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Strategies to harmonize urbanization and flood risk management in delta's[1]

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Abstract

In many countries, major cities are located in flood-prone areas at the confluence of rivers and sea. The expansion of these cities and the expected effects of climate change are increasing the risk of floods. Recent thinking about flood risk management stresses the importance of reserving space for water, restricting city expansions into flood-prone areas and flood-proofing cities. The Dutch flood risk policy is paying more attention to these approaches, but the consequences for the urbanization in the Netherlands have not yet been well explored. Thus it is worthwhile to learn from the experience in other areas that are tackling this problem. In the paper we describe the approaches in a number of "typical" urbanized deltas: Yokohama along the Tsurumi river, New Orleans in the Mississippi delta, the Randstad in the Rhine-Meuse delta, Wuhan along the Yangtze, and Dhaka in the Ganges-Brahmaputra delta. From these cases we identify 3 main strategies to harmonize urbanization and flood risk management: keep floods away from urban areas; prepare urban areas for floods; keep urban areas away from floods. We give examples, requirements and constraints of these strategies and draw some lessons for the Randstad.

Keywords: flood risk management, urbanization, Japan, New Orleans, Randstad, Wuhan, Dhaka

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[1] Study commissioned by the Directorate General of Water Affairs (DGW) of the Dutch Ministry of Transport, Public Works and Water Management (V&W)

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1. Introduction

Like many areas in the world, the economic heartland and major cities of the Netherlands are located in a flood-prone area at the confluence of a large river and the sea. The expansion of these cities (urbanization) and the expected effects of climate change are increasing the risk of floods. A recent near-disaster in the Netherlands has led to a change in flood policy with more attention for spatial measures and the regulation of land use. The consequences of this policy for the urbanization in the Netherlands have not yet been well explored. As the decisions on urban expansion involve large investments and have long-term implications, it is wise to look at the experience of other countries that are confronted with the same problem. This exchange of experience is the core of the project "Urbanized flood-prone delta's".

The project was set up as an exchange of experience between partners working on the interface of water management and spatial and urban planning in flood-prone areas with a high degree of urbanization. Partners were asked to write an essay on the flood problems and the urbanization process in their cases and to describe the strategy to harmonize urbanization and flood risks, and were invited to address other themes, such as the level of dialogue between urban planners and water managers, multiple use of space, the role of aesthetic value, the attitude towards risks, process and policy instruments and financing. The cases and partners participating in the project are listed in Table 1. Two additional cases - Venice Italy and London UK are participating in the project; however their results are not yet in.

In this paper we present summary descriptions of the 5 case studies, based on the essays and the interviews that we conducted during visits to the respective countries. From the case studies we then attempt to identify the main strategies to harmonize urbanization and flood risk management. In the discussion, we raise the issues that appear to be relevant from a Dutch perspective. These issues are the opinion of the authors and do not necessarily reflect the position of DGW or V&W.

Table 1 Cases and partners contributing to the project

Country and city	Author(s)	institute
Japan - Yokohama	Mr. Kazuo Umeda Mr. Hideto Namiki Mr. Masahiko Nagai	Infrastructure Development Institute Tokyo
USA - New Orleans	Mr. Falcolm Hull Mr. Edwin Lyon	US Army Corps of Engineers Mississippi Valley Division, New Orleans
Netherlands - Randstad	Mr. Maarten van der Vlist Mr. Camiel van Drimmelen Mr. Willem Oosterberg	Rijkswaterstaat – RIZA, Department of Water Management and Spatial Planning, Lelystad
China - Wuhan	Mr. Wuqiang Lu Mrs. Ningrui Du	Central China Normal University College of Urban Planning and Environmental Science, Wuhan Wuhan University, School of Urban Studies, Wuhan
Bangladesh - Dhaka	Mr. Rafiqul Islam Mr. Liakath Ali	Program Development Office for Integrated Coastal Zone Management Plan, Dhaka

2. Cases

2.1. Japan – Yokohama

2.1.1. Flood problems

River basins in Japan are small and steep. Rainfall intensities during summer storms and typhoons are very high, causing frequent flash floods and landslides. 80% of Japanese municipalities have experienced instances of floods, waterlogging or landslides in the past 10 years. Per year some 100,000 houses are affected. Urbanization has exacerbated these problems by increasing surface runoff. Due to the restricted size of the river basins, instances of waterlogging generally coincide with instances of high river discharge.

2.1.2. Urbanization

Post-war Japan has experienced a rapid urbanization. At present, 50% of the population lives on 10% of the land surface, most of which is in a lowland ribbon along the coast and the rivers. Spatial planning sets little restraints on the urbanization process. Land ownership is highly dispersed and still reflects the original rice-field lots. Land owners have strong rights in deciding whether to build, and what; expropriation is hardly possible. Thus the cities of Japan are chaotic from a distance, and contrast-rich and multi-functional at close range (Figure 1).

2.1.3. Strategy

The post-war flood policy has mainly focused on decreasing flood probability. The driving force behind this policy was the requirement of rapid urbanization of the lowlands along the coast, to which the flood policy was to a large degree subordinate. Until the '80s the emphasis was on technical measures, in combination with upstream reservoirs. After the '80s, a change in policy has set in. The factors behind this change were the growing contribution of urbanization to the flood problem, the stall in the implementation of planned measures, and a growing public demand for better

Figure 1 Japanese cities: chaotic from a distance; contrast-rich and multi-functional at close range (pictures by Paul Chorus)

protection. This new phase saw the involvement of public players (prefectures, municipalities, sewerage companies) in flood policy. The present policy, while maintaining an emphasis on technical measures, has invested heavily in spatial measures in or near urbanized areas and has put in place a highly sophisticated early-warning system. The policy is moving towards comprehensive river basin flood risk planning. River managers are receiving increasing powers to ensure infiltration in new developments and to obtain land adjacent to rivers for the construction of retention areas; in addition river managers can set rules for the operation of urban drainage with the aim of preventing downstream flooding. Flood hazard maps are being prepared for the most vulnerable river basins. Whereas these elements were introduced in 1980 on a voluntary basis, a law adopted in 2003 makes these elements compulsory for specific watersheds that are designated by the national government. The Tsurumi basin in the greater Tokyo region, with the city of Yokohama, is the first watershed (out of 17 candidates) that has in effect been designated. Thus the flood risk policy is moving not only towards a more comprehensive, but also a more forceful approach.

