

ISET WORKING PAPER

URBAN DEVELOPMENT AND FLOOD RISK IN VIETNAM: EXPERIENCE IN THREE CITIES

Synthesis of flood case studies and policy issues

December 2016

ISET-INTERNATIONAL

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LIST OF ACRONYMS

ACCCRN	Asian Cities Climate Change Resilience Network
ADB	Asian Development Bank
CCCO	Climate Change Coordination Office
CFSC	Committee for Flood and Storm Control
HUDSIM	Hydrological and Urban Development Simulation Model
ISSET	Institute for Social and Environmental Transition
DoC	Department of Construction
DoNRE	Department of Natural Resources and Environment
PC	People's Committee
VIUP	Vietnam Institute for Urban and Rural Planning

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BACKGROUND – URBAN DEVELOPMENT AND FLOOD RISK IN VIETNAM

Urbanization is accelerating in Vietnam, which had one of the highest growth rates in urban population in East Asia between 2000 and 2010. During this decade, the percentage of the country's population living in cities increased from 19% to 26%. The urban population growth rate of approximately 4.1%/year is expected to continue for the foreseeable future, as the country's economic structure continues to shift towards manufacturing and service industries (World Bank, 2015). In 2013, there were 770 officially designated urban areas in Vietnam (MOC, 2014). By the end of 2015, 20 new urban areas had been added for a total of 790 (Tran, 2016). Vietnam's cities are categorized by rank: there are two "special cities" of sufficient size to merit national administrative standing (Ho Chi Minh City and Hanoi), and three cities administered centrally as the equivalent of provinces (Can Tho, Da Nang and Hai Phong). All other cities fall under the administrative jurisdiction of the provinces within which they lie. There are 12 Class 1 cities, 21 Class 2 cities, and larger numbers of Class 3 and 4 urban areas. The five cities that are responsible directly to the national government receive favourable administrative and fiscal privileges, so all Class 1 cities aspire to promotion to this rank, in order to receive additional resources and powers. To qualify for direct central administration, cities must meet a series of criteria related to population, size, and infrastructure, among others.

Climate change is also a growing risk for Vietnam's cities. Most of Vietnam's cities are located in coastal or river delta sites at low elevation. They are vulnerable to sea level rise, high tides and storm surge, typhoons, and to extreme rainfall events either in the city itself or upstream. Climate models suggest that in central Vietnam extreme

rainfall events are likely to increase in intensity and frequency. Sea level will slowly increase and tides will be higher. Typhoons may become stronger. The combined effects of these climate factors will lead to greater flood risk in growing urban areas, unless preventive measures are taken (Optiz-Stapleton and Hawley, 2013).

But Vietnam's cities already face significant flood risk. In the period 2012-2015, there have been major flooding events in Hanoi, Quang Ninh, Da Nang, Can Tho and Ho Chi Minh City, among others. The hazards are especially serious in peri-urban areas – those areas that are undergoing rapid change and development on the edge of the built-up urban area. Many of these areas are not yet fully serviced with urban infrastructure, yet the density of residential, commercial and even industrial development in these areas is increasing rapidly. These areas of rapid change move outwards as the urban population grows, and as infrastructure and urban construction fill in the city's development.

This study compares the experience of urban planning and development in peri-urban areas affected by flooding in three Vietnamese cities: Hue, Da Nang and Can Tho. In each case, the study examined the causes of specific flood events, and the role that urban planning and development played in contributing to the floods. In addition, this synthesis reviews the planning process in each city and describes institutional conditions that contributed to the flooding outcomes. By better understanding the localized causes of specific flood events in context in Vietnamese cities, we can identify what factors to adjust in order to reduce this type of flooding and better prepare for more severe climate events in future.

METHODS

Flooding is a complex situation and often results from multiple causes. While flooding is a natural phenomenon in Vietnam, the increase in flooding that local residents have observed in urban areas is not merely due to “natural disaster”. Our analysis suggests that key causal factors are related to poor planning and decision-making in which flood prevention is not a priority.

This synthesis summarizes the results from field studies in each of the three cities. The methodology used in each case was consistent. The researchers selected a specific recent peri-urban flood event (or a small number of similar events) and then used historical hydrological records and secondary data related to records of the event itself, combined with interviews with local residents, to reconstruct the sequence of flood events. In addition to the information on water flows, depths and pathways collected from residents and hydrological records in this fashion, the study teams also used spatial analysis to identify recent urban development and infrastructure construction activities. Interviews with local planning authorities and field site inspections were used to verify construction details and sequencing of development. GIS was used to map urban development changes in relation to flood flows in order to identify causal relationships. In each case, results from the flood event reconstruction and spatial analysis were discussed with local experts familiar with development patterns in the area, in order to verify the logic and substance of our conclusions.

For our assessment of the planning issues in each case, the study team reviewed existing planning documents and conducted interviews with local government officials from several different

departments in order to clarify the responsibilities and authority of different agencies in the urban development process.

