few years the Thai government has been trying to cope with several major challenges in the water sector: water shortages, flooding, and excessive waste water production. Factors which are responsible for these problems include drought or excessive rainfall, forest and waterway encroachment, population growth, urbanization, economic and industrial development and pollution. Thailand’s yearly flooding due to heavy rainfall have been seriously affecting Thai urban areas, in particular Bangkok and industrial zones. Discharge of untreated urban, industrial and agricultural wastewater is polluting surface, ground and sea water while water consumption is rising and integrated water management is inefficient.

The Thai government has adopted an integrated nationwide strategy on national sustainable water resource management for the period between 2015-2026. This strategy seeks to revive water sources and tackle water shortages, flooding, and water quality issues through water management projects in the country’s 25 river basins. It also aims to make Thailand a model country for water management in the Asia Pacific region and to ensure that potable water is available for every person in the country by 2017.

The estimated budget for the 12-year plan is around BHT 900bn. (more than USD 25bn.).

Both foreign and domestic companies are encouraged by the Thai authorities and the private sector to participate in bidding processes or get involved in projects in other ways. Although getting access to the competitive Thai water market can be challenging and complicated, the mentioned developments provide business opportunities for Dutch companies.

Congested ports and waterways are hindering Thailand's ambitions to become the regional transport hub. Thailand's Transport Infrastructure Development Strategy (TIDS) for the period of 2015-2022 will be an important framework for the development of Thai infrastructure, of which an important objective is increasing and improving the water transport network, including the development of inland and coastal ports. The implementation of this strategy is expected to lead to an increased demand for (advisory) services and supply of technology in dredging, port development and harbour logistics. (The Embassy Kingdom of The Netherland, 2017)

The Master Plan for Water Resources Management, formulated by the Thai government in 2012 (SCWRM, 2012)

The Master Plan for Water Resources Management, formulated by the Thai government in 2012 (SCWRM, 2012), states that, to manage floods properly, structural and nonstructural measures should be applied synchronously. The structural approach includes measures to store and divert water. Conversely, nonstructural measures aim to create room for the river, meaning that increased areas of land should be available for floodwaters to spill into flood retention areas. Unfortunately, because of various issues, the application of this Master Plan was suspended. Therefore, to date, no actions have been taken and no progress has been made towards implementing additional flood countermeasures in the CPRB, except for minor measures such as structural rehabilitation, dredging for drainage improvement, and dam deregulation. (Jamrussri and Toda, 2017)

Thailand: Short and Long-Term Measures in Flood Mitigation and Rehabilitation Efforts in 2010

"The Government has approved a package of measures to help flood victims in its flood mitigation and rehabilitation efforts. The Council of Economic Ministers, during its meeting on November 3, gave the green light to the measures to be implemented in both short and long terms.

The five measures involve immediate assistance, rehabilitation to help affected farmers and the general public after flood waters recede, finance and fiscal measures, reconstruction of infrastructure, and long-tern flood prevention and mitigation. Among the target groups who will benefit from the assistance measures are the general public, the underprivileged, farmers, entrepreneurs, and those who cannot help themselves. The measures will be carried out in a systematic manner to bring about a quick recovery. In the short term, immediate assistance will be given directly to all groups of flood victims in all affected areas, so that the affected people will be able to survive during the crisis.After flood waters recede, rehabilitation measures will be implemented to enable farmers and the general public to make a living. The assistance will be in the forms of compensation for damaged crops, housing, occupational credit, and repairs on houses. In addition, disease prevention and mental rehabilitation will be emphasized. Damaged schools, hospitals, roads, the electricity and waterworks systems, and government offices will be reconstructed. In the long term, the Government will accelerate the installation of integrated disaster warning, flood prevention, and water management systems. It will also work out disaster prevention and mitigation plans, with clear guidelines for operations to cope with the evolving situation. Mechanisms to deal effectively with natural disaster risks will be developed urgently, as well.

The Council of Economic Ministers heard a report prepared by the Disaster Prevention and Mitigation Department that, from August to October 2010, 65 provinces in Thailand were affected by severe floods. At present, 27 provinces still face the flooding situation. A preliminary survey shows that 1.2 million families, with about 3.8 million people, have been affected. The flooding also damaged 11,300 houses. The agricultural sector has suffered more than 36 billion baht in damage. As a result, Thailand's overall economic growth was expected to decline by 0.32 percent. Divided by regions, economic growth in the Northeast was likely to drop by 0.14 percent, the central region 0.12 percent, and the North by 0.06 percent.
As for the compensation of 5,000 baht for each affected family whose property has been damaged, Prime Minister Abhisit said that the compensation would be paid through the Government Savings Bank. Around 632,000 families would be entitled to the compensation.” (Government of Thailand, 2010)

4.6 Flood Situation in Bangkok city

This map (Figure 4.6) from Land Development Department, Thailand represents shows three main areas in the Bangkok city which have been facing flood over the last 10 years : the North, the East and the West. **Pale blue** represents areas where

floods occurred 1 to 3 times over the 10 year period (2007-2017) ; **Deep blue** represents areas with a more repetitive flood scheme, from 4 to 7 times over the 10 year period. It is important no notice than the repetition of 4 up to 7 flood events over the period occurs only on the Eastern part of the city. Though the map doesn't reveal the severity of the flood events, it tends to reveal than the Chao Phraya River might not often be the base of the flood events and that over sources have to be taken into account. A lear understanding of the land use map can be used in parallel for this purpose.