The Tsurumi basin plays the role of example-case for the changes in Japanese flood policy. The basin has been rapidly urbanized since the 1970's as a bedroom suburban area of Tokyo. It offers some striking examples of retention in combination with intensive forms of land use. A tennis court doubles as a reservoir of excess rainfall; school playgrounds are equipped to flood during heavy rainfall; grass roofs are subsidized; swimming-pool sized basins have been constructed in the middle of residential areas (Figure 2). A necessary prerequisite for this type of measures is the separation of the sewerage system and the rainfall drainage system. The secondary functions, although intensive, are generally forms of recreation. The Tsurumi Retarding Area is a 83 ha retention area designed to accommodate 20% of the design flood discharge of the Tsurumi river. It holds a park, sports fields and a football stadium and is crossed by a highway on pilars. Interesting feature is the fact that the inflow of this retention area cannot be controlled, in order to prevent ad-hoc discussion about the timing of operation.

A comprehensive river basin flood risk plan has been prepared. Interesting feature of this plan is the fact that every part of the basin is assigned a role in flood risk reduction, be it by rainfall infiltration, rainfall retention, river flow retention, or by adjustments to housing and infrastructure.

Figure 2 Tennis court and school playground equipped for water storage during excess rainfall

2.1.4. Dialogue

In the post-war period until 1980, water policy was subordinate to the urbanization process. Urban planners demanded that water managers provided safety by technical means and were not inclined to listen to warnings of low safety levels. The dialogue may have improved, but as of yet is not considered to be good from the viewpoint of water managers. The recent law, which strengthens the position of water managers, may be instrumental in forcing a better dialogue. In contrast, the dialogue between water managers and the local population and interest groups has improved considerably since the '80s.

2.2. New Orleans

2.2.1. Flood problems

New Orleans developed at the point where the southern bank of Lake Pontchartrain and the Mississippi river practically meet (Figure 3). The area consists of salt- and freshwater marshes, lakes, lagoons and natural river levees. The initial city expanded from the elevated natural levee along the river, into the surrounding marshes. Major parts of the city (Orleans parish; Jefferson parish) are in the depression between river and lake and at or under sea level. The city is confronted with the risk of river floods, hurricane-associated storm surges into Lake Pontchartrain, and waterlogging.

Figure 3 New Orleans in the Mississippi Delta. Lake Pontchartrain is to the north of the city.

2.2.2. Urbanization

At present it is very difficult to further expand the city due to the strong protective status of the surrounding wetlands. What development does take place is on higher ground on the northern shore of Lake Pontchartrain, an area which is connected with the city center via 2 bridges across the lake. This development is not driven by flood risks but rather by the availability of a good connection and social problems in the city center. The population of New Orleans (Orleans Parish and Jefferson Parish) is 1.0 million and has been stable over the past 20 years. The city is spaceous and population density is low (13 persons/ ha).

2.2.3. Strategy

River floods

The risk of river floods appears to be well under control. A disastrous flood in 1927 (the largest since monitoring started 200 years ago) set the start for the Mississippi River and Tributaries project that continues until today. The project consists of a combination of measures, the most important of which are the dykes along the river, dredging, and a number of floodways and spillways that divert part of the river water at extreme discharges. (Figure 4). All of these measures have been completed. The river can now safely handle a flood of a magnitude above the 1927 flood (approximately a 1:500 year event).

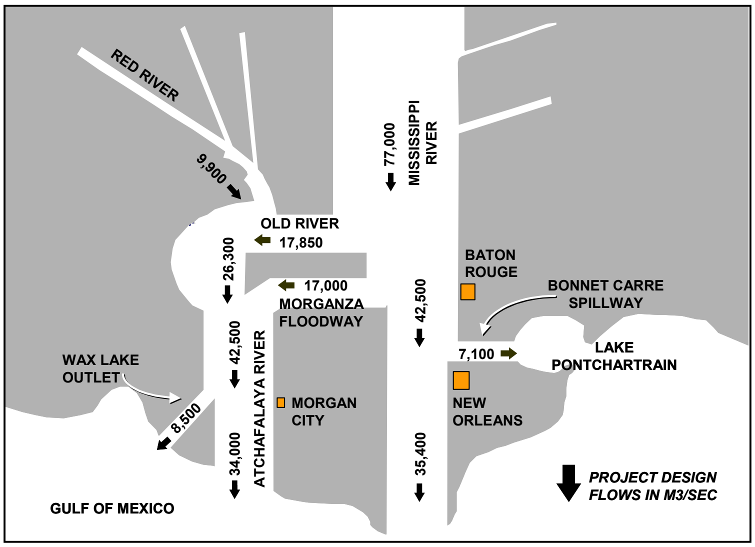

Figure 4 System of floodways and spillways upstream of New Orleans

Waterlogging

The problem of waterlogging of the city is tackled by an extensive drainage system and a large pump capacity (2200 m3/s for Orleans and Jefferson Parish). The development of this system has been disaster-driven to a large extent; instances of serious waterlogging saw the addition of new pumps beside the old ones. The system is capable of handling a 1:10 year rainfall event (300 mm in 1 day), and considerably decreases the damage from more extreme events. The system has very little storage; there are no lakes in the city, the canals are concrete-lined and dyked and do not have floodplains. An element of storage that is being introduced, is the profiling of roads in a way that can hold a certain level of water before drainage to the system starts. Wider roads are often constructed with a higher middle portion where cars can park during excess rainfall.