Each of the case studies is documented in more detail in a separate report, which is available in Vietnamese language from ISET. This report summarizes results from all three cases and synthesizes key conclusions from the analysis of flood events and of the planning and urban development processes that affected these events.

DA NANG



Thanh Ngo, 2014. ISET

The expansion of Da Nang city is constrained by the sea to the north and east, and by mountains to the north and west, so the city is developing towards the south. But in this area lies the floodplain of the Vu Gia – Thu Bon river system. While the floodplain area is only about 500 km² in size, the upstream area drained by the basin is over 10,000 km², and characterized by short, steep rivers. Average annual rainfall at the coast is about 2000 mm, but in the mountains at the head of the watershed less than 100 km away, precipitation reaches up to 4000 mm/year, mostly within the rainy season from September to December. The river's behaviour is modified by several hydro-electric reservoirs of varying sizes upstream. Because of this geographical situation, the downstream areas can be subject to rapid changes in water flow with limited warning. This is a potentially dangerous situation at best, but is made more hazardous when inundation patterns become less predictable as a result of floodplain development.

As in other cities studied, flooding is not unusual in parts of Da Nang. The study area historically was subject to two or three floods per year during the rainy season. Residents are accustomed to these seasonal floods, but in recent years the behaviour of floods has become unpredictable, with floodwaters deeper and longer lasting than in the past, causing unexpected damage to local residents' homes, businesses and agricultural activities.

The study examined flooding and urban development in three wards, Hoa Chau and Hoa Tien, both in Hoa Vang district, and Hoa Xuan in Cam Le district. These areas are strongly affected by the interconnected river system of the Vu Gia – Thu Bon delta, including at least half a dozen waterways and channels that can carry large volumes of water in floods through these wards. The area faced severe floods in November 2007 and November 2013, both of which were the subject of analysis for this study. In this case study, researchers also used the HUDSIM model from a previous ACCCRN project (Tran and Tran, 2014) to analyze topography and flood depths under varying water flow conditions. Results were compared with interview data and validated with local community leaders.

Description of flood events

On November 10, 2007, the approaching typhoon #6 began to generate heavy rains over a broad area in central Vietnam, including Da Nang city and upstream areas. The rain continued for the next 4 days. River water started inundating Hoa Tien area from 10 pm on 14 November, reaching its peak at 5 am. The flood started receding from 10 am on 15 November. An Trach and Le Son 2 hamlets, which had just planted an experimental new rice variety in early November, were the first two flooded. La Bong and Cam Ne hamlets were flooded about 1 hour after Le Son 2. Water levels

FIGURE 1
MAP OF PROJECT STUDY SITE SOUTH OF DA NANG CITY (SHOWN IN 2012)



TABLE 1
COMPARISON OF THREE WARDS IN DA NANG STUDY SITE

	Hoa Tien	Hoa Chau	Hoa Xuan
Location	SW part of study area	Central study area	Northeast part of study area
Population (2014)	16,000	14,000	13,000
Area (ha)	1394	980	990

remained high inside houses for 2 to 3 days and submerged the streets for up to 4 days. At its peak, river levels were recorded as 10.36 m at Ai Nghia station, upstream just inside the border of Quang Nam province, and 3.98 m at Cam Le station in the floodplain, both exceeding the highest warning level. The flood inundated portions of 26 wards throughout the city, damaging more than 28,000 houses and directly affecting over 100,000 people. Three people were killed, along with many tens of thousands of cattle and chickens lost in the agricultural areas of the floodplain. In Tay An hamlet in Hoa Chau, the floodwaters were over 2 meters deep. Similar levels of flooding and damage occurred in September 2009 under the influence of

typhoon Ketsana, generating record water levels at Ai Nghia, but lower levels in Cam Le than 2007.

In November 2013, Da Nang was affected by a series of tropical storms and typhoons, generating heavy rains from Nov 6–8, and then again from Nov 15–18. The second storm, coming after the ground was already saturated and reservoirs full, created special challenges as a result of heavy and prolonged rainfall throughout Da Nang and Quang Nam provinces. Water level at Ai Nghia station and Cam Le station reached a peak at 9.99m and 2.67m respectively on 16 November, exceeding the third (or highest) warning level. The flood lasted until 18 November 2013.

Part of the difference in the flood behaviour was due to upstream reservoir management. By 2013, there were four hydropower reservoirs in the upper Vu Gia - Thu Bon basin. Safe operating procedures for multiple reservoirs in flooding season were issued in the Decision No. 1880/QD-TTg dated 13/10/2010 by the Prime Minister. Operational data from the A Vuong, Dak Mi 4 and Song Tranh 2 reservoirs during the November 2013 flood confirms the role of hydro reservoirs in contributing to the flooding. By the time that high rainfall forecasts were issued by the provincial Committee for Flood and Storm Control in Quang Nam, water levels in several reservoirs had already reached or exceeded design capacities, in part due to heavy rains in previous weeks. This meant that operators had no choice at that point but to fully open all discharge gates as reservoir levels continued to rise. Heavy rain combined with simultaneous discharge from multiple reservoirs created massive flooding in a very short time downstream.

