Bangkok Flood Risk Management: Application of Foresight Methodology for Scenario and Policy Development

Sreeja Nair
National University of Singapore
Singapore

Wong Kai Wen
National University of Singapore
Singapore

Chow Mei Ling
National University of Singapore
Singapore

Abstract

Between end 2011 and early 2012, Bangkok was hit by massive flooding due to intense rainfall which together with high tides overwhelmed the poor drainage infrastructure of the low-lying city. The floods impacted not just local residents and businesses, but also disrupted the local operations of foreign companies and affected the confidence of foreign investors in Thailand as an important production location in the global supply chains. Unfortunately, such floods are likely to recur with greater intensity and frequency in future with climate change and rapid urbanisation. This article presents an application of 'futures thinking' and foresight methodology to identify key drivers, futures scenarios, and policy options for the management of flood risk in Bangkok.

Keywords: Bangkok, flood risk management, climate change, foresight, scenarios

Introduction

Bangkok is one of the many coastal megacities in South East Asia vulnerable to impacts of recurrent flooding. Apart from being the capital it is home to substantial national and regional economic investments that contribute substantially to Thailand's GDP (World Bank, 2010). Rapid urbanisation in the 1980s led to the formation of The Bangkok Metropolitan Region (BMR) – one of the largest "mega-urban regions" in Southeast Asia. BMR initially had extensive canal networks for agriculture and transportation which deteriorated to make space for settlements and economic activities (Davivongs, Yokohari and Hara, 2012). The location of

Bangkok on the Chao Praya River delta (see Figure 1), its flat low-lying topography and the presence of a thick soft clay layer at the ground surface makes the city flood-prone (Jha, Bloch and Lamond, 2012; Phien-wej, Giao and Nutalaya, 2006). According to the first global assessment of port cities, Bangkok ranked among the top 10 cities in terms of population likely to be exposed to coastal flooding due to climate-related risks by 2070 (Nicholls et al., 2008).

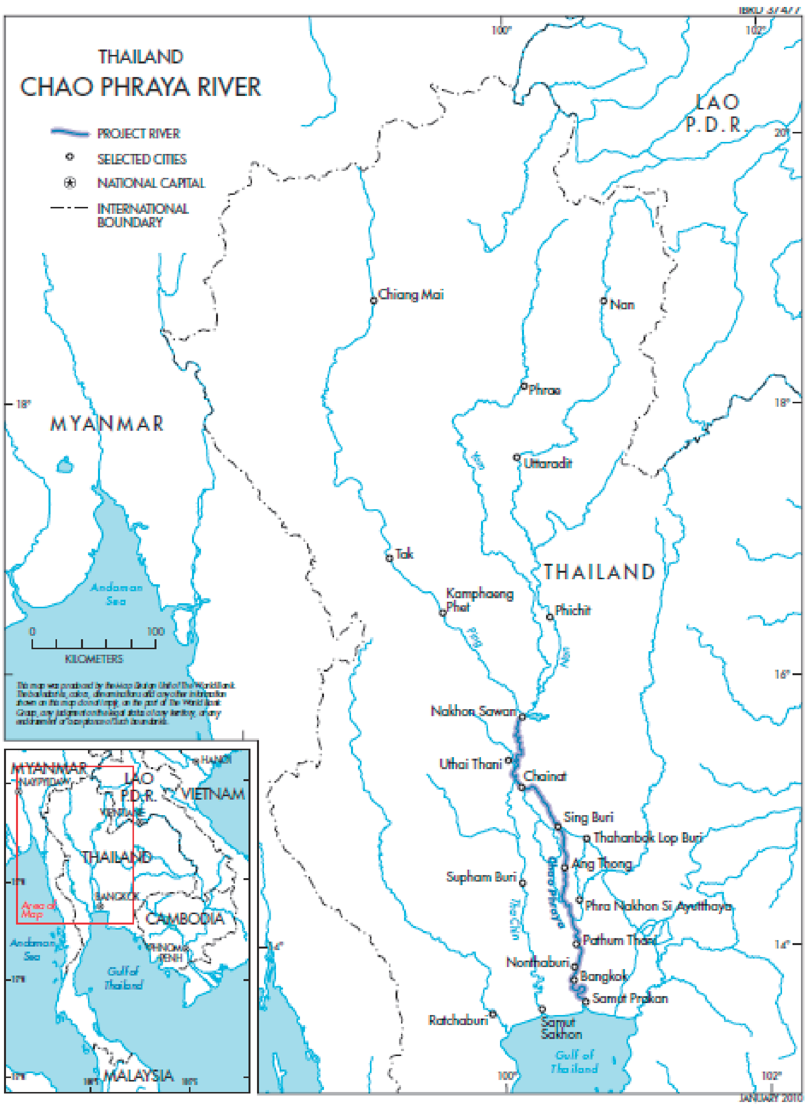


Figure 1. Location of Bangkok in the Chao Praya river basin (Thailand map IBRD 37477 in World Bank, 2010)

Though floods have been rampant in Bangkok, the 2011 flood was unusual owing to its high intensity (1439 mm which was 143% of the average rainfall recorded during 1982-2002) and duration, extending from the monsoon period to mid- January 2012 in some parts of the city. The scale of damage caused by the 2011 floods was unprecedented, resulting in 813 deaths (national figures)[1], inundation damage to seven industrial estates and 804 companies, with total losses estimated at 1.36 trillion baht (Komori et al., 2012). The issue of flooding in Bangkok is an example of a “wicked problem” (Conklin, 2006) with many dimensions to the problem, diverse stakeholders involved and no clear solutions to address all concerns satisfactorily.

Apart from climatic factors, the rapidly rising population in Bangkok can also heighten the city’s vulnerability to floods by increasing pressure on the city’s drainage infrastructure. Bangkok is likely to also continue being vulnerable to increased river flow owing to sea level rise and projected increase in the frequency of high intensity rainfall events due to climate change. At the same time, the continued withdrawal of groundwater to meet the population demands is likely to aggravate the natural subsidence of Chao Praya delta and consequently heighten Bangkok’s risk to flood inundation (Nicholls et al., 2007).

As flooding in Bangkok becomes more frequent and severe in the future, both the impact of flood and the responses are likely to remain uneven given the presence of many stakeholders and their differential access to power and resources. For example, poor residents especially in the slum settlements are most vulnerable to floods. Diversion of floodwaters to area outside Bangkok to protect key areas of Bangkok-the center of Thai politics and also the Thai royalty has been seen in earlier flood events (Lebel, Manuta and Garden, 2011). The 2011 flood has also shown how national and city priorities in flood management can diverge due to the different political affiliations of the national government and city authorities (Dalpino, 2012).

While this paper focuses on Bangkok, the foresight methodology applied in this study has broader relevance for assessing flood risks and consequent policy development in other cities around the world that face similar challenges.

Methodology

Strategic foresight attempts to integrate multiple perspectives and methods for identifying current and emerging issues and trends and help assess policy options for attaining a desired future (Habegger, 2010). Foresight can be instrumental for environmental planning by providing insights about a range of futures of social-ecological systems and critical thresholds, and thus aid in anticipatory planning to avoid adverse impacts (Bengston, Kubik and Bishop, 2012). Foresight can inform policy by enhancing the knowledge base for thinking about and designing policies (Da Costa et al., 2008). This article demonstrates the application of strategic foresight using multiple foresight tools to identify emerging issues and scenarios that can aid policy development for flood risk management in Bangkok. Firstly, environmental scanning was conducted to collect information about the macro-environment (Choo, 2003) related to flood risk in Bangkok. The sources include: reports by governments, non-government organizations (NGOs) and international organizations, journal articles, newspaper articles, web-blogs, magazines and relevant conference reports. Morphological Analysis was then conducted using Singapore’s Risk Assessment and Horizon Scanning (RAHS) software[2] to explore relationships between factors influencing flood risk in Bangkok and the stakeholders involved. The above steps lead to the identification of key drivers, emerging issues and trends, stakeholders, along with local and global responses to flood risk.