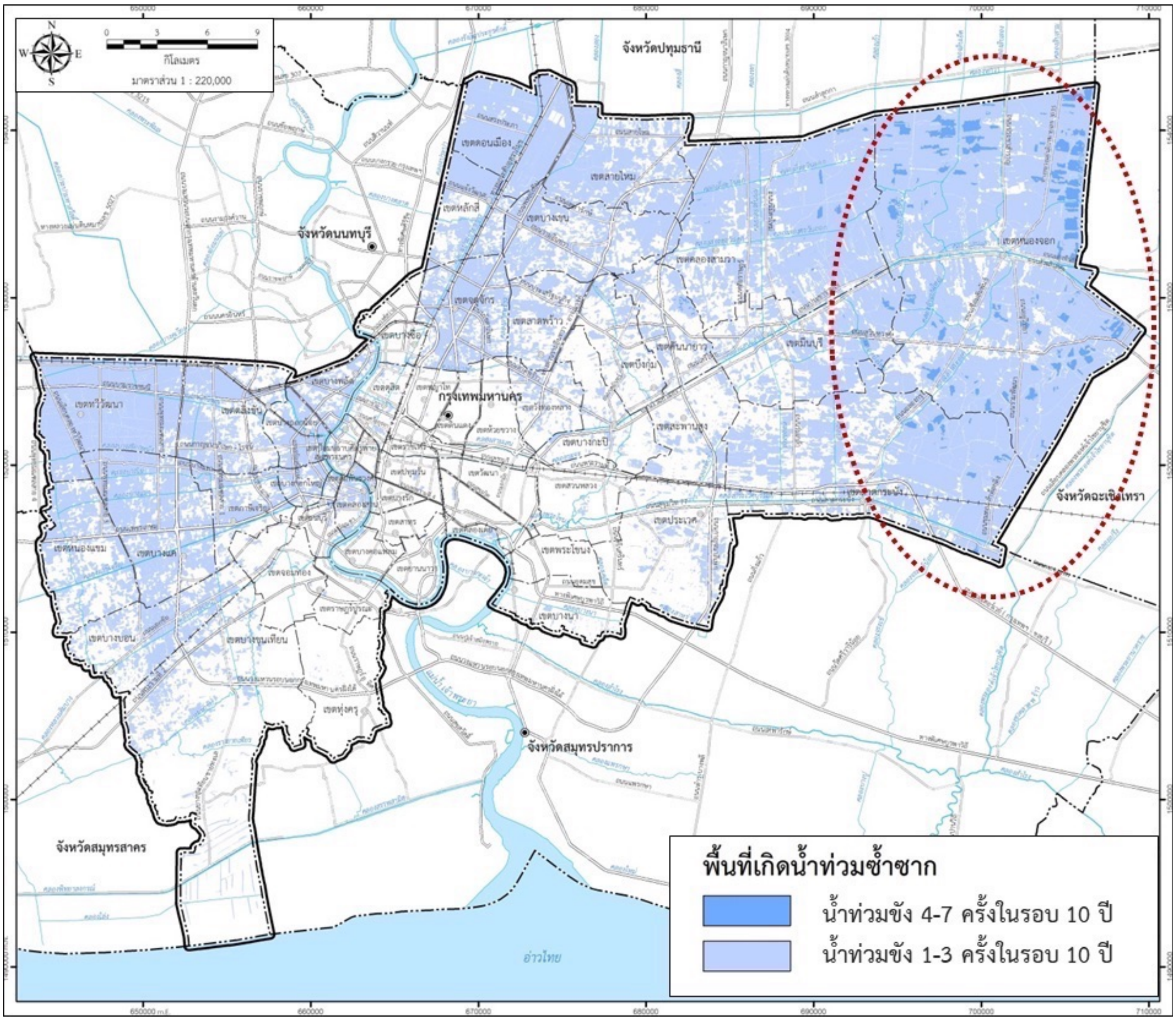
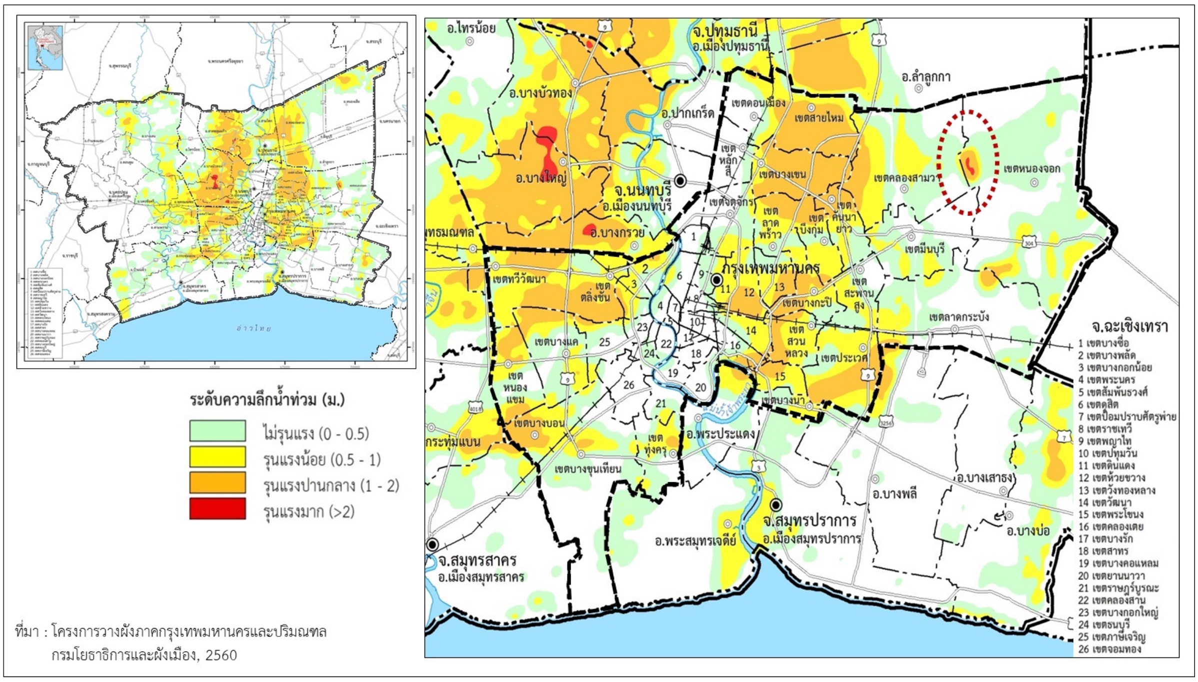


Figure 4.6: Number of Flood events over a 10 year's period in Bangkok city (2007-2017), Project of region Bangkok comprehensive plan and Metropolitans.
Source: Land Development Department, Thailand

The Recurrence mapping of floods in Bangkok city

These maps (Figure 4.7-4.11) demonstrate the recurrence of flooding in 5 years, 10 years, 25 years, 50 years, and 100 years from 2017. The legend is divided in 4 parts depending on the level of water which would affect the area : low level in green (<=0,5m), medium low level in yellow (>0,5 and <=1m), medium high level in orange (>1m and <=2m) and high level in red (>2m). The model reveals that one major area in the center east of the city will have to face high level of water (above 2m) during floods. By the end of the century, more than half of the city will deal with medium to high water level. The city center should remain safe or be affected by low levels of water (<50cm). For Don Mueang district, the North east of the area will deal with rather important water level after 10 years.

Climate change will increase the severity of the rainfall events which could lead to the scenarios described in the maps below. Considering the vulnerability of the area, it is of vital consideration to elaborate a complete and efficient policy upon flood risk management in the town, especially for stormwater management, stormwater identified in chapter 2 as the main cause for floods within Bangkok city area.



ที่มา : โครงการวางผังภาคกรุงเทพมหานครและปริมณฑล
กรมโยธาธิการและผังเมือง, 2560

Figure 4.7: The Recurrence of flooding in next 5 years from 2017
Source: Department Public Works and Town & Country Planning, Thailand

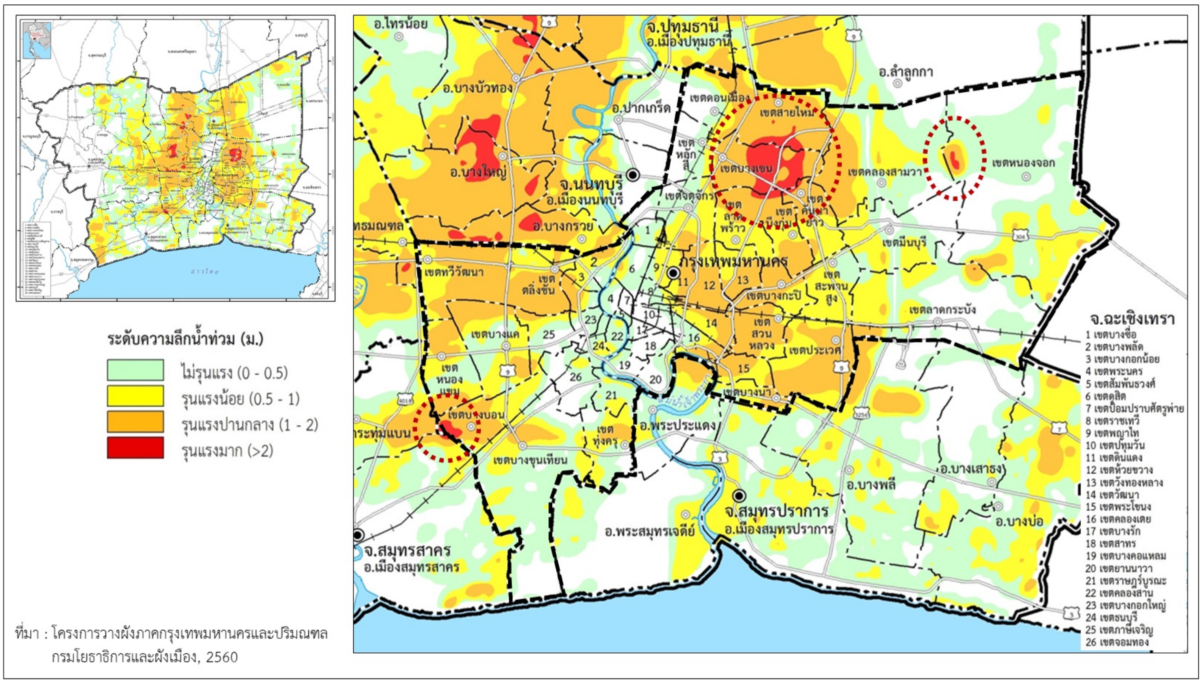


Figure 4.8: The Recurrence of flooding in next 10 years from 2017
Source: Department Public Works and Town & Country Planning, Thailand