Storm surges

The 1965 hurricane Betsy put the risk of storm surges on the agenda. At present, this risk is considered to be much larger than the risks of river floods or waterlogging. The projects that were triggered by the 1965 hurricane focus on the raising of levees, wetland protection and efficient evacuation; the option to close off Lake Pontchartrain with a storm surge barrier is under consideration. Authorities are optimising the process of evacuation, by preparing the highway to serve as a 1-way lane; ensuring all-weather operability of bottlenecks such as bridges and tunnels and avoiding repairs to roads during the hurricane season. In September 2004, when hurricane Ivan approached the city, the major of New Orleans advised a general evacuation. Approximately 1 million people in the area did leave and were part of a slowly moving traffic flow out of the area for 10 - 20 hours. When the hurricane landed without causing damage to the city, people returned home and business continued as normal. This near-miss appears not to have induced policy changes or additional funding.

Wetlands south and east of the city act as barriers against the force of hurricanes and storm surges, but are slowly disappearing due to erosion and subsidence. The erosion is caused in part by the decreased sediment input from the leveed river and the dredging of canals in the wetlands. Thus, there are linkages between the policy for hurricane-related floods on the one hand, and the policies for river flood management, nature protection and navigation on the other.

The role of flood insurance

Flood insurance is an important element of flood policy in the United States. The National Flood Insurance Program (NFIP) was introduced in 1968 and offers flood insurance to all at reasonable costs (FEMA 2002). In return, the program sets certain requirements on municipalities and on property owners. Municipalities must adopt a strategy for floodplain management and must enforce that the lowest floor of new buildings is above the 1:100 year flood level (the Base Flood Elevation or BFE). The area subject to 1:100 floods and the corresponding levels are indicated on maps that are provided by NFIP. The possibility of flood insurance is only provided to inhabitants of municipalities that comply. For many municipalities, the NFIP has been the first exposure to land use planning. Flood insurance is provided for all existing property, also if this is located below BFE. However, property that is rebuilt after serious flood damage must be (re)built above BFE. NFIP subsidizes the cost of elevation. Flood insurance is available to all property owners, but is a legal requirement in order to obtain a mortgage in areas subject to 1:100 floods.

At present, approximately 50% of the households in New Orleans have flood insurance. The average cost is $ 500 per year. For the inhabitants of the city, the insurance is a financial safety-net that reduces the perceived risk of waterlogging, hurricane floods and river floods. Without this insurance, the city could lose part of its attraction.

The NFIP could be a strong driver to slowly lift the city of New Orleans. New property in the city is now generally built on an elevated basis, a return to the practice that was common until the mid 20th century. However, NFIP does not prescribe how the BFE criterium is met, and will accept if this is attained by raising dykes or installing more pumps.

2.2.4. Dialogue

In the past, there were many missed opportunities for finding optimum solutions to flood problems because dialogue between planners and managers occurred too late in the process. Major interactions only took place when a plan reached the stage of obtaining permits. At this stage, usually only minor modifications could be made to the plan without adversely affecting the owner's major investments. A trend toward taking a collaborative approach where planners, managers, and stakeholders work together in the conceptual stages of a project, is growing. Federal, state, and local levels realize that solving large complex flood problems is beyond the scope and the technical and financial capability of any single agency.

2.3. Randstad

2.3.1. Flood problems

The case focuses on the western low-lying and most urbanized part of the Netherlands (Holland). This area consists of a central area of reclaimed wetlands (polders), with a barrier of sand dunes along the coast and a sand plateau to the east, and is intersected by (branches of) the rivers Rhine and Meuse. The area faces the risks of sea floods by storm surges, river floods, and waterlogging due to excess rainfall. Legally prescribed protection levels from sea floods (1:4000 - 1:10,000 years) and river floods (1:1000 years) are very high. Rainfall is not high (800 mm/year) but the polders require active drainage of rainfall surplusses. At present there are no legally prescribed protection levels for waterlogging, but systems are typically designed to meet 1:20 - 1:100 year occurrences. The focus of the case is on river floods and waterlogging.

2.3.2. Urbanization

Historically, the cities of Holland developed on the fringe of the central wetland area with the dune coast to the west and the sand plateau to the east, at strategic locations along rivers or near lakes. The oldest core of these cities developed on relatively flood-free higher ground, but with further urbanization often expanded into surrounding flood risk areas. However, the central area of peat polders (the "Green Heart") remained relatively free of urbanization. At present, the main cities - Amsterdam, The Hague, Rotterdam and Utrecht - practically form a ring around the Green Heart. This conglomerate of cities, referred to as the Randstad ("fringe city"), is the economic heartland of the Netherlands. A major part of the further urbanization in the next decade is planned here (Figure 5).

2.3.3. Strategy

The high level of urbanization of the Randstad area was made possible by an effective flood policy over many centuries. Different phases can be distinguished on the basis of the available technology and organization. Initially, habitation was forced to take a

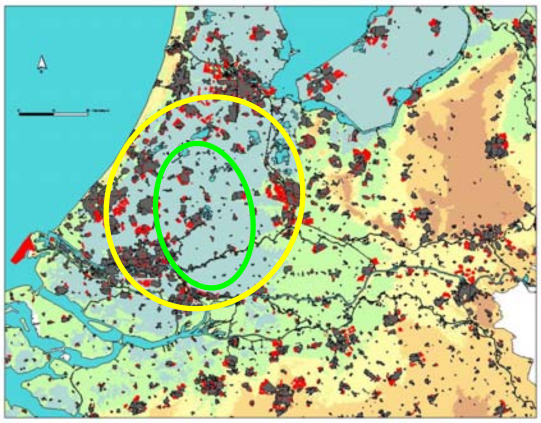

Figure 5 Randstad (yellow circle) and Green Heart (area inside green circle) with present urbanization (black) and planned expansion until 2015 (red). Blue area is below sea level.

defensive attitude, building on higher ground, along natural river levees, along the coast, or on man-made mounds. With the introduction of windmills and later steam pumps, the construction of polders took a large flight. With the advent of modern technology the importance of water in spatial decisions decreased even further. Rivers were restrained by dykes; dams and dykes were constructed to protect against sea floods to a high standard of safety; drainage systems and pumps were designed to prevent waterlogging and high groundwater levels in the polders, thus practically eliminating the constraints for the urbanization of areas that originally had a high flood risk. Floods and waterlogging all but ceased to be an issue in land use planning and urbanization. The Green Heart was protected from urbanization; however the motives were the preservation of landscape, nature and agriculture, rather than the risks of floods and waterlogging.