Morphological Analysis offers several advantages for identification of the 'boundary conditions i.e. limits and extremes of different contexts and problem variables' and new relationships or configurations that may not be apparent or ignored by less-structured foresight approaches (Ritchey, 2009).

A Trend Impact Analysis was subsequently carried out to identify the relative impacts (I) and probability of occurrence (P) of key drivers into the future. This was followed by an Uncertainty-Importance Mapping to plot the drivers that are 'most important' and 'most uncertain' in relation to flood risk in Bangkok. Four scenarios are then constructed. (See Appendix 1 for an outline of the methodology).

Key drivers of flooding in Bangkok

Bangkok is likely to face the impacts of climate change and variability via changes in temperature and rainfall patterns, sea level rise (SLR), changes in frequency and intensity of extreme events (including high intensity precipitation and storm surges) (Vitoolpanyakij, 2008). The key drivers identified from environmental scanning and morphological analysis, are as follows:

Increase in high-intensity rainfall

In Bangkok, temperature increases of 1.9° C and 1.2°C for the high and low emissions scenarios respectively are linked with an increase in mean seasonal precipitation by 3 % and 2 % respectively, by 2050 (World Bank, 2010). Kure and Tebakari (2012) present a specific future projection for the time period 2010-2099 and indicate that events of extreme flooding and high-flow discharge are likely to increase in frequency in the future due to projected intense precipitation.

Sea-level rise

The Gulf of Thailand is likely to face a rise in sea level by 0.29 and 0.19 meters for the fossil-intensive growth A1FI and moderate growth B1[3] scenarios respectively (Panya Consultants, 2009).

Urbanisation

Bangkok's suburbs are rapidly developing. The Bangkok Metropolitan Region witnessed a 74% increase in urban development between 1998 and 2003 (World Bank, 2010).

Population and industrial growth

The population of Bangkok has increased four times from 1960s, to nearly 9 million today. During this period, the city has witnessed rapid industrialisation, attracting large-scale investments especially for banking, automotive, and semiconductor industries (Alverson, 2012).

Deterioration of drainage systems

Urbanisation has turned Bangkok, "once a water-based city" into a "land-based city" (Davivongs, Yokohari and Hara, 2012, p.13) and resulted in drastic deterioration of natural drains hence increasing Bangkok's flood risk (Phien-wej, Giao and Nutalaya, 2006).

Land subsidence

Deep well pumping over past 35 years has led to land subsidence in Bangkok. Land subsidence is likely to vary from 0.05 to 0.30 meters by 2050 and can exacerbate the impacts of SLR and storm surge in Bangkok (Panya Consultants, 2009).

Trend Impact Analysis & Uncertainty-Importance Mapping

The probabilities of occurrence of the six key drivers identified in the last section and their expected impacts over the next 20 years and beyond were depicted using Trend Impact Analysis. The probabilities of occurrence and impacts over time were assigned by authors' based on literature and historical records from Bangkok, and indicate that while the probability of all drivers is likely to increase over time, the impact of high intensity rainfall and urbanisation is relatively higher (see Table 1). Subsidence and SLR though important variables, are relatively slow-onset, compared to others.

Table 1. *Trend Impact Analysis*

	5 yrs	**10yrs**	**15yrs**	**>20yrs**
High intensity Rainfall	I = 0.3 P = 0.1	I = 0.4 P = 0.2	I = 0.5 P = 0.3	I = 0.6 P = 0.4
Urbanization	I = 0.2 P = 0.2	I = 0.3 P = 0.3	I = 0.4 P = 0.4	I = 0.5 P = 0.5
Drainage	I = 0.1 P = 0.2	I = 0.2 P = 0.3	I = 0.3 P = 0.4	I = 0.45 P = 0.5
Population Growth	I = 0.2 P = 0.2	I = 0.3 P = 0.3	I = 0.4 P = 0.4	I = 0.4 P = 0.5
Subsidence	I = 0.05 P = 0.3	I = 0.1 P = 0.4	I = 0.2 P = 0.5	I = 0.3 P = 0.6
Sea level rises	I = 0.05 P = 0.05	I = 0.1 P = 0.10	I = 0.15 P = 0.15	I = 0.2 P = 0.20

The Uncertainty-Importance Mapping reveals that the two most important and uncertain variables are high intensity rainfall and urbanisation (see Figure 1). Factors in the upper right (most important and uncertain) form the "critical uncertainties" and thus become the basis for defining likely future scenarios (Swanson and Bhadwal, 2009). While the relationship between rainfall and flooding is an important one, it is also at the same time highly uncertain as there is much variability in rainfall intensity. As for urbanisation, it is an important driver of flooding. However, as there are many factors influencing urbanisation such as rural-urban migration, and the level of foreign investments which is tied to the global economy, it is difficult to project the urbanisation rate with certainty.

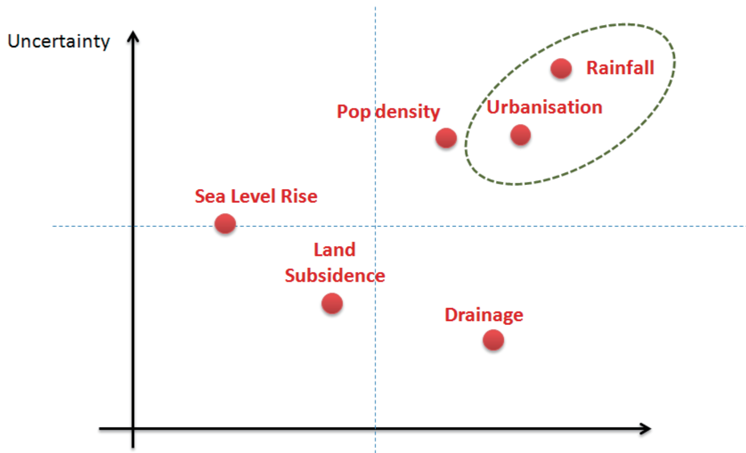


Figure 2. Uncertainty/Importance Mapping

Policy Responses and Innovations in the Context of Flood Risks

In this section, the current responses to the impact of floods based on environment scanning of flood risk management measures proposed and/or implemented in cities worldwide have been outlined. This section focuses on responses that mitigate the impact of floods rather than their frequency which is mostly due to biophysical drivers such as rainfall patterns and sea-level rise.

Flood management paradigms

There are two key "paradigms" in flood risk management. The first is typified by the system of dikes used in Netherlands to fortify its riverbanks to prevent flood water seepage (Kuster, 2008). The second is the one seen in Venice which allows water to flow through the city through its canals.

Types of responses

In general, flood risk management responses entail a combination of technical solutions and disaster management systems. Flood prevention technologies include: protective infrastructure e.g. embankments, dikes, and seawalls (for example Netherlands); water structures e.g. floodgates (Venice/MOSE, England/River Thames); and solutions to mitigate impact of flooding e.g. raised infrastructure and expressways, flood-proof housing and communities (RIBA & Norwich Union, 2008).

Disaster management systems refer to flood resilience programmes which include: surveillance and monitoring and alert systems; disaster management and community impact mitigation; outreach and education[4]; as well as insurance and financing schemes. New measures e.g. crowd-sourcing of weather information (Kessler, 2012), portable sensors, and cloud-based monitoring and control systems (Mims, 2012) are lowering the cost, and enhancing the performance of monitoring systems. By complementing "traditional" disaster relief programmes by Governments and NGOs (e.g. in the aftermath of Hurricane Katrina), social-media (Sato and Yamazaki, 2011) is enabling alternative spaces, information and informal networks to be set up by local citizens and communities for self-help in a quick and cost-effective manner (Sternberg, 2011).