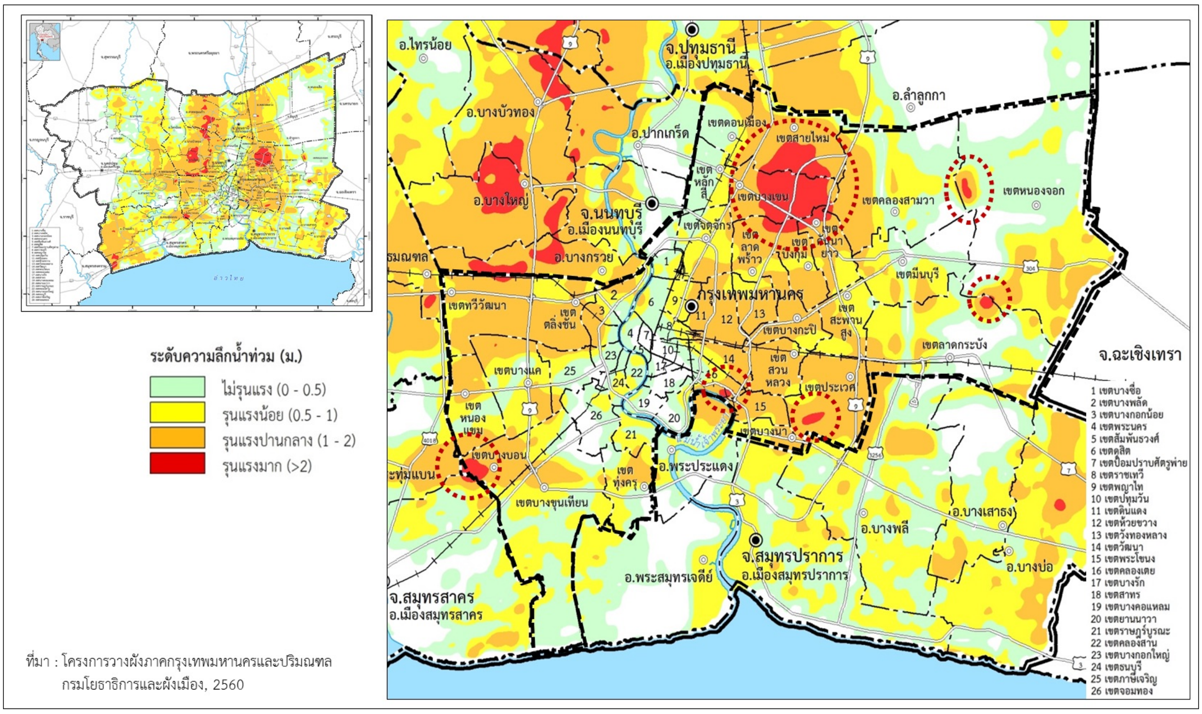


Figure 4.9: The Recurrence of flooding in next 25 years from 2017
Source: Department Public Works and Town & Country Planning, Thailand

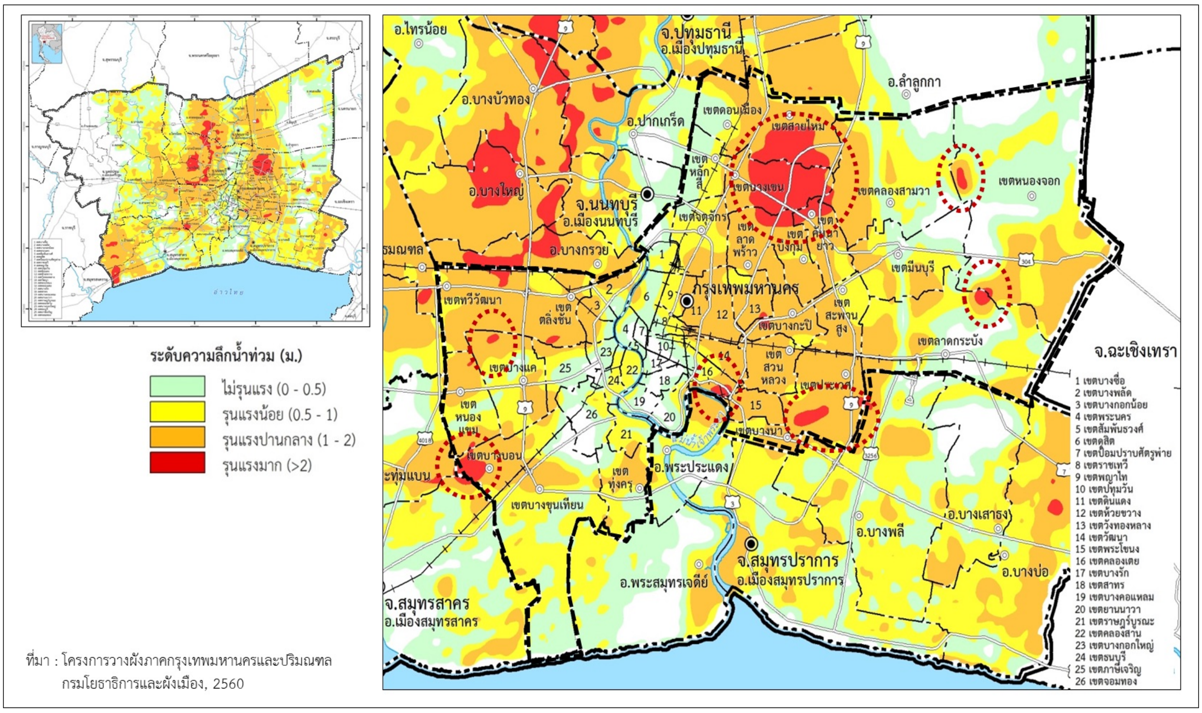


Figure 4.10: The Recurrence of flooding in next 50 years from 2017
Source: Department Public Works and Town & Country Planning, Thailand