This period may have ended with the occurrence of 2 instances of near-floods of the rivers Rhine and Meuse (1993 and 1995), together with the occurrence in the same years of instances of extensive waterlogging of polder areas. These instances triggered a fundamental change in the Dutch policy with regards river floods and waterlogging. The main elements of this new policy are described below.

River floods

The manager of the major rivers (Rijkswaterstaat) must plan for an increase in peak river discharges, taking the effects of climate change into consideration. The aim is to accommodate this increase with spatial measures - the removal of obstacles from the floodplains, the laying back of dykes, the creation of retention areas, the creation of secondary channels to circumvent urban bottlenecks. The heightening of dykes should only be considered as a last option. The set of measures for the adjustment of the river system has recently been accepted by the national government in principle, and now enters the phase of legally prescribed public consultation and design.

Waterlogging

The water managers of the polder areas (the water boards) must appraise that their water systems are in order, taking account of the expected increase in rainshower intensity due to climate change, as well as increases due to planned urbanization. Measures to accommodate the increase in excess water must be selected foremost by retaining water (eg. extra infiltration), then by storing water (eg. flood meadows) and can only consider additional pumping as a last resort.

The water boards must translate the results of this exercise into spatial claims. The provinces decide whether these spatial claims are incorporated into the provincial spatial plans. The claims that are laid down in the provincial spatial plans, must be then incorporated into the legally binding municipal zoning plans. This process must be completed by 2009. Likewise, urbanized municipalities at risk of waterlogging must find spatial solutions for the increase in excess water resulting from climate change and further urbanization, and propose solutions in the prescribed order of retaining water, then storing water and finally discharging it to the surroundings.

New development plans - at the level of provinces or municipalities or individual housing projects - require a Water Assessment. In this Water Assessment, the initiators of the plan (generally the municipality) must consult the water manager (generally the water board) at the inception stage, and attempt to accommodate the demands and comments of the water manager. The water manager has the opportunity to express his opinion on the final plan in a specific water paragraph. However, formal decision power about urbanization plans and projects remains with the municipalities and provinces.

The success of this new policy will become evident in the coming years. As stated in the introduction, the consequences for the urbanization of Holland have not yet been well explored. It is in the regional arena, the arena of provinces, municipalities and waterboards that the consequences of the new policy will be felt the most.
Small-scale solutions in line with the new policy are appearing in some municipalities. Over the board, it appears that solutions for individual houses in new developments are relatively easy to implement. However, water managers still have little say in decisions as to the location of new developments, or the reconstruction of existing urban areas.

2.3.4. Dialogue

Until recently, water managers and urban planners had little need of each other in order to do their work properly. Water and space were separated and both professional groups could develop within their own domains. Water managers did not concern themselves with locating urban areas. If at all, the dialogue occurred very late in the process and was concerned with "nuts and bolts" - the dimensions of a sewer system or the construction of a drainage system. Spatial planners and water managers hold strong opinions of each other. Spatial planners tend to see water managers as a closed group of male analytically minded experts, far removed from politics and social dynamics. Water managers tend to see spatial planners as fashionable, dominant and impatient dreamers, process-oriented and close to political decisionmaking. As a consequence of the new flood policy, and specifically the obligatory Water Assessment, a dialogue must develop, with more clout for the water manages vis-à-vis the spatial planners.

2.4. Wuhan

2.4.1. Flood problems

Wuhan, is located at the confluence of the Han and Yangtze river, some 1000 km upstream from the coast. The city is located on a large and low-lying alluvial plain and is confronted with comparable flood problems as cities in delta's. The area contains a large number of lakes and wetlands, and has always been very vulnerable for river floods. In the last 50 years, extensive reclamation of the lakes and marshes upstream of Wuhan for agriculture has considerably reduced the natural retention capacity; and strengthening of dykes has magnified downstream problemens. Floods of the rural areas upstream of Wuhan are very frequent.The city itself was flooded in 1931 and experienced near-floods in 1954 and 1998.

Extensive waterlogging of the city occurred in 1998 and 2004; some waterlogging of low-lying parts of the city occurs nearly every year.

2.4.2. Urbanization

After Shanghai and Beijing, Wuhan is the third largest city in China. At present it is experiencing a rapid economic and population growth. The city itself has expanded from 190 km2 in 1990 to 340 km2 in 2004. The present population of the city itself is approximately 4 million, and is expected to increase to 5 million over an area of 430 km2 by 2020. Due to its population size and economic dynamism, the position of the municipality is strong and is in direct contact with the national level, bypassing the provincial level of Hubei to a large extent.

2.4.3. Strategy

River floods

Traditionally, flood prevention relied on a system of dykes, and a large natural retention capacity in the form of lakes and wetlands. Following the 1954 near-flood of the city, an ambitious policy of spatial measures along the Yangtze river was imposed by the national level, leading to the construction of a large number of retention areas upstream and around Wuhan (Figure 6). However, due to the high demand for agricultural and residential land, the retention areas now harbour millions of people and operation for flood prevention has become all but impossible. During the last major flood of the Yangtze (1998) the city of Wuhan was close to flooding, and upstream polders adjacent to the retention areas did indeed flood by spontaneous or deliberate dyke breaks. However, the retention areas themselves appear not have been put into operation.

As a consequence of the 1998 flood, the Chinese Central Government is investing in the improvement and strengthening of dykes, and the relocation of people out of floodplains and retention areas. In addition, the Three Gorges Dam is expected to contribute considerably to the reduction of flood probability. There is good progress with the implementation of the technical measures. As an example, a new river dyke and river front in the centre of the city was constructed at high speed. The result is an attractive, 500 m wide river front that holds parks, sports utilities, discotheques and restaurants. However, progress in the relocation of people from the floodplains and retention areas is very difficult, as there is no unoccupied space to relocate them to. A solution is being sought in permitting farming to continue in these areas, while creating secure locations where farmers can retreat in emergency situations.