Current responses in Bangkok

Large scale engineering measures in the Thai capital include floodgates and embankments around the city and pumped drainage systems. During peak flooding events, as in 2006, 2010 and 2011, these measures reduced the impact on Bangkok's city center, but only by flooding peri-urban and agricultural lands outside the embankment and north of the city. The city still needs a solution that considers the wellbeing of less advantaged residents inside and outside Bangkok (UNDP, 2012).

Thailand is now putting in place a new flood prevention response (Vimolsiri, 2012). Drawing from the King's Initiatives regarding water management, the response is two pronged: (i) holistic water management, which includes upstream restoration of ecosystem and thus water retention, increasing areas for flood retention and capacity of dams/rivers; and (ii) technical solutions based on a defence ring wall concept which includes building dike roads with water gates, raising roads and infrastructure and local wall defence for key installations. This is similar to the dike system in Netherlands.

However, downstream wall defence is a targeted technical solution aimed at floodwaters up to a certain maximum height (determined by the previous worst flood). This limits its applicability to more extreme scenarios. Unintended problems of social fallout, economic loss and political isolation could occur when the walls are breached, which was what happened when surrounding areas had to be sacrificed in the 2011 floods in order to protect key installations in the inner core (see Appendix 2).

Stakeholders

Besides technical solutions and disaster management systems, it is also important that the different stakeholders involved are engaged in managing the impacts of floods, whether in conceptualizing or implementing the different flood risk management schemes. The engagement of the different stakeholders in flood risk management helps to ensure that the needs of affected communities will more likely be taken into account and this will help enhance the successful implementation of the flood risk management schemes (Jha, Bloch and Lamond, 2012; Manuta and Lebel, 2005).

Through morphological analysis, we identified many stakeholders involved in the issue of flooding in Bangkok (see Appendix 1). These include the government at different levels (local, city and national), the different political parties, NGOs, residents (including the poor communities), industry and businesses (including foreign companies with operations in Bangkok), as well as other "players" in Thai politics such as the military and the royal family.

The presence of different stakeholders means that the proposed flood management strategy should ideally be able to take into account their different interests and concerns. The proposed strategy should also be sensitive to the differing access to power and resources by these different stakeholders when it comes to implementation. The challenge is how to bring the different stakeholders at the same level to agree upon the strategy and to implement it together.

Community-based flood risk management is one such approach where different stakeholders can participate in developing and implementing initiatives and schemes to better manage the impact of flooding (Jha, Bloch and Lamond, 2012). This involves raising awareness of flood risk and building capacities for flood risk management among the different stakeholders through workshops, group planning and design sessions, field visits and townhall meetings. At such forums, appropriate tools to facilitate decision-making by the wider community can be used such as geographical information systems to map vulnerable areas and communities, flood impact models, simulation games, and planning exercises (Jha, Bloch and Lamond, 2012).

There are however potential pitfalls in the community-based approach to flood risk management (Manuta and Lebel, 2005). Firstly, there is the issue of how to divide up the roles and responsibilities among the many different stakeholders involved especially given their differing interests, priorities and access to resources. There is the risk that responsibilities for flood risk management are shifted to the local communities without a corresponding increase in funds or support from the local government authorities. Secondly, while community-based programs take into account local needs, poor coordination across the different communities may lead to duplication of efforts and wastage of resources in the implementation of flood risk programs. Finally, given the limited resources, community-based programs may not be sustainable in the long term.

Scenarios for Bangkok

Based on the results of the Trend Impact Analysis and Uncertainty-Importance Mapping, four future scenarios are created based on rainfall and urbanisation as the two most important yet uncertain drivers for flood risk in Bangkok (see Figure 2).

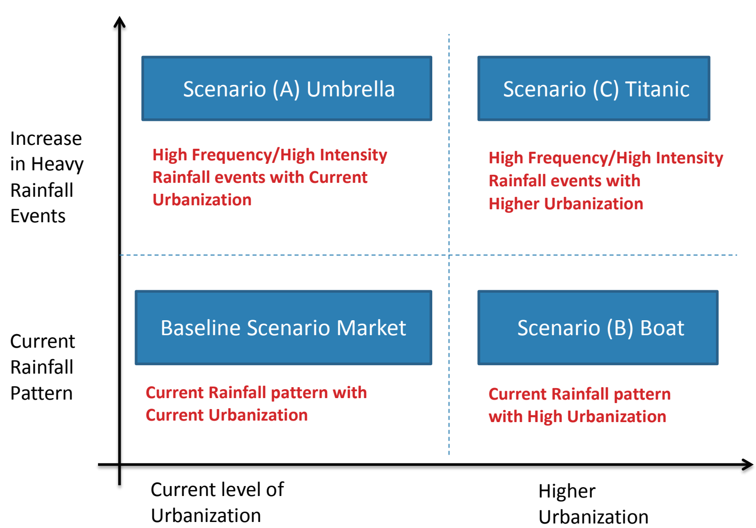


Figure 2. Four future scenarios for flooding in Bangkok

Baseline scenario: Market

In this baseline scenario, the current rainfall pattern with current rates of urbanisation will continue. Frequency and severity of flooding will remain unchanged from today.

Life in Bangkok will go on as usual, as complacency sets in with regard to the vulnerability of Bangkok to floods. As a result, there remains a lack of investment in proper drainage systems to manage floods. Political battles continue between the national and city government on who should be responsible for putting in the flood mitigation measures.

Scenario A: Umbrella

In this scenario, the current rates of urbanisation remain but there are more high intensity rainfall events. There will be a significant increase in frequency of flood events.

With repeated floods, the government becomes more experienced in anticipating, handling and managing the impact of floods. As urbanisation rates remain unchanged, there is capacity for the government to enhance the drainage systems. There is strong involvement from the community in managing flood risks.

Scenario B: Boat

In this scenario, the current rainfall patterns remain but with higher rate of urbanisation. The frequency of flood events remains unchanged but will be more severe due to the higher concentrations of people who will be affected.

Similar to Scenario A, the government becomes more experienced in anticipating, handling and managing the more severe floods. However, rapid urbanisation places strains on the measures which are put in place to manage flood risks. With the continuous movement of people into and out of the city from the poorer parts of Thailand, community disaster risk management programs are tough to implement due to the lack of sense of community in the population. At the same time, the poor rural immigrants bear the brunt of the social and economic impact of flooding.

Scenario C: Titanic

In this worst-case scenario, there is higher frequency of high intensity rainfall events with higher rates of urbanisation compared to current rates. There will be a significant increase in frequency and severity of flood events.

Bangkok will be flooded most of the time. A significant portion of the population will live in flooded areas with the poor being affected the most. The economic impact of the flood will be many times that of today with widespread disruption to businesses and industry. Urban infrastructure such as housing, roads and train systems will be damaged by frequent flooding, thus further reducing the capacity of the city to cope with the huge influx of population. There are calls for the relocation of the capital city but these are strongly resisted by the city government as well as the royal family.

Policy options

Approach

First, we identified all the possible responses to floods for the different scenarios from a global scan of responses. We then "bundled" the responses into policy options for each scenario. We found some responses to be equally necessary in any of the four scenarios as they plug the current gaps in Bangkok's flood management system (see Appendix 3 for details). In this section, we focus on policy recommendations that are tailored specifically to each scenario (see Chareonwongsak and Kitthananan, 2009 for details of approach).

Baseline scenario: Plug existing gaps

The policy option here focuses on addressing gaps in the current situation. The responses that have been implemented or proposed in Bangkok assume that current rainfall patterns and urbanisation will be unchanged from today. Hence, the responses continue to focus on technical solutions such as dikes, afforestation on the upstream parts of the water catchment, flood retention ponds and increasing river capacity. However, these technical solutions ignore the uneven impact of flooding on different stakeholders especially the poor who are most affected by floods.