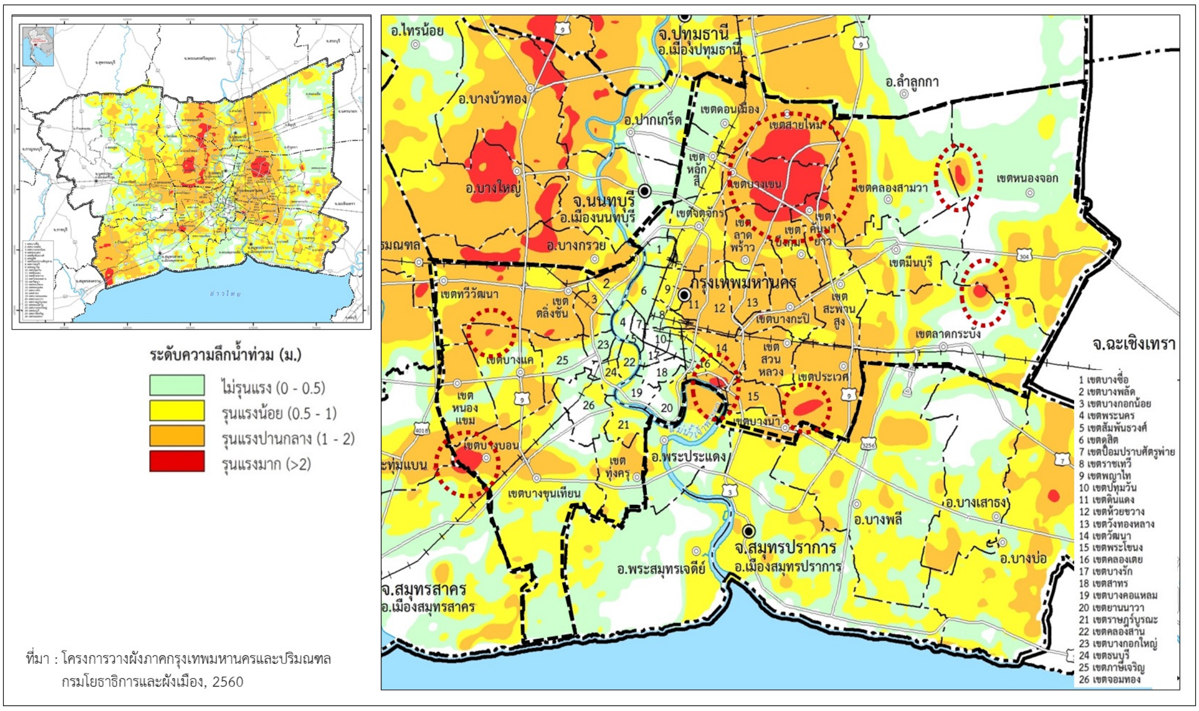


Figure 4.11: The Recurrence of flooding in next 100 years from 2017
Source: Department Public Works and Town & Country Planning, Thailand

The Bangkok Comprehensive Plan Study: Focusing on The Open Space Plan

Evolution of land use between 2006 and 2013

The Comprehensive Plan is the major document of urban planning, for which a new version is edited every 5 years. It is divided in 4 documents : the land use zoning plan, the transportation plan, the open space plan and the public utility (infrastructure) plan. In this thesis, focus is made on both land use zoning and open space plans. It is on key importance to consider the land use zoning first because it sets the identification of possible activities in the area. Indeed, for instance, it is impossible to create open space in historical areas (city center). The main point of this is to show that the open space plan can fit within the land use of Bangkok city, especially in our case study, Don Mueang district.

The city land use can be divided in three major parts according to the Comprehensive Plan map (Figure 4.12). The city centre and its nearby boroughs, along the Chao Phraya River, are high density areas (brown areas, Figure 4.12) with some historic conserved buildings (salmon) and many commercial buildings (red). Then, about a quarter of the city consists in low density residential areas (Yellow). Though the pale green and dark green areas are supposed to be respectively about “rural and agricultural conservation”, and “rural and agricultural use”, these areas have been built on the same model than the residential areas in yellow. The green areas of the city are just remaining into few parks.

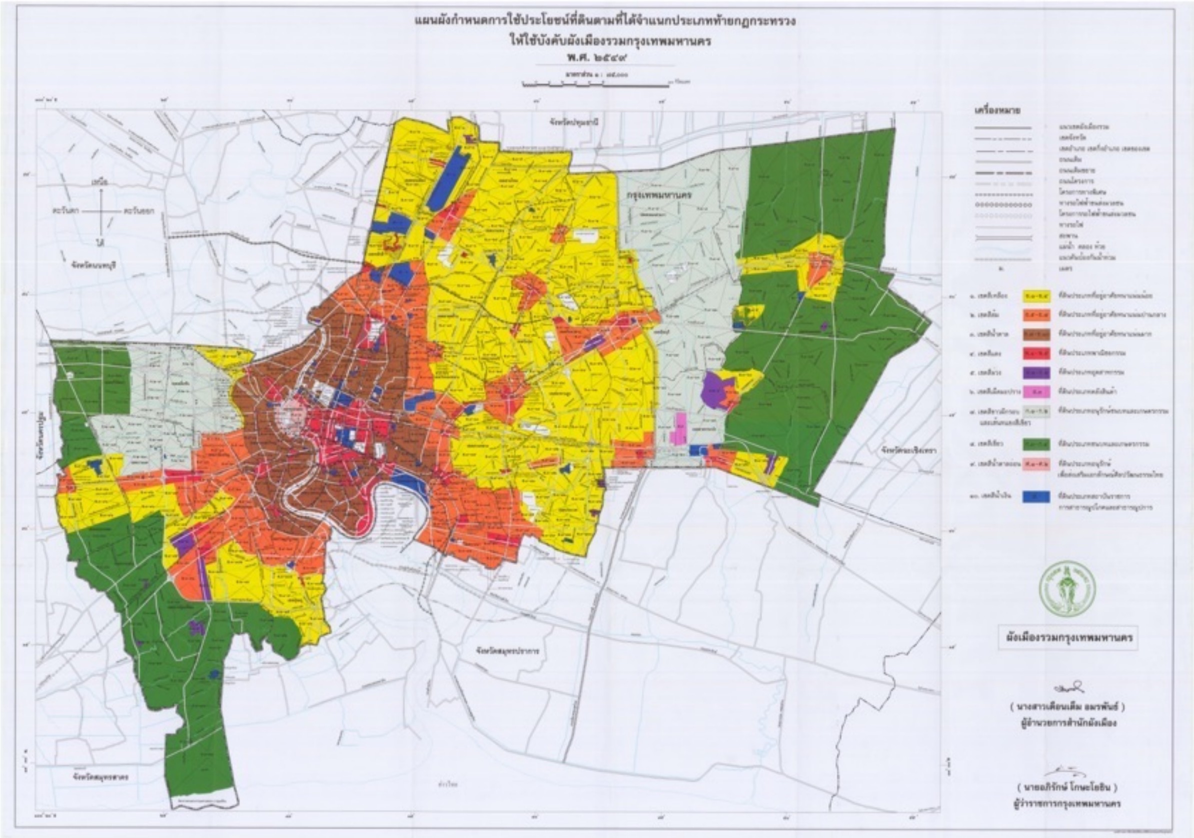


Figure 4.12: The land use Zoning Plan in the Addendum to the Ministerial Regulation on The Bangkok Comprehensive Plan 2006
Source: City Planning Department, Thailand

A closer look at the Open Space Plan map of 2006 (Figure 4.13) reveals that many parks were under project also over the city except in the centre. The difference in colour between them is used for the different purposes and also different sizes of the related projects, from pale green (neighbourhood scale park) to deep green (city scale park). Most of the projects were situated in the western part of the city. Yet, 12 years later, all the parks mentioned in this plan have remained under project consideration and none was actually built.