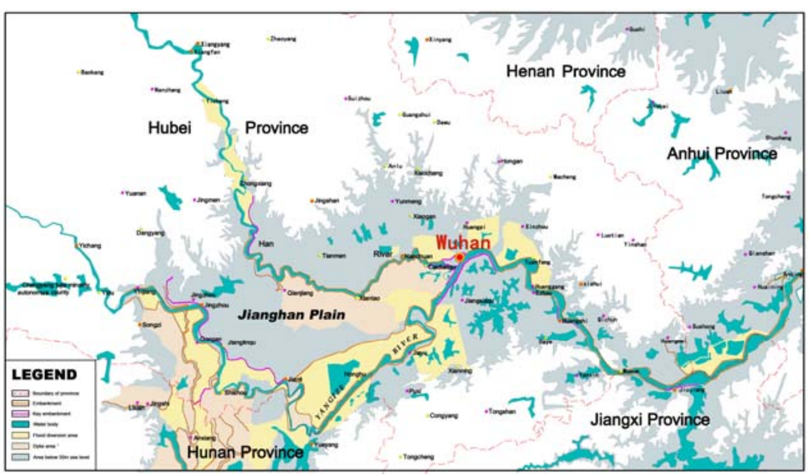

Figure 6 City of Wuhan, alluvial plain (grey) with lakes, retention areas (yellow) and polders (pink).

Waterlogging

Wuhan is known as the city of the 100 lakes, many of which are now encircled by the city (Figure 7 left). The originally open connections of these shallow lakes with the river are now controlled by sluices. In the past half century, many of the smaller lakes have disappeared due to siltation or infilling for agriculture and urban development. However, at present the maintenance of the remaining lakes and lake borders is vigorously enforced, motivated by reasons of landscape quality and recreation. Roads constructed into lakes have been removed. Whether the lakes play an important role in the mitigation of waterlogging, is not clear. It appears that the larger part of the sewage and urban drainage has been de-coupled from the lakes in order to prevent water quality problems, and is discharged by free-flow and pumps to the river system.

Figure 7 Center of Wuhan with lakes and green zones (left) and sketch of plan for city expansion (right)

Traditionallly there is a strong spatial planning system in place that protects the lakes and green zones in the present urbanized area. There are plans to connect and flush the lakes more intensively with river water, in order to improve water quality. Future growth of the city is projected outside a green zone around the present urbanized area (Figure 7 right). This green zone includes retention areas around the city; however, some of these are already developed with high-rises and industrial areas .

2.4.4. Dialogue

On a policy level, there is a good dialogue between spatial planners and water managers. In the new spatial plan for the city, considerable attention is given to the large-scale structure of the expanding city in relation with the conservation and inter-weaving of green areas and lakes. Flood risk management is an explicit element in the development of this plan, and water managers are consulted in the planning process. The attractive new river front of Wuhan is a successful example of the combination of flood prevention and urban design.

2.5. Dhaka

2.5.1. Flood problems

The southern part of Bangladesh is a delta formed by the alluvial deposits of the Ganges and Brahmaputra rivers. Historical Dhaka is located on the southernmost point at which topography renders it relatively flood-free. The city is located on an area of slight elevations intersected by natural channels that drain towards the rivers surrounding the city (Figure 8). Outside the city, are extensive areas of fertile floodplains and wetlands that are used for rice production.

The city suffers from frequent river (near) floods and waterlogging. An exceptionally large river flood in 1988 swamped most of the city for approximately 1 month. It was the trigger for the total embankment of the city. With this embankment, the problem of river floods has receded, but still affect the surroundings of the embanked city on a yearly basis and cause considerable material and personal damage in the slum areas that are developing outside the embankment.

The embankment of the city has increased the problem of waterlogging during torrential rains. Waterlogging is a yearly problem, and was exceptionally serious in 1998 and 2004, leaving large parts of the city waterlogged for more than a month.

2.5.2. Urbanization

Dhaka is a city with a very high population growth. Whereas the population in 1960 was 1 million, it now stands at 12 million and is expected to increase to 23 million by 2015. A large part of this growth is caused by migration from rural areas. At present 30% of the city population are below the poverty level and live in slum areas. At such high growth rates, and given the uncontrollability of slum development, urbanization is to a large degree unplanned.

2.5.3. Strategy

River floods

The main elements in the strategy to reduce river flood risk are the embankment of the city, the prevention of development of river floodplains surrounding the city, and a well developed early-warning system. On many stretches, the embankment forms a sharp boundary between the city and the countryside of paddy fields. The fact that the area outside the embankment does indeed flood every few years, is a strong impediment for development. Once a certain level of safety is provided by embankment, it is all but impossible to prevent a process of rapid and spontaneous urbanization. A case in point is the "fate" of an area to the south of central Dhaka. This area of some 60 km2 was embanked in 1968 with the aim of irrigated rice production, but has since then been rapidly urbanized and at present has all but lost its original function.

Waterlogging

The embankment of Dhaka transformed the "natural" question of the internal drainage of the city into a management problem. The policy consists of maintaining the original system of natural canals inside the embanked city intact (Figure 8), and draining excess water via sluices and pumps to the surrounding rivers. However, the urbanization pressure has led to a continuous encroachment on the natural canals and the remaining agricultural plots within the embankment.

Inside the embanked city, and also in the immediate surroundings, smaller and larger mounds are being built by accumulating clay and silt. These mounds serve as relatively safe bases for the construction of houses and high-rise buildings. As a consequence, the storage capacity and the drainage capacity within the embanked city has decreased. Whereas the legal basis exists for the protection of the natural canals, the juridical delineation of these canals has not been ensured and the enforcement of their status is not systematic. Poor coordination between local authorities responsible for water management, sewerage and road construction add to the problem.