Therefore, the policy option for this scenario should also include political mechanisms that address the current inadequacies in the institutional structures and processes that fail to take into consideration the needs of the poor (Lebel, Manuta, and Garden, 2011). For example, slum upgrading should also be considered as part of the policy option for the baseline scenario.

Response Scenario A: Umbrella – Implement permanent structural responses

The policy option here comprises of a fully comprehensive permanent structural response to combat the frequent high intensity rainfall, and hence will be costlier than the policy option for the baseline scenario which focuses on addressing current gaps. The structural response can be in the form of either a ring-wall defence concept to block off floodwaters or a canal/floodplain system to allow water to flood through the city. Technical infrastructural solutions such as improvement in drainage capacity, revised floodwalls, embankments, dredged rivers/widening of canals, drinking water management should also be implemented.

Infrastructural improvements within individual premises and community are also needed, e.g. the development of flood-proof premises by moving the activity/ living quarters above the flood level, having water retention areas, flood-proofing whole communities by providing alternative walkways/circulation system during floods (RIBA and Norwich Union, 2008), thereby allowing Bangkok to switch to "flood" mode with ease, without disruption to operations/daily living. The ideas and technology for the additional measures are readily available, and so can take- off into the implementation stage without difficulty.

Response Scenario B: Boat – Towards community-based measures

The policy option for this scenario takes into consideration the constraints posed by rapid urbanisation and thus solutions will be temporary in nature but will require a high level of stakeholder engagement.

The focus will be on flood control mechanisms that can be set up quickly and cost effectively to handle the impact of floods. These include demountable flood walls/barriers, and temporary floodgates such as the rapid deployment floodwall (Geocell Systems, 2012) which can be implemented in tight, urbanised settings.

In addition, disaster management systems should focus on community-based flood-risk management which involves educating the various stakeholders on steps to be taken during floods, including evacuation of residents at the lower grounds who might not be protected adequately by the flood control structures. This will help ensure that the community is equipped with measures to better respond to floods, even when the tight urbanised setting cannot allow for permanent flood control structures.

Response Scenario C: Radical change

This extreme scenario will call for radical changes. Hence, it will be the costliest and will require the highest level of stakeholder engagement among all the scenarios. There are two possibilities from our environmental scanning of global responses:

Possibility 1: Move Bangkok

One possibility is to move Bangkok. This is based on the premise that Bangkok has exceeded its capacity to support its population and manage the flood waters. The proposal is to relocate the capital city, or at least the key installations and government offices to higher ground (Watts, 2011). The large industrial base built up in Bangkok will need to be considered for relocation in this scheme. However, the relocation of key installations to higher ground, while leaving the general urban population at the lower grounds to cope with floods, is likely to be controversial and will require careful consultation and deliberation with the stakeholders.

Possibility 2: Venice of the East- Ayutthaya

Another possibility is to adapt to flood risk onsite in Bangkok with a radical approach to urban planning. This option involves allowing low-lying areas in Ayutthaya and Aug Tong to be flooded, and developing new elevated transport systems. For example, a new scheme “Ayutthaya 3.0” was proposed by Architects-Shma in response to The Association of Siam Architects’ call for a vision for Thailand after the 2011 floods (see Appendix 4) (Holloway, 2012; Furuto, 2012). In this innovative scheme, the slabbed-over canal system would be re-instated to the original water channels, and a new “water detention network” is created to retain water during the rainy season for agricultural use in the rest of the year. This scheme also involves the blurring of distinction between the industrial and the agricultural areas, and envisaging a patchwork of rice fields, water storage infrastructure and settlements. Ayutthaya 3.0 would also plan for elevated mass transit, amphibious vehicles and other symbiotic technologies (Holloway, 2012).

This possibility is a long-term proposal, and can potentially be very costly as water canals have to be restored and existing developments over the channels may need to be removed. In addition, a cost effective transport system that can operate both on land and water is still in the incubation stage.

Insurance for Bangkok

The above two possibilities for Bangkok are expected to incur significant costs, much more than the expected cost of 900bn Thai baht for the baseline scenario (The Nation, 2011). Issuance of Government bonds is one possible way to meet the financial needs for post-flood reconstruction efforts, but it is likely to increase further the fiscal deficit of the Thai government (HSBC Global Research, 2011).

A different approach to financing the flood control measures would be required.

Recognizing that flood has become endemic in Bangkok and everyone has a part to play in flood mitigation efforts, this approach requires all residents, industries, and businesses in Bangkok to acquire flood insurance, which is then pooled together to fund flood mitigation measures and compensate those affected by the floods (Hansson, Danielson and Ekenberg, 2008). As Bangkok becomes increasingly protected by mitigation measures, the flood risk falls and the cost of insurance is expected to drop accordingly. This is not an unusual process, for instance, UK has automatically included flood insurance in all household policies and prepared a Flood Risk and Insurance Roadmap to 2013 and beyond (DEFRA, 2011).

Evaluation

In Table 2 below, we suggest a template for evaluation of the proposed policy option for each scenario based on their likely cost, how they are governed and resourced, level of stakeholder engagement, intended and unintended consequences, and the winners and losers.

Table 2. *Evaluation of different policy options*

Evaluation criteria		Policy Options			
		Baseline	A	B	C
		Plug existing gaps	Permanent structures	Community based measures	Radical changes
Cost (see note 1)		+	+++	++	++++
Resourcing		Government	Public-Private Partnership (PPP)	Government with assistance from NGOs, international organisations and donors	All stakeholders, and insurance and financial industry
Stakeholder engagement (see note 1)		+	++	+++	++++
Type of governance		Technical experts at city level – within and outside the Bangkok Metropolitan Authority	Technical experts at national level – Central and municipal government, private consultancies, and scientific experts	Collaborative – engagement with communities, NGOs, and all key stakeholders	Participatory transition management – visioning, consensus building across all stakeholders
Consequences	Intended	Protect key areas	Protect all areas even with higher rainfall	Enhanced sense of ownership by stakeholders	Involve all stakeholders in thinking holistically about the future of Bangkok
	Unintended	Poor communities left unprotected	Permanent structures increase tax burden on poor communities and reduce space for development	Local communities bear the burden of funding and implementing measures. Lack of coordination across communities for a unified response.	Radical solutions may alienate stakeholders and key decision makers, leading to lack of action
Affected parties	Winners	Industries and key installations	Potentially all, including construction industry	Communities with strong flood-response capacities	Potentially all, including construction industry
	Losers	Slum dwellers and the poor	Tax payers or those who bear most of the cost	Communities which lack such capacities due to constant flux in residents	The poor and most vulnerable people who may be left out of the radical plans

Note 1: Level of cost and stakeholder engagement required denoted by "++++" for highest and "+" for lowest.

Conclusions

The management of flood risk in Bangkok involves many dimensions, stakeholders, responses and policy options. The purpose of this study is to present an example of application of select foresight tools to identify four plausible future scenarios for Bangkok that can aid in policy development for flood risk management in the city.

Based on our assessment, plugging of existing gaps is the baseline response that is required for all scenarios, and can be implemented at minimal cost. Nevertheless, the city municipal authorities should prepare for the worst case scenario (Titanic) given that increasing rainfall intensity and rapid urbanisation are likely to occur for Bangkok. However, in view of the significant cost involved, implementation of policy options for the Umbrella and Boat scenarios can be considered first, pending further monitoring of the trends. This is as the construction of permanent structures (Umbrella scenario) will require more time to plan, fund and implement. Time is also needed to develop community capacities and forge stakeholder consensus (Boat scenario) in adapting to the radical solutions required in the Titanic scenario. Given these considerations, we propose the following timeline for the implementation of the policy options in Table 3 below.