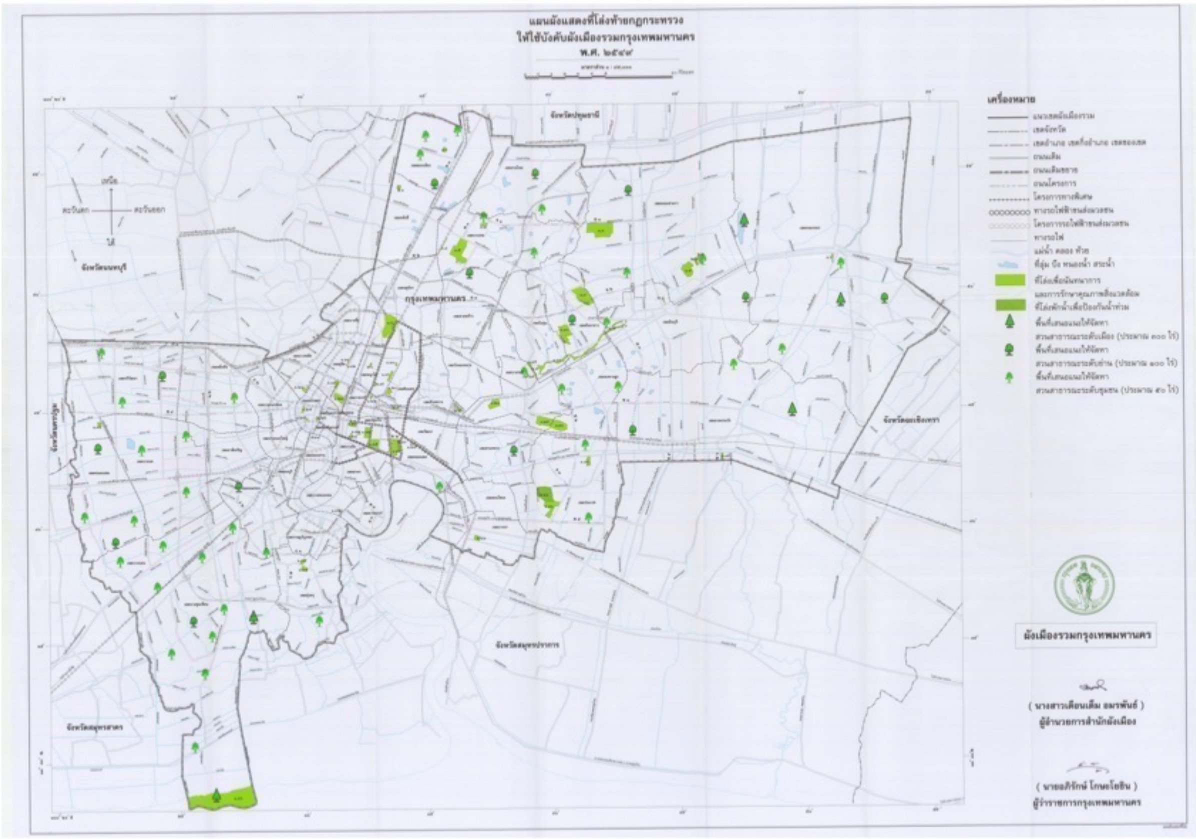


Figure 4.13: The Open Space Plan in the Addendum to the Ministerial Regulation on The Bangkok Comprehensive Plan 2006
Source: City Planning Department, Thailand

The land use zoning plan of 2013 (Figure 4.14) is rather similar to the 7 years earlier version. There are therefore a few differences. Some areas have been designated in white colour. These are military zones. A closer look on the western part of the city shows an increase in the low-density residential areas upon the “agricultural land”, witnessing urban sprawl ; though the area has been used already for residential purpose.

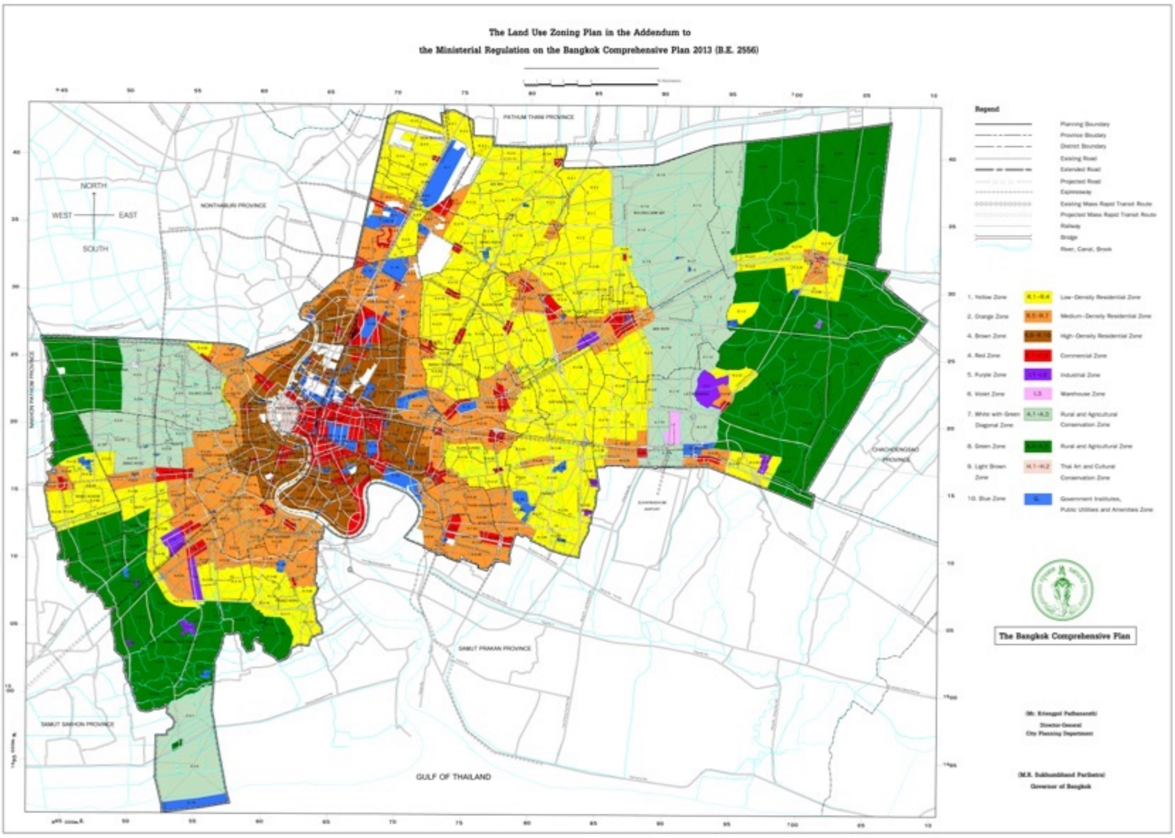


Figure 4.14: The land use Zoning Plan in the Addendum to the Ministerial Regulation on The Bangkok Comprehensive Plan 2013
Source: City Planning Department, Thailand

The open space plan of 2013 (Figure 4.15) has a very different structure than the previous one. 5 different open spaces were designated, depending on the function they are suppose to have :

- OS.1(light green) : Open space for Recreation and Environment Conservation
- OS.2 - OS.3 (dark green) : Open space for Environment Conservation along the roadside, riverfront and canal
- OS.4 (white and green diagonals): Open space for Natural flood Way Conservation
- OS.5 (green diagonals): Open space for Water Retention and Flood prevention
- OS.6 (blue diagonal) : Open Space for Coastal Environment conservation and Restoration

The most significant areas designated for "natural flood way conservation" match with the white and green diagonal areas of the comprehensive plan map. As mentioned above, the eastern part has been built as a residential area. The

effectiveness of the plan can then be challenged regarding its application. It also appears irrelevant to establish a flood prevention area only in the southern part of the city, nearby the coastal conservation area where there isn't a strong vulnerability. So far, there are no areas dedicated to flood prevention on the upper part of the city (North). The other open spaces of the city consist in Recreational spaces distributed on the eastern side from the city center.