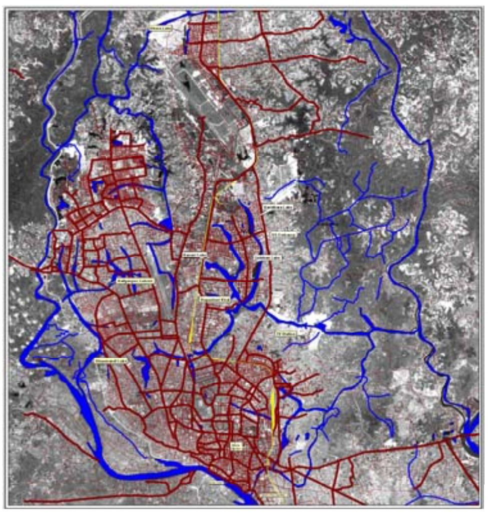

Figure 8 Network of natural drainage channels and rivers (blue) in and around Dhaka. Present city is in left half of picture (main roads are in red).

Alternative strategies for future expansion

The rapid population growth of the city forces authorities to select new areas for urbanization, most of which at present are flood-prone. Thus, providing safety is a strategic decision in the future development of the city. In part, this decision is being forced by the development of new slums to the east of Dhaka, at the "unsafe" side of the present embankment. In response to the flood of 2004, the discussion has gained momentum. At the political level, the preference has been stated for the embankment of the area to the east of present Dhaka (Dhaka East). For the financing of project costs an appeal is made to international donors, who thus acquire a say in the matter. Central issue is the question whether the negative consequences of embankment of Dhaka can be avoided in Dhaka East. Other issues are the reduction of water flushing and deterioration of water quality in an embanked urban area, and the benefit of the embankment as a ring road around the city. Some local water experts and authorities express their doubt and propose an alternative strategy: the creation of large mounds to serve as a safe basis for urbanization, while maintaining the natural drainage system intact (Figure 9). A third option is the development of satellite cities on the higher grounds north of Dhaka. This option has the attractions of offering a natural solution to the flood risk problem, as well as preventing the daunting prospect of an uninterrupted city of 23 million inhabitants. In this option, the provision of good infrastructure links with central Dhaka is probably a crucial element. It is uncertain whether the migrants from the countryside will be tempted to choose for the satellite cities, rather than the proximity of the city center where they attempt to earn a living in the informal sector.

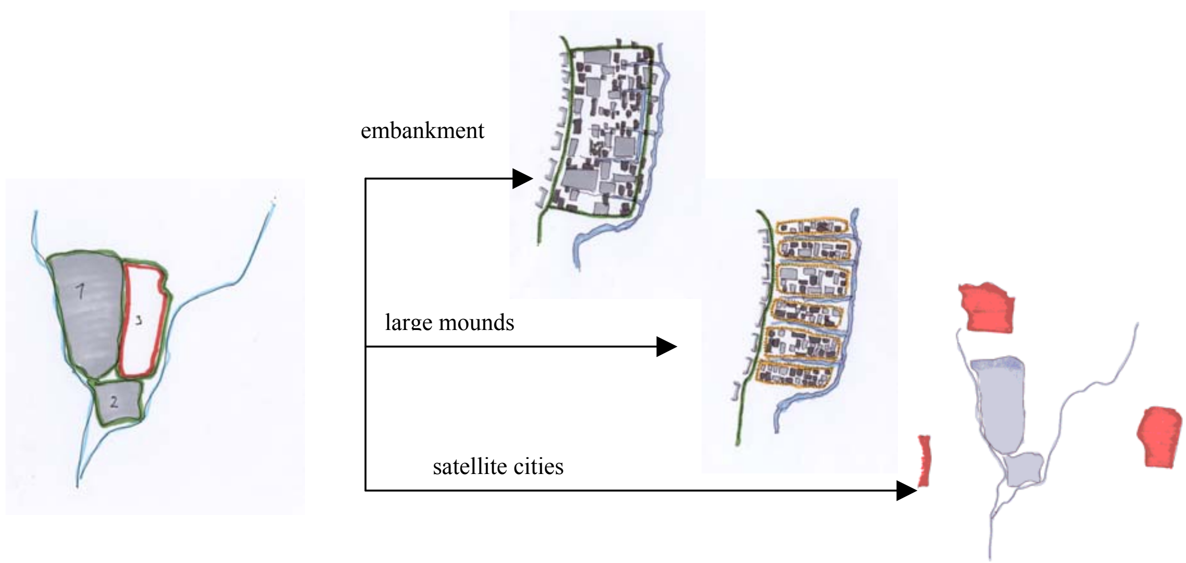

Figure 9 Alternative strategies for the urban expansion of Dhaka

2.5.4. *Dialogue*

In Dhaka the problems of urbanization and flood prevention are closely interlinked. Water managers and urban planners are aware that flood risk reduction is the main driver of spontaneous urbanization, and the question where and how Dhaka should expand is to a large degree synonymous with the question where and how safety from floods is provided. Water managers have expertise of and vision on the interrelationship between flood risk strategies and urbanization processes. The dialogue with urban planners is improving, often triggered by actual flood emergencies. However, from the side of water managers the level of this dialogue is still considered to be insufficient. A complaint is the absence of expertise on water management with the urban planners. In addition, urban planning is in close proximity of political power, and therefore not easily approached.

3. Strategies

In this chapter we attempt to find the main strategies to harmonize urbanization and flood risk management that are apparent in the case studies (3.1). We describe these strategies on the basis of examples from the case studies and explore some of the pre-requisites and consequences (3.2). In the discussion we evaluate the classification and draw lessons that the Randstad can learn from the strategies in the other cases (3.3.).

3.1. Classification

With the recent priority of floods on the political agenda, a growing number of reports and articles pay attention to the classification of measures for flood risk management (Petry 2002, Kron 2002, Van Alphen & Van Beek 2005, ICPR 2002, IRMA-SPONGE 2001, EU 2004). These schemes often contain the same elements, and gradually a consensus is developing about the best classification.

Many schemes are based on a risk approach, in which

flood risk = flood probability * potential damage

Measures to reduce flood risk are then assigned as reducing flood probability (often denoted as "structural measures") or reducing potential damage ("non-structural measures").