Table 3. *Proposed timeline for implementation of policy options*

Policy option	Timeline
Plug existing gaps	Now – 5 years
Permanent structures	5 – 10 years
Community based measures	5 – 20 years
Radical changes	Up to 50 years or more

The scenarios generated on the basis of review of literature and historical records of flooding and key drivers of flood risk in Bangkok can be developed further by generating scenarios based on worldviews of specific stakeholders using methods such as CATWOE (Checkland, 1999). In addition to the scenarios, the impact of changes in the political system (e.g. change in ruling party) as well as other emerging political priorities that may conflict with the implementation of the above options for Bangkok also need to be taken into account.

Notes

1 Retrieved from http://www.adrc.asia/nationinformation.php?NationCode=764&, 7 October 2012

2 The Risk Assessment and Horizon Scanning (RAHS) programme was launched in 2004, as part of the National Security Coordination Secretariat (NSCS) and explores methods and tools that complement scenario planning in anticipating strategic issues with significant possible impact on Singapore. Retrieved from http://app.rahs.gov.sg/public/www/home.aspx

3 These represent scenarios of greenhouse gas emissions as identified by the IPCC (http://www.ipcc.ch/ipccreports/tar/wg1/029.htm). The A1 describes a future world

of rapid economic growth, peaking of global population in mid-century followed by a decline, and rapid introduction of new and efficient technologies. One of the directions of technological change in the A1 scenario is A1FI- a fossil-fuel intensive scenario. "The B1 scenario describes a convergent world with global population that peaks in mid-century and declines similar to A1 but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies."

4 See Arkstorm Scenario, led by the United States Geological Survey (USGS) and hundreds of scientists and experts from many disciplines, which details impacts of a scientifically plausible storm similar to the Great California Storm of 1862 in the modern day. The scenario led to several important scientific advancements and will be used by emergency and resource managers to improve partnerships and emergency preparedness (Arkstorm Movie, 2011).

Correspondence

Sreeja Nair
Lee Kuan Yew School of Public Policy,
National University of Singapore
469 C Bukit Timah Road
Oei Tiong Ham Building, Singapore 259772
Email: sreeja.nair01@nus.edu.sg

References

Alverson, K. (2012). Vulnerability, impacts, and adaptation to sea level rise: Taking an ecosystem-based approach. *Oceanography, 25*(3), 231–235.

Arkstorm Movie. (2011). Retrieved on October 5, 2012, from http://www.youtube.com/watch?v=8P-N-HA9iS8

Bengston, D. N., Kubik, G. H., and Bishop, P. C. (2012). Strengthening environmental foresight: potential contributions of futures research. *Ecology and Society, 17*(2), 10.

Chareonwongsak, K. and Amornsak, K. (2009). Aligning a Futures Studies into Policy Analysis: A Scenarios Approach. *Lee Kuan Yew School of Public Policy. Working Paper Series Working Paper No.: SPP09-02*. Retrieved on October 28, 2012, from http://www.spp.nus.edu.sg/docs/wp/2009/wp0902.pdf.

Checkland, P. B. (1999). *Systems Thinking, Systems Practice*. Hoboken, NJ: John Wiley.

Choo, C. W. (2003). The Art of Scanning the Environment. In Joseph, V. (Ed.), *Reframing Environmental Scanning, Australian Foresight Institute, Monograph Series 2003 No. 4* (pp. 7-18). Melbourne: Swinburne University.

Conklin, J. (2006). Dialogue mapping: Building shared understanding of wicked problems. Chichester, England; Hoboken, NJ: Wiley.

Da Costa, O., Warnke, P., Cagnin C. and Scapolo F. (2008). The impact of foresight on policy-making: insights from the FORLEARN mutual learning process. *Technology Analysis & Strategic Management, 20*(3), 369-387

Dalpino, C. (2012). Thailand in 2011: High Tides and Political Tensions. *Asian Sur-*

vey, 52(1), 195-201.

Davivongs, V., Yokohari, M. and Hara, Y. (2012). Neglected Canals: Deterioration of Indigenous Irrigation System by Urbanisation in the West Peri-Urban Area of Bangkok Metropolitan Region. *Water, 4*, 12-27.

DEFRA. (2011). Flood risk and insurance: A roadmap to 2013 and beyond. Final report of the flood insurance working group. United Kingdom Department of Environment, Food and Rural Affairs. Retrieved on October 5, 2012, from www.defra.gov.uk/environment/flooding/.

Furuto, A. (2012). "Water City" Proposal / Shma 08 Jun 2012. ArchDaily. Retrieved on October 13, 2014, from http://www.archdaily.com/?p=240595

Geocell Systems. (2012). Introducing the rapid deployment flood wall. Retrieved on October 5, 2012, from http://www.geocellsystems.com/.

Habegger, B. (2010). Strategic foresight in public policy: Reviewing the experiences of the UK, Singapore, and the Netherlands. *Futures, 42*, 49-58.

Hansson, K., M. Danielson, L. Ekenberg. (2008). A framework for evaluation of flood management strategies. *Journal of Environmental Management*, *86*, 465-480.

Holloway, J. (2012). Ayutthaya 3.0: Bold take on flood-defence would restore "Venice of the East" to former glory. Gizmag. Retrieved on October 5, 2012, from http://www.gizmag.com/shma-ayutthaya-water-city/23011/

HSBC Global Research. (2011). Emerging Market Strategist – Funding of New Thailand Plan. Retrieved on September 4, 2012, from https://www.research.hsbc.com/midas/Res/RDV?p=pdf&key=PT6hfYXK83&n=316350.P.

Jha, A., K., Bloch, R. and Lamond, J. (2012). *Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century*. Washington D.C.: The World Bank.

Kessler, S. (2012). 8 new solutions for the world's oldest problem - weather. Retrieved on October 5, 2012, from http://www.fastcompany.com/pics/weather-apps?slide=5#1.

Komori, D., Nakamura, S., Kiguchi, M., Nishijima, A., Yamazaki, D., Suzuki, S., Kawasaki, A., Oki, K. and Oki, T. (2012). Characteristics of the 2011 Chao Phraya River flood in Central Thailand. *Hydrological Research Letters, 6*, 41–46.

Kure, S. and Tebakari, T. (2012). Hydrological impact of regional climate change in the Chao Phraya River Basin, Thailand. *Hydrological Research Letters*, *6,* 53–58.

Kuster, A. (2008). From Control to Management: Changes in Dutch Flood Mitigation, In *Perspectives on Business & Economics - Benelux: Integration and Individuality*, Lehigh University, Martindale Centre, Vol 26, 2008, Retrieved on October 5, 2012, from http://www.lehigh.edu/~incntr/publications/documents/FromControl.pdf.

Lebel, L., Manuta, J. B., and Garden, P. (2011). Institutional traps and vulnerability to changes in climate and flood regimes in Thailand. *Regional Environmental Change, 11*, 45–58.

Manuta, J. B., and Louis L. (2005). Climate change and the risks of flood disasters in Asia: crafting adaptive and just institutions. In Presentation to Human Security and Climate Change: An International Workshop, Oslo, 21–23 June. Retrieved on October 28, 2012, from http://faculty.unlv.edu/wjsmith/smith-test/ClChgAndHumanSecurityJesseM.pdf.

Mims, C. (2012). How the 'Internet of Things' is turning cities into living organisms. Retrieved on October 5, 2012, from http://www.fastcompany.com/biomimicry/how-the-internet-of-things-is-turning-cities-into-organisms.

Nicholls, R. J., P. P. Wong, V. R. Burkett, J. O. Codignotto, J. E. Hay, R. F. McLean, S. Ragoonaden and C. D. Woodroffe. (2007). Coastal systems and low-lying areas. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 315-356). UK: Cambridge University Press.

Panya Consultants. (2009). *Climate Change Impact and Adaptation Study for the Bangkok Metropolitan Region*. Final Report. Bangkok: World Bank.