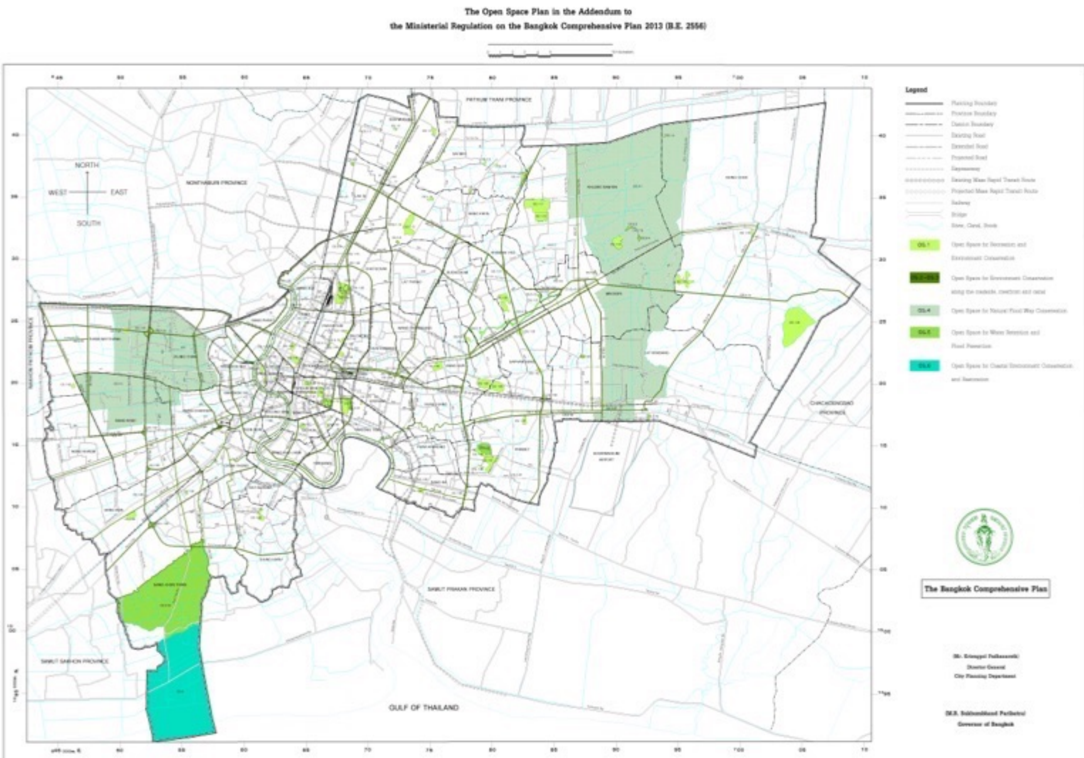


Figure 4.15: The Open Space Plan in the Addendum to the Ministerial Regulation on The Bangkok Comprehensive Plan 2013
Source: City Planning Department, Thailand

Both land use plan and open space plan, from 2006 to 2013 reveal a a lack of effective governance from the urban planning stakeholders. The zonation of the land use plan has not always been taken into account and the park projects have been abandoned for the moment. While comparing the land use map and the flood occurrence map from the previous part, it appears that, as identified in chapter 2, the flood events must have a non-river based origin : it can come either from stormwater runoff due to a strong surface impervious cover or a sewage overload capacity, with water coming out on street.

The case study: Don Mueang District

According to the evolution of Bangkok comprehensive plan from 2006 - 2013 and more specifically the open space plan on 2013, land planners wanted to provide many types of open space for different purposes :

1. Open space for Recreation and Environment Conservation
2. Open space for Environment Conservation along the roadside, riverfront and canal
3. Open space for Natural flood Way Conservation
4. Open space for Water Retention and Flood prevention
5. Open Space for Coastal Environment conservation and Restoration

This study will focus on Don Mueang district the main purpose of this research is to find areas for to store water when the city faces floods from stormwater. So, this areas should be located outside of the city center, in a upper area. Don Mueang district appeared to fulfil these conditions for the study because this district is located in the North of Bangkok city and faces lack of open space for flood prevention.

In this research, it is admitted that open space areas should be implemented out of the city center on one side. On the other side, such areas have to be implemented uphill the area to protect, considering the drainage systems and the stormwater flow processes. Don Mueang district is a valuable case study for such purposes because the pressure on land property is lower than the pressure of the denser areas, with can improve stakeholder's decision making to establish open space in some parts of the district. So far, in 2013 most of the area in Don Mueang district was designed in yellow colour (Figure 4.16) which stands for residential area with low-density, except on the eastern part, the former international airport, in blue. Also, in white colour, there are few areas designated for military purpose.

The detail of the land use in Don Mueang reveals that about 2/3 of the surface area is theoretically suitable to establish open space areas. Though, it is of course essential to provide terrain studies (topology, pedology, hydrological pathways) to know which parts of the district could eventually be used for this purpose. According to the mapping of Number of Flood events over a 10 year's period in Bangkok city (2007-2017), The Northern area of Bangkok city is at risk of flooding and lacks of open space or areas to prevent this disaster. So that is why this area has to benefit from an integrated open space plan in order to create open space and green areas for a valuable flood prevention contribution, as identified earlier in the literature review of chapter 2.

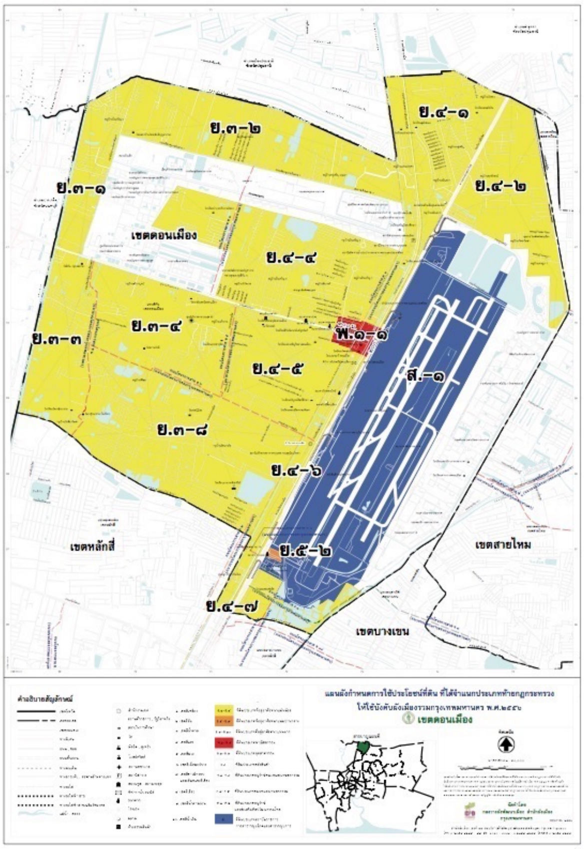


Figure 4.16: Don Mueang District 2013
Source: City Planning Department

This section showed the result of the first hypothesis " The efficiency of non-structural flood countermeasure by open space, which can protect from flooding, has not been considered much yet in Bangkok's master plan for water resource management by land use regulation." Don Mueang district will be at risk of flooding in the future, based on recurrent mapping of flood in Bangkok city and the Bangkok comprehensive plan from 2006-2013. Focusing on open space, the plan showed that this area does't have open space for flood prevention. The open space plan of 2006 suggested to create different green areas in this district but this project failed. After that, with the update the Bangkok comprehensive plan again of 2013, the latest open space plan proposed to provide many types of open space for different purposes :

- 1. Open space for Recreation and Environment Conservation
- 2. Open space for Environment Conservation along the roadside, riverfront and canal
- 3. Open space for Natural flood Way Conservation
- 4. Open space for Water Retention and Flood prevention
- 5. Open Space for Coastal Environment conservation Restoration.

Though this plan takes more into consideration flood risk management than the previous one, it does not cover the Northern area of Bangkok city, especially on our case study where management efforts should be done. This is why current open space plan is considered not being integrated into the spacial planning policy.