Reinsurance companies, who play an important role in the discussion of flood risk management, tend to use a risk approach with three factors (eg. Kron 2002):

flood risk = hazard * exposure * vulnerability

with

hazard = flood probability

exposure = capital and population in flood risk areas

vulnerability = unpreparedness for a disaster and its consequences

These three factors can then be "inverted" into three main strategies for flood risk management (Kron 2002, Petry 2002, Van Alphen 2005):

hazard reduction = "keep the floods away from the people"

exposure reduction = "keep the people away from the floods"

vulnerability reduction = "accept floods and clean up afterwards"

which we have renamed to:

"keep floods away from urban areas"

"keep urban areas away from floods"

"prepare urban areas for floods"

We have used these three strategies as the basis for the classification. We ranked the measures in these strategies in ascending order of the level of constraints to the urbanization process. We then scored the cases on the extent of application of the measures on a 4-point scale. As a last step we added what we saw as the main institutional requirements for success of the strategies, and the main instruments[3] that facilitate implementation. The result is in Table 2.

3.2. <u>Description of strategies</u>

3.2.1. Keep floods away from urban areas

This strategy is the backbone of flood risk management in all cases.

[3] We distinguish between measures and instruments. Measures are tangible elements of a flood risk strategy ("the dyke", "the house on poles", "the evacuating citizen") and instruments are governance tools to achieve these measures ("the plan", "the law", "the information").

Technical measures are prominent, as can be expected. River floods are reduced by dykes, spillways and dredging; waterlogging is reduced by an adequate drainage systems and pumps. Technical measures set little constraints on urbanization, except for the area where the measures are taken - in the case of Wuhan, for example, the riverfront development required the removal of existing houses.
It is interesting to note that *spatial measures* are also quite common. Examples for river floods are the bypass of the Mississippi River upstream of New Orleans; the retention area along the Tsurumi river in Yokohama; the planned lay-back of dykes along the Rhine branches in the Randstad; the large retention areas along the Yangtze river upstream of Wuhan. Examples for waterlogging are the multifunctional tennis courts and school playgrounds, the infiltration areas, protected rice paddies and scattered retention ponds in the Tsurumi basin; the profiling of roads in New Orleans; the spatial claims for water retention and storage in the polder areas of the Randstad; the protected status of the lakes in Wuhan; and the maintenance of the natural canals inside the embanked city of Dhaka. Not all spatial measures are successful. In the case of Yokohama, the scattered retention ponds required protecting legislation in order to prevent their gradual disappearance. In the case of Wuhan, the retention areas are inhabited by millions of people and can be considered to be at least partly dysfunctional. Also in the case of Dhaka, the natural canals are succumbing to the urbanization pressure. The lesson drawn from these failures appears to be that spatial measures in or near urbanized areas must be safeguarded by strong enforcement, in order to keep them operative.

The strategy calls for a strong water management organisation, with a clear mandate, secure financing and powers to let the interest of flood risk management prevail over other land uses in crucial zones such as floodplains and depressions.

3.2.2. Prepare urban areas for floods

This strategy takes the view that urbanization of flood risk areas can proceed if people take precautions and make adjustments to their houses. It makes an appeal to individual and local responsibility and relies on the provision of information.

Early warning and emergency response has not been the focus of the project. However, it clearly plays an important role in all cases. Japan and Dhaka have good early warning systems to which people respond, thus decreasing damage and loss of life. In Japan evacuation schemes for subways and underground malls are in operation. In the Netherlands early warning and evacuation is well developed for river floods (although seldom put into practice) but is less developed for storm surges and waterlogging. In Wuhan thousands of people are mobilized to protect dykes at high river levels. In New Orleans, evacuation during hurricane warnings is well prepared; essential evacuation routes have been established and have an additional safety margin against floods. Apart from adjustments to subways or evacuation routes, these measures set no hard constraints to urbanization. However, the communication of flood risks depresses the demand of houses in flood risk areas, which in itself is an intended effect.

We found relatively few examples of *adjustments to individual houses and infrastructure* in the cases. Most prominent is Dhaka where the construction of mounds and slum houses on poles are common. In New Orleans the ground floor levels of new houses are often raised, and roads are profiled to allow flood-free parking of cars during heavy rainfall. In the Randstad many designs exist for adjustments to houses and greenhouses, some of which have been implemented.

We did not find examples in which the occasional flooding of a city was seen as a benefit, with the exception of Dhaka where floods serve to flush the natural drainage system.

The strategy calls for the public acceptance of occasional flooding of their property, the willingness of all parties to prepare for these occasions, and the discipline of all parties when floods occur.

Flood risk maps and flood insurance are logical instruments in this strategy. *Flood risk maps* can serve a number of functions: it can influence local planners in their decisions for new developments; form the basis for the regulation of adjustments to houses in flood risk zones, inform the public on the flood risks of the property they intend to buy, inform the public on the evacuation routes in case of floods; or serve as the basis for the provision of flood insurance. Flood risk maps play a role in Japan and New Orleans. In

Japan, flood risk mapping has recently been made a priority. At present, the most important function appears to be the information to the public on emergency routes; however, it is expected that the maps will also play a role in the planning of future developments. In New Orleans, the most important function of the flood risk maps is the provision of flood insurance.

In the cases in this study, *flood insurance* is available in New Orleans and Japan. In New Orleans, the insurer requires that the base of new developments is above the 1:100 flood level, which is a driving force for adjustments to new housing. However, the insurer is also content if the 1:100 flood level is achieved by dykes and pumps. Thus, the effect of flood insurance is mixed; it stimulates adjustments to individual houses, but also motivates citizens to pressure authorities to invest in technical measures to reduce flood probability. The terms for insurance in Japan have not been studied.

The above elements often come in a package. Local regulations for adjustments to individual houses are generally based on flood risk maps. Insurers are instrumental in demanding these adjustments, and use (and often make) the flood risk maps to determine insurability and set their premiums. In the case studies, this package is prominent in New Orleans. The package is also prominent in France, England and Germany.