Phien-wej, N., Giao, P.H. and Nutalaya, P. (2006). Land subsidence in Bangkok, Thailand. *Engineering Geology, 82*, 187– 201.

RIBA and Norwich Union. (2008). *Flood-proof houses for the future: A compendium of design*. Retrieved on October 5, 2012, from http://www.architecture.com/Files/RIBAProfessionalServices/CompetitionsOffice/Resultsbooklets/NorwichUnionFloodProofHouseoftheFuture.pdf.

Sato, N., and M. Yamazaki. (2011). How Generation Next is Rebuilding Japan. Harvard Business Review Blog Network. Retrieved on October 5, 2012, from http://blogs.hbr.org/cs/2011/05/how_generation_next_is_rebuild.html.

Sternberg, S. (2011). Japan crisis showcases social media's muscle. USA Today. Retrieved on October 5, 2012, from http://usatoday30.usatoday.com/tech/news/2011-04-11-japan-social-media_N.htm?csp=34news&utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+usatoday-NewsTopStories+%28News+-+Top+Stories%29&utm_content=Google+International.

Swanson, D. and S. Bhadwal (Eds.). (2009). *Creating Adaptive Policies: A Guide for Policymaking in an Uncertain World*. Thousand Oask, CA: Sage.

The Nation. (2011). Govt: Bt900bn needed. Retrieved on September 4, 2012, from http://www.nationmultimedia.com/national/Govt-needs-Bt900bn-30168866.html.

United Nations Development Programme (UNDP). (2012). *One planet to share: Sustaining human progress in a changing climate.* Asia- Pacific Human Development Report. New Delhi: Routledge.

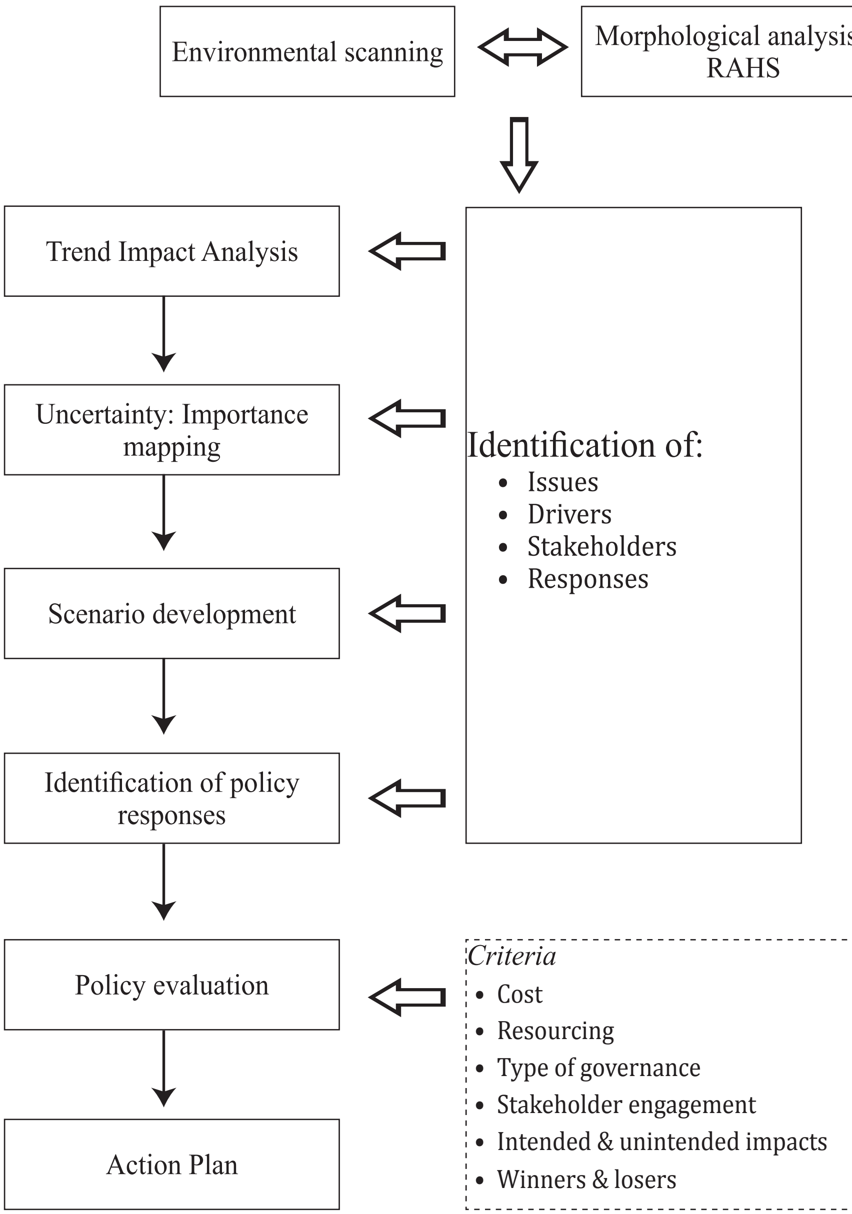
Vimolsiri, P. (2012). *Post-Flood Investment Environment*. In Presentation to the Thailand Office of National Economic and Social Development Board. Retrieved on September 4, 2012.

Vitoolpanyakij, C. (2008). *Coastal cities and adaptation to climate change: Bangkok* *study.* In Presentation to cities at risk: Building adaptive capacity for managing climate change in Asia's Coastal Megacities, START (global change SysTem for Analysis, Research and Training) workshop, Bangkok, Thailand, February 26-28, 2008. Retrieved on October 5, 2012 from http://start.org/download/car-ppt/2-vitoolpanyakij.pdf.

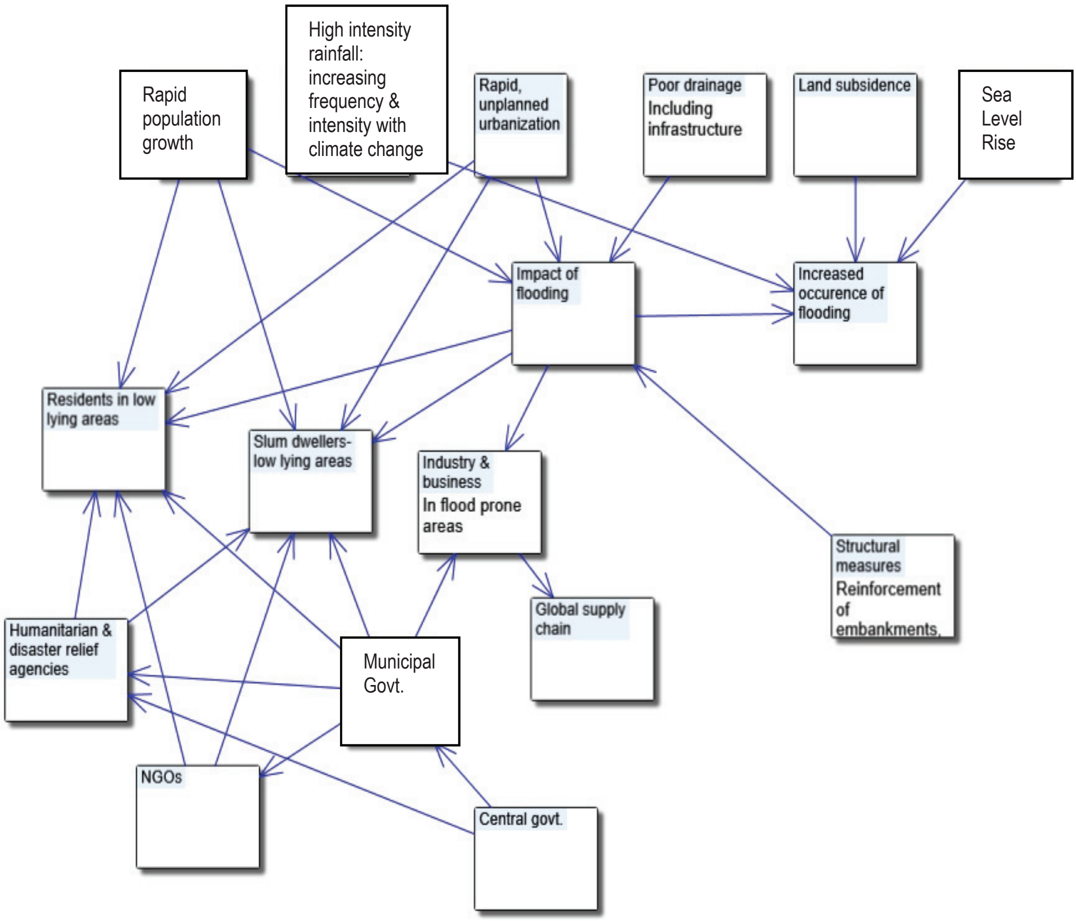
Watts, J. (2011). Thailand seeks flood prevention plan as Bangkok clean-up operation continues. *The Guardian*. 26.12.2011. Retrieved on October 20, 2012, from http://www.guardian.co.uk/world/2011/dec/26/thailand-flood-plan/print.