The observations based on the data gathered from the mapping of open space plan and the recurrence of flooding in Bangkok city, integrated with our case study in Don Mueang will help to establish the conceptual model presented on introduction that the flood prevention by open space and flood risk management mapping is an imperative tool for an effective cooperation between planners and local government. This part of research concludes further that due to insufficient research on urban flood prevention by open space plan and common lack of data to describe it, the regulation of open space plan for flood prevention in Bangkok city is more theoretical than practical. Such a situation results in cities that may have been recently flooded and lacked of efficient plan for mitigation and also having effect on the quality of life for the citizens who are living in this city. As a result, it is essential to provide such conceptual model on urban planning, focusing on flood prevention and integrated with open space regulation plan like a tool for flood prevention. Such a notion drives then the analysis presented in the next section.

4.7 Analytical Framework for Flood Prevention based on Open Space Plan

The result of the second hypothesis is “Open space areas can be added into the local comprehensive plan to support an overall flood prevention strategy”. This is showed after analysing the data. This section will try to provide a conceptual model as an analytical framework by using the master plan for flood prevention by open space in local area (Bangkok city).

Table 4.2 (Figure, 4.18) presents the analysis of data and attempts to illustrate the conceptual model of flood prevention by open space. Two conditions have been taken into consideration. Firstly, the functions of open space were addressed in

active and passive function. Secondly, strategy was provided on three period of time which can deliver a progressive improvement : short term, medium term and long term.

In terms of active function : when the stormwater is coming into the area, the open space can collect it to keep away water from the city center and also from the main axes in the district.

In term of passive function : During normal events, there is no flood. Open Space can be used like a park or public space for citizen who live in the neighbourhood.

About providing strategy in three period of time (short term, medium term, and long term)

In Short term : meeting stakeholders and the decision makers, scientists, sewerage and drainage system managers, environmental organisations, citizen's spoke-persons and every other body or public/private organisation involved so far in land use and city's development/protection, should be done to enhance the cooperation between the different bodies. It is a necessary step in urban planning to address solutions, here about flood prevention. A round table makes possible to evoke the different goals and expectations of the participants though these expectations are not always fully compatible with each other. The success of such meeting goes through a stronger governance from the public bodies leading urban planning and their capacity to take action from the different points of view expressed during meetings. These meetings, associated with an effective use of the comprehensive plan and a clear understanding of the solution which should be provided for flood risk management act like a starting point to establish a longer and efficient strategy. Public consultations can also be a useful tool to implement even if it would require some time before people participate in it if they are not use to.

In Medium term: improve regulation upon the open space plan since so far there is a lack of effective utilisation to this plan in the Bangkok Comprehensive Plan. In the next update of the Comprehensive Plan, open space plan and land use plan must be considered on stronger and equal level by the stakeholders so that the policy follows the legal framework. Considering the example of Don Mueang district,(Figure 4.18) the current land use plan doesn't take into account the different existing parks in the area. On the same base than the 2006 open space plan, different parks should be added within the area for different purposes : flood risk reduction, recreational... Then, the model could be applied in the other district of Bangkok to

establish a strong global network of open spaces once they have been done. Political will is an essential key to succeed in the process.

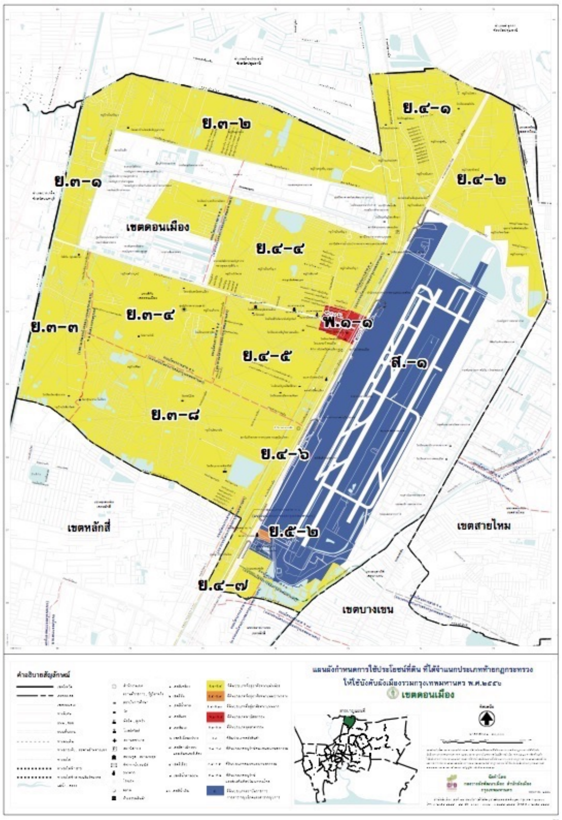


Figure 4.17: Don Mueang District 2016
Source: City Planning Department

In Long term: different things here have to be considered. Long term period has to deal with building the city resilience against flood events. It has been acknowledge in the study that green areas such as open space have to be integrated to provide an efficient and sustainable flood management strategy. A strong improvement of the flood risk management organization has to be settled. Such entity has to be able to provide step by step action to improve prevention and mitigation measures on flood risk and to consider building resilience thinking on a multi-decades time scale. Of course, improving flood risk management organisation has to be done in parallel with a stronger partnership and coordination between the different actors involved in urban planning so that strategies and policies follow the same way.

Table 4.2: Analytical Framework of Flood prevention strategy based on function and three periods of time

Terms / Action	Short Term	Medium Term	Long Term
Active	• Improve emergency response measures on flood events	• Highly effective institutional arrangement for emergency management (Alexander et al., 2016)	• Improve flood risk management organization and catchment flood management plans for multi-decades time scales
	• Awareness raising campaign for the citizens	• Co-working and sharing data between public sectors	• Efficient drainage systems which separate house's waste water and stormwater
	• Set up a system of real-time flooding tracing	• Creation of evacuation spaces for flood prevention	• Encourage people to save land property for open space threw tax savings
Passive	• Cooperation between public/private organisations	• Effective collaboration between land use regulation and open space plan	• Create functional open space areas protected with strong urban regulation
	• Protect the remaining open spaces	• Improve general knowledge regarding ecological based flood prevention	• Integrated management linking policies, strategies and actions (Vigar, 2009)
	• Establish the best possible use of open spaces	• Improve perception of open space used for flood prevention	• Establish databases of flood situations with public and private organizations

Edit by Netchanok Sariwat, 2018

Figure 4.18: Analytical Framework of Flood prevention strategy based on function and three periods of time
Source: Netchanok Sariwat, 2018

As a result of this chapter were presented the results of the secondary data of Statistics of Rainfall at Meteorology station, Bangkok 2003-2015, Bangkok comprehensive plan, focusing on the open space plan between 2006 and 2013 with analyses and flood forecasting data of The Recurrence of flooding mapping from the Land Development Department. Most of the areas in Bangkok city will be at risk of flooding in the future. In addition, the areas in the northern part of Bangkok are still lacking of open space to support water in case of flood crisis. That's the case in Don

Mueang district. This area is vulnerable to the disaster and there are no open spaces to store the water so that one of the above hypotheses can be answered. The important part of this chapter is the answer of the second hypothesis “Open space areas can be added into the local comprehensive plan to support an overall flood prevention strategy.” Thereby, the researcher used the proposed method as an analytical framework. The goal of these open space is to be integrated, through open space plan, within the strategy of flood prevention in three phases: short, medium and long term. The analytical framework could then be used as a local tool for stakeholders. It can match with the city plan to apply benefit for the area.

Chapter 5
Discussion

The purpose of this research was firstly to protect the city centre of Bangkok by using open space plan and to examine the efficiency of non-structural flood countermeasures by open space, which could be further implemented into the Thai master plan for water resources management with a strong link with the land use zoning of the Bangkok comprehensive plan. The global flood situation of Bangkok city hasn't been addressed in details in purpose.