3.2.3. Keep urban areas away from floods

Strong constraints on urbanization are set when considerations of flood risk influence the choice of *location for urban expansion*, or force the *development of discontinuous satellite cities*. In the cases, there are some examples of this approach, but these examples are at the level of policy formulation or are experiencing difficulties with implementation. In the Randstad, the mandatory dialogue between spatial planners and water managers that is prescribed in the Water Assessment is a recently adopted instrument that could prevent urban expansion into areas prone to waterlogging; however, it has not yet had that effect. In Wuhan, constraints were in place to prevent the urbanization of retention areas around the city, but these constraints appear to have failed. In the case of Dhaka, urban expansion into the floodplains surrounding the city is prohibited, but there is strong pressure to expand the city by embankment of part of these floodplains. The strategy appears to be most successful when alliance is sought with nature, landscape and recreation. In the case of the Randstad and Wuhan, policies are in place to maintain large green belts around the present cities for the purposes of landscape, nature and recreation, which stimulates the formation of satellite cities. These green belts partly coincide with flood-risk areas, thus creating a "coalition between green and blue". However, in these examples, nature and landscape protection are the prime motives for the protected status of the green belts, rather than flood risk reduction. In the case of the Randstad, the green belt is under pressure of gradual urbanization; in the case of Wuhan the green belt policy has been adopted only recently.

At the extreme, a drastic increase in flood risk (f.e. due to climate change or soil subsidence) or a large disaster could lead to *de-urbanization*, that is the abandonment of urbanized area. This conflicts with the self-evident dictum in spatial and urban planning that an urbanized area will remain urbanized forever. In none of the cases, de-urbanization of flood-risk areas takes place or is being considered. Elsewhere, there are examples of de-urbanization in the USA and France, but only on the scale of individual houses and small communities (Pinter 2005).

The strategy calls for a strong position of water managers in discussions on land use and urbanization. In addition, the strategy requires a strong spatial planning system, which may explain that the strategy is not prominent in Japan and New Orleans. In the case of Dhaka, it is not the strong spatial planning system, but the yearly floods that sets the constraint on urbanization of the floodplains surrounding the present city. The examples show that it is difficult to keep an area "empty" indefinitely, when the pressure on land is high. Legally binding spatial plans can be a remedy, but plans can be changed. Floods can impede urbanization, but floods can be prevented.

3.3. Discussion

Classification

The classification is "soft" in the sense that the boundaries between cells in Table 2 are often porous rather than rigid. The distinction between flood probability reduction and potential damage reduction is appealing, but is also problematic as in practice many measures contain elements of both, especially if these measures are taken in areas that are under urbanization pressure. Constructing a retention area, for example, is a measure to reduce flood probability, but it only makes sense if potential damage inside the retention area (f.e. urbanization) is prevented. Likewise, preventing the expansion of a city into a floodplain or setting new houses on poles reduces the potential damage, but also enables the use of this area for flood storage, which reduces flood probability elsewhere. Flood risk maps can play an important role in a strategy to prepare urban areas for floods, but also in a strategy to keep urban areas away from floods. Local responsibility can be placed on a spectrum stretching from the total abandonment of central involvement in the issue, to a delegation of the work but under close scrutiny by the cental level. Early warning and emergency measures are generally implemented under strong central guidance. A system of strong spatial planning can distinguish between areas where urbanization is prevented, and areas where urbanization can proceed under the provision that preparations are made for flood events.

Thus, the main value of the classification scheme in Table 2 is to serve as a basis for reflection on questions such as "are there other strategies that could be applied?", "what would be the consequences?" "which countries have experience with these strategies?". In the next section we address these questions from the perspective of the Randstad.

Lessons for the Randstad

Until recently, the strategy in the Randstad has been to keep floods away from urban areas via technical measures. The recent policy change added spatial measures to the current strategy, and introduced elements of the strategy to keep urban areas away from floods.

The approach of spatial measures is well developed in all cases; sometimes successfully, sometimes less so. However, the approach is valid, and lessons can be learned from the success and failure factors in other countries.

In contrast, the strategy to keep urban areas away from floods is not well developed in the cases. The reason is obvious: the driving forces behind the urbanization process are strong and are difficult to constrain if other solutions to the flood risk problem are viable. The Randstad is pioneering this strategy, to a certain extent together with Wuhan, and to a lesser extent with Dhaka. The Randstad is in a good position to do so due to the strong spatial planning system in the Netherlands, but there is little evidence from the cases that this strategy can succeed, or the conditions for success.

The strategy to prepare urban areas for floods is less developed in the Randstad than in other cases. It is worthwhile to explore the benefits and costs of adopting this strategy. The strategy could be used in addition to the other strategies, for example in the management of small flood events; or it could be seen as an alternative to the strategy to keep urban areas away from floods, if this strategy proves to be unsuccessful in steering urbanization away from flood risk areas.

Whether it is possible to combine all strategies, may depend to a large extent on a clear demarcation of the spheres of application of the individual strategies, and a good communication of these demarcations to the public and local authorities.

4. Literature

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Table 2 Strategies to harmonize urbanization and flood risk management, and extent of application in selected urban areas.

Strategies	Keep floods away from urban areas		Prepare urban areas for floods		Keep urban areas away from floods	
Classic risk approach	Flood probability reduction		Potential damage reduction			
Risk approach of insurers	Hazard reduction		Vulnerability reduction		Exposure reduction	
Measures	Technical measures	Spatial measures	Early warning and emergency measures	Adjustments to individual houses and infrastructure	Location of new city districts; developing satellite cities	De-urbanization
Constraints to urbanization	No constraints	No constraints, except at location of measures, where constraints are strong	No constraints; except adjustments for evacuation	Weak constraints	Strong constraints	
Japan	++	++	++	(+)		
New Orleans	++	+	+	+		
Randstad	++	0	+	(+)	0	
Wuhan	++	++	+		0	
Dhaka	++	+	+	++	0	
Institutional requirements	Strong sectoral water management		Individual and local acceptance and responsibility		Strong spatial planning	
Instruments	Legal mandate Secure financing Expropriation or "priority use"		Information Flood risk maps Flood insurance		Mandatory dialogue of water managers and spatial planners Legally binding spatial plans	

++ applied on a large scale

\+ applied regularly

(+) applied occasionally or partly

0 part of policy or dialogue, but not yet implemented, or difficult to implement