World Bank. (2010). *Climate risks and adaptation in Asian coastal megacities. A synthesis report*. The World Bank, Washington D.C., pp.97.

Appendix 1
Outline of Methodology

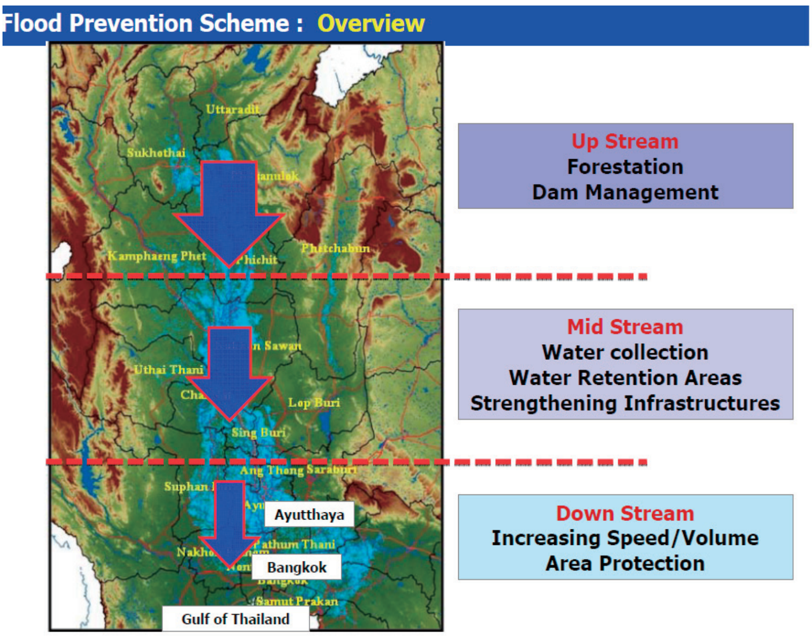


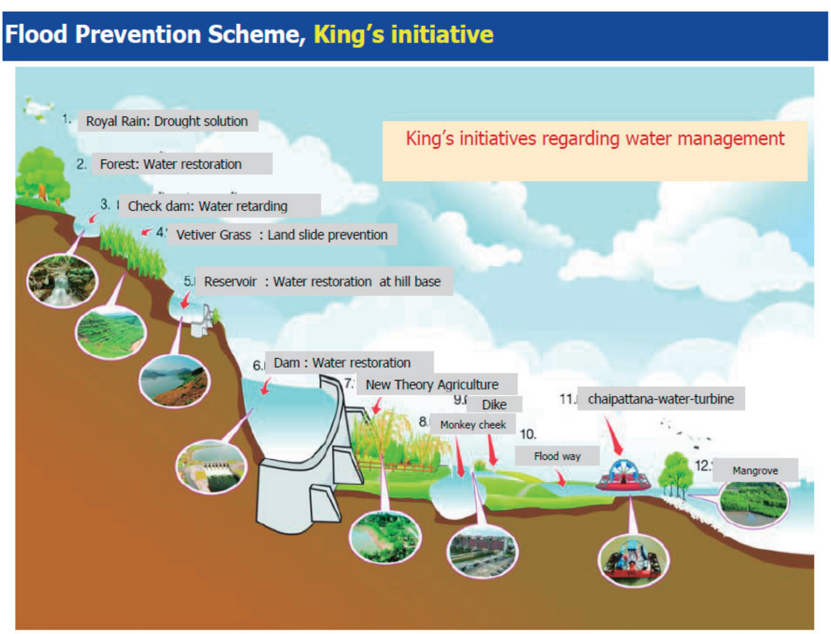
Morphological analysis done in RAHS

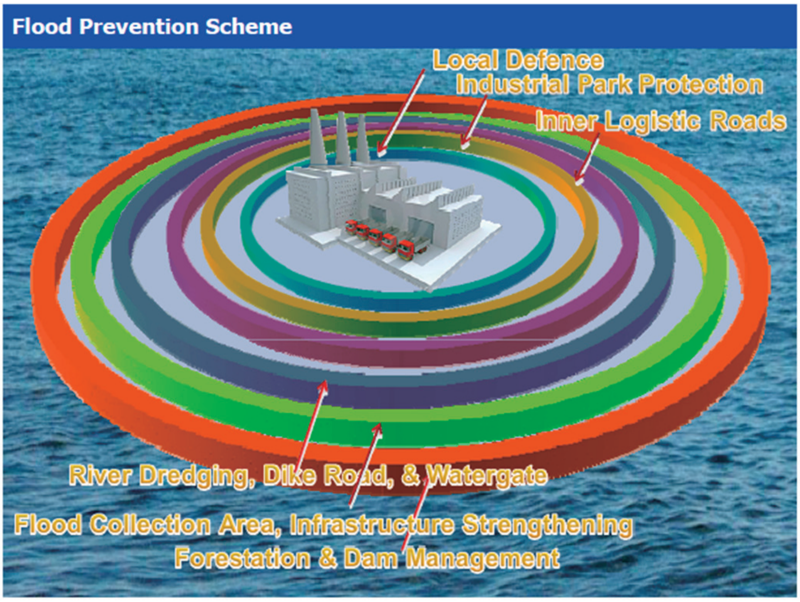


Appendix 2
Current flood responses in Bangkok

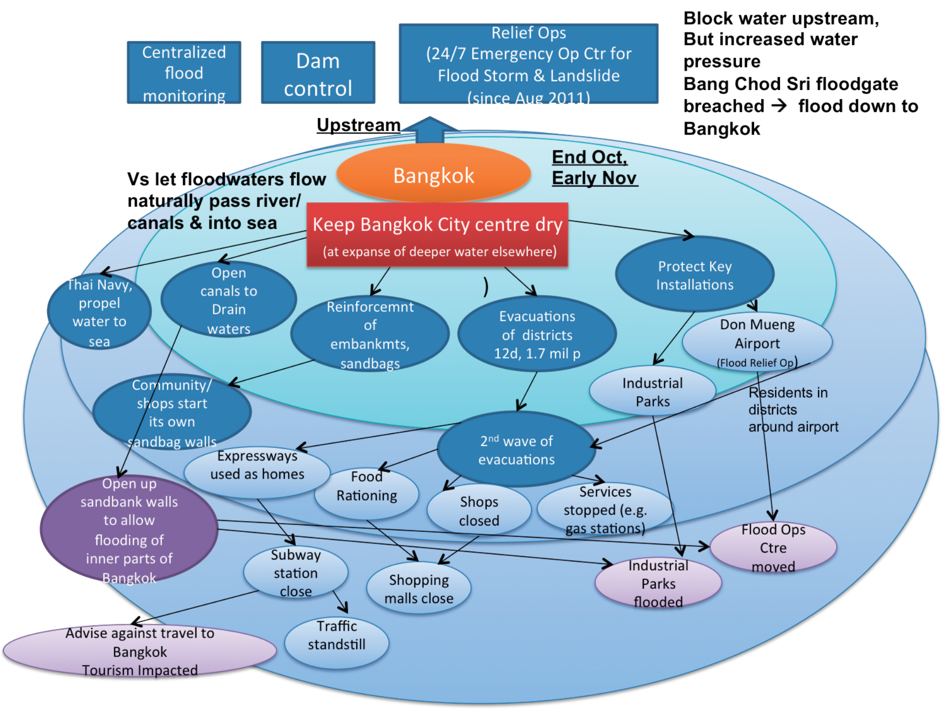
Bangkok Flood Prevention Plan
[Source: Courtesy of Vimolsiri (2012)]