From the perspective of this study two notions resulting from the literature analysis are certain. Firstly, open space plan has to be integrated in practical rather than staying on a theoretical level. Regarding the research results, it has to be taken into account with the spatial planning policy to improve the terrible situation and suggest solutions for this problem. Secondly, another suggestion is to attempt to deliver a conceptual model by separating open spaces in two functional ways, active and passive. Also, in order to propose a complete approach on flood prevention, it is necessary to provide effective strategies in three time scales (short term, medium term, and long term).

The result from the literature review showed that (1) open space have many purposes and many functions and the one of important is flood prevention like a green infrastructure to protect the environment and urban areas at the same time (2) flood prevention is becoming a main issue in many areas and nowadays it has many solutions in terms of structural solutions (civil engineering). Though, in this research focus was made on non-structural ways and concerned on sustainable ways (3) stormwater is the main reason for flooding in the urban area from two main reasons, climate change and the urban planning. For example, there is a lack of space to retain the water and the drainage system is unadapted (4) local area: Don Mueang district tries to integrate the local policy for a more effective and easier organisation (5) spatial planning: Bangkok comprehensive plan is a strong tool for urban planning to control the activities in the urban area and can set the policy of flood prevention.

The presentation of the Bangkok Comprehensive Plan in the previous section revealed a lack of consideration of the open space plan in the overall spatial planning policy of the city. Indeed, either in 2006 or 2013, none of the projects presented in each open space plan, and suitable regarding the land use zoning plan, were actually conducted. This observation is also suitable for the case study, Don

Mueang, where the land use is dominated by low-density residential areas (theoretically suitable areas to implement open spaces due to the low number of structures with high value) but where no more open spaces areas were installed, since the open space plan is still not a strong tool in urban planning. The key highlights of this presentation is that governance must be efficiently improved for the effective implementation of the open space plan as one of the 4 main documents of the Comprehensive plan. Also, related planning policy stakeholders need to work together to establish an overall integrated and complete approach of urban planning, for which flood prevention, and the open spaces/green infrastructures with it, are on vital consideration regarding the activities and the different major issues at stake above it. The increasing risk of flooding in the city in the years to come due to climate change urges a narrow partnership between the decision makers in urban planning. On the mid to long term approach, the effective use of open space plan will be helpful to enhance Bangkok's resilience to natural hazards such as floods. This could be achieved by a strong enhancement of the flood management organisation, which, as part of city and planning, is still not fully integrated with the other urban fields of interest.

The analysis from the secondary data from Statistics of Rainfall at Meteorology station, Bangkok 2003-2015, Bangkok comprehensive plan, focusing on the open space plan revealed that most of the areas in Bangkok city will be at risk of flooding in the future. And in the same way, the government attempts to improve the open space plan to control the land use for the flood prevention according to the open space plan in 2006 -2013 can be seen the evaluation of flood prevention. A new version of the Bangkok Comprehensive Plan should be edited in 2018. As a step forward from this thesis, a detail review of the use of the new version of the Comprehensive Plan in the next years would be a meaningful use of the study above to establish wether or not governance was actually improved. At the same time, it could also be valuable to review the evolution of the flood prevention strategy in order to show if the open space plan has become a real legal tool in this field.

The approach developed throughout the theoretical-framework section resulted in an attempt to deliver a conceptual model, that might be of use for planners who try to find the solution for flooding situation in Bangkok city and focusing on local level. Though, the approach presented in the study only deals with one specific tool of global flood management strategy. In order to access an integrated flood management strategy, over approaches can be addressed in flood prevention strategy in particular level and over flood management strategy tools in the global level.

Chapter 6
Conclusion and Summary

Floods are becoming a crisis state in many countries and flood risk management is a big challenge for urban planners who have to find solutions and plan to protect the city and urban areas. The main reasons of flooding come from natural sources such as rain season, and also man-made reasons like climate change, or in term of urban areas, cities face flood because of the important impervious cover of land. Indeed, the impervious cover doesn't allow water to infiltrate in the ground. Associated with a lack of bumped areas to store water, this land use leads to very important water discharge within the streets threw runoff water. Evacuation systems reach their maximum capacity too quickly to allow water to flush away : this leads to surface water based floods.

Consequently, flood and risk management is necessary in this situation. Though many governments and organizations attempt to consider sustainable plan for flood prevention, it has not been very successful in many areas, including Bangkok city, Thailand. So, one of the sustainable solutions for flood and risk management is flood prevention approach, using open spaces and green infrastructures because open spaces can make a valuable contribution to manage surface water runoff. This is a particular concern associated with the effects of climate change, notably the anticipated increasing frequency of heavy rain events. Associated within urban spatial planning with open space plan, open spaces and green infrastructures can form part of critical flood risk management systems by providing space for flood management, protecting built up areas.

The Comprehensive Plan is the key tool for urbanists to settle spatial planning for long term. Open space areas face important pressure in dense areas since they are considered as unproductive areas. A strong connectivity with the flood prevention stakeholders allow to ensure that such areas have in fact a key importance in urban areas. Their efficiency to collect stormwater during strong rainy events prevents overflow in streets. Though, open spaces cannot be implemented or kept in may areas. Considering the Comprehensive Plan, and especially the land use zoning plan within, the Open space Plan should be discussed with the different stakeholders involved in spatial planning to address the benefits that such areas would answer if installed or kept in place. Of course, open space areas must not be the only way to improve ineffective flood prevention policy. The analytical framework

presented above from the case study in Don Mueang could be part of a reorganization of flood prevention policy. Indeed, the summarised table tends to present step by step and overall directions that flood managers and the other urban stakeholders should consider on priority. On one side, the stormwater based floods events are reported to increase in the years to come and civil engineering is not able and will not be able to flush away a sufficient amount of water onto the Chao Phraya River downhill despite capacity improvement. Store the water has to become part of flood prevention strategy and can make valuable contribution in other topics reduce the heat effect in urban areas by cooling the air, or help to fill up the groundwater tables. On the other side, a stronger interconnected policy of urban stakeholders, associated with a efficient risk awareness policy for citizens will improve the efficiency and the resilience of the flood management policy. Cooperation is indeed a major step forward to provide a complete answer on flood prevention policy.

Governance might be a key element for a successful flood prevention policy. It means that the policies have to be implemented step by step from short to long term approach despite the possible change in the governance organization. One of the danger could be a refund of the policies with new governance organization, thus failing the efforts which have been made in the previous policy.

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Flood Prevention by Open Space plan : Spatial Planning integration at local level in Bangkok city, Thailand

Abstract

Risk and Hazard management is a main issue and challenge for urban planners because natural conditions are related to many parts of the city development. Introducing the spatial issue on "Flood Prevention by Open space plan: Spatial Planning integration at local level in Bangkok city, Thailand", this research focused on Bangkok city, capital city in Thailand, a growing urban center which faces flood on yearly period occurrence. It attempted to fill the gaps in the existing local open space plan for flood prevention by focusing on the related 4 mains issues : (1) flood prevention ; (2) open space ; (3) urban area and (4) the spatial planning policy. These issues were developed by literature review as an analytical tool to study empirical facts.

The case study, Don Mueang district, was chosen as a valuable example due to its northern location and its potential to implement open space areas. Through this case study, this research tried to demonstrate how the open space plan can be connected with flood prevention in urban areas. The research, with the conceptual model of flood prevention, highlighted the key importance of stronger governance and interconnected urban land planning policies in order to use open space plan more efficiently as part of urban planning plans.

Keywords: flood, flood risk management, flood prevention, open space plan , stormwater, spatial planning, Bangkok city

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