Systems map summarising responses to 2011 floods
[Source: Compiled by authors from environment scans of online articles]



Appendix 3

Responses for the various scenarios

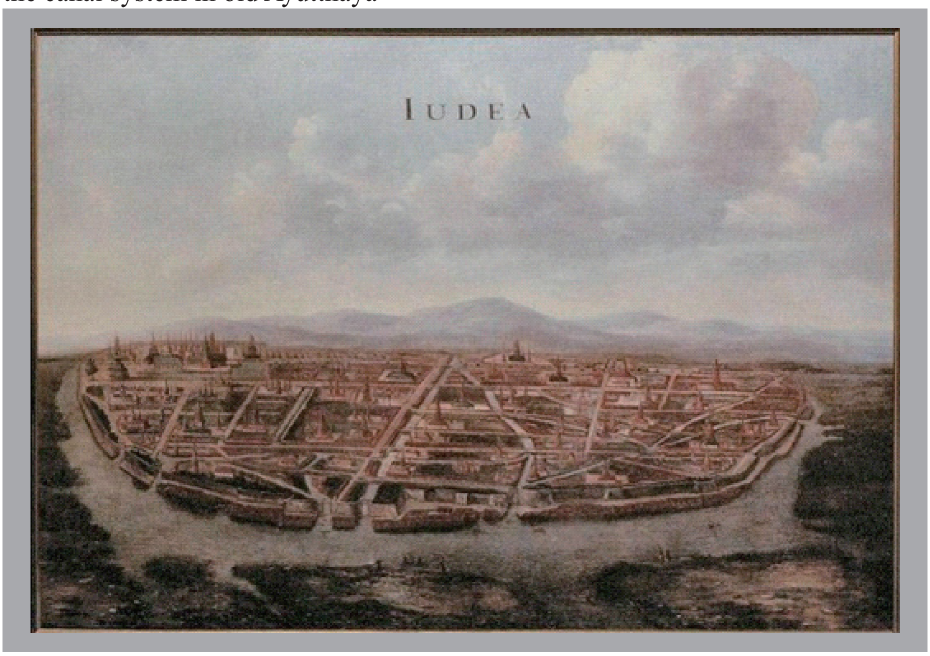
Responses	Baseline Scenario	Scenario A Umbrella	Scenario B Boat	Scenario C Titanic
Afforestation in upstream areas	x	xx	x	xxx
Dikes & Sea walls	x	xx	x	xxx
Flood retention pools	x	xx	x	xxx
Dredging of rivers to increase capacity	x	xx	x	xxx
Increasing drainage capacity/ separation from sewage system	x	xx	x	xxx
Slum at low lying areas to be upgraded and protected from floods	x	xx	x	N.A. (low lying areas may already be submerged)
Temporary flood control structures (demountable flood barriers etc.)			x (in areas where urbanisation constrains permanent structures)	
Flood proofing of individual premise/ house e.g. through raised living quarters, elevated basements, retention pools in premise		x		
Flood proofing of whole communities etc thru alternative raised circulation, e.g. raised walkways.		x		
Building flood shelters			xx	xxx
Temporary relocations of people, business and industries during floods			xx	
Education and raising awareness in community		x	xx	xxx
Capacity building (urban planners, local govt.)		x	xx	xxx
Building volunteer groups to help during floods		x	xx	xxx
Early warning systems, flood forecasting & monitoring systems	x	xx	xxx	xxx
Permanent relocation of key installations				x
Allow part of Bangkok to flood (New approach or urban planning)				x
Revival of previous canal system (New approach for urban planning)				x
Alternate transport methods during floods e.g. amphibious vehicles (New technology)				x
New financing mechanisms (Bonds, insurance)	x Govt. bonds	xx (PPP financing for structural solutions)	x Community funding of community response	xxx (High cost financed through join Insurance)

Note 1: Level of importance of responses denoted by “xxx” for highest and “x” for lowest.

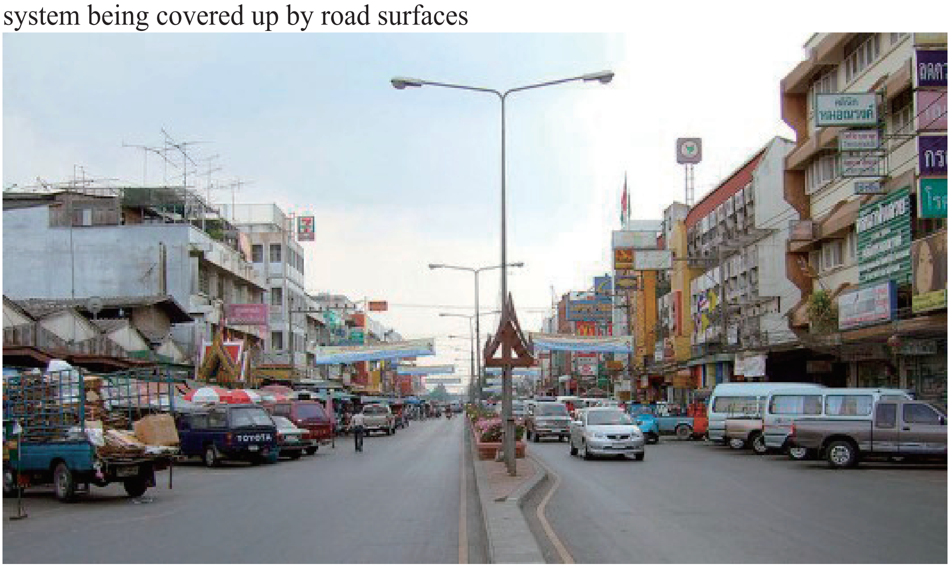
Summary of responses by scenario

Appendix 4
'Venice of the East- Ayutthaya'

[Source: Holloway (2012)]
A painting of Ayutthaya commissioned by the Dutch East India Company: Observe the canal system in old Ayutthaya



[Source: Holloway (2012)]
Modern-day Ayutthaya, built to the east, is distinctly canal-free: Observe the canal system being covered up by road surfaces



Shma's scheme- " Ayutthaya 3.0"

[Source: Images courtesy of http://www.shmadesigns.com/ as cited in Furuto (2012)]

Shma's proposal is to develop a "water detention network" where rainwater during the rainy season could be retained for agriculture use in the other months of the year. This will require a paradigmatic shift from the existing mode of rice cultivation where growing only occurs during the rainy season to a notion of "double-cropped" fields and "floating agriculture" to ensure that these fields and reservoirs are productive all year round. This proposal also blurs the distinction between the industrial and the agricultural land-use, envisaging instead a patchwork of rice fields, water storage infrastructure and settlements. The proposal also suggests the following economic benefits: agricultural waste can become an energy source for the city through biomass or gasification, waste from urbanised areas could be put to use as fertilizer. Ayutthaya can possibly emerge as a centre for agri-tourism, and agri-production with elevated high-speedrail linkages (Holloway, 2012).