The reservoirs are supposed to be designed with excess flood capacity to play an important role in retaining floodwaters, and slowing the speed of flooding downstream, especially during rainy season. However, most of the hydropower plants on the Vu Gia - Thu Bon Basin have small reservoirs with limited flood retention capacity (except for A Vuong). So in the flood season, the hydropower plants have limited capacity to buffer downstream inundation. Hydro power authorities have an incentive to operate their plants at maximum output levels, so they are reluctant to reduce reservoir levels when rainfall is uncertain, and they can be surprised by intense storms, as appeared to happen in 2013. The reservoir operators did not receive accurate forecasts in time to lower reservoir levels to create capacity for flood runoff. Heavy rains in the upper reaches of the watershed lasted for 6 hours on November 15, while the lower reaches in Da Nang had almost no rain. Only 2 hours after rain started, the Dak Mi 4 hydropower reservoir was full. Several operators had to urgently implement emergency flood discharge to secure their reservoirs. The discharge led to rapid and

large scale flooding for downstream areas, causing serious consequences.

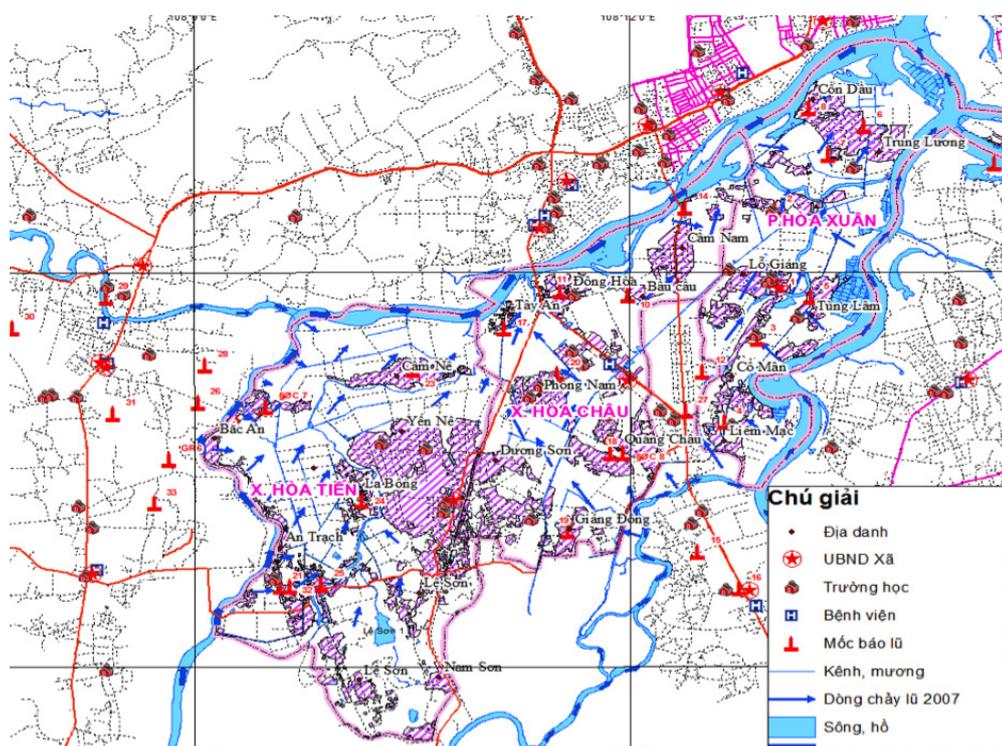
Factors affecting flooding in the study area

Many local residents confirmed that direction and flow of floodwaters across the study area has been consistent regardless of the type and duration of the flood. But locally, the reported experience in many locations is that flooding has become faster, deeper and lasts longer. To verify this, we conducted surveys near flooding meter HV22 in Bac An Hamlet, Hoa Tien commune and flooding meter HV17 in Tay An hamlet, Hoa Chau commune. The results showed that, while the 2013 flood was lower than that of 2007, it created more damage in the study area. A comparison shows how the changing development context contributed to unexpected flood risk, along with the rapid rise of floodwaters.

The upgrading of 1A National Highway in 2003 (raised by 50 cm), DT605 road, An Hai radio broadcast station and South Cam Le resident area (2003-2004) also impeded flood drainage. This can be seen in the impact of the 2007 flood, which submerged Tay An under 2 meters of water partly because it was located upstream of the newly upgraded DT605 road. Floodwater caused damage to crops, livestock and the environment. The flood lasted 3 days, disrupting daily life, study and production. But that year had less rainfall than in previous years. Local residents suggest that the flood was not caused primarily by the storm and heavy rain but by the changes in local topography and drainage. In previous floods, the surrounding areas, which were rice fields at that time, also served as retention areas where flood waters could spread out and quickly dissipate. But with urbanization and road construction, overland flow and drainage were impeded, leading to deeper flooding and longer inundation.

Drainage and flood channels have been impacted in the study area by urban development activities that have blocked overland water flow. These activities include the upgrading or construction of transport links such as 1A Highway, DT605 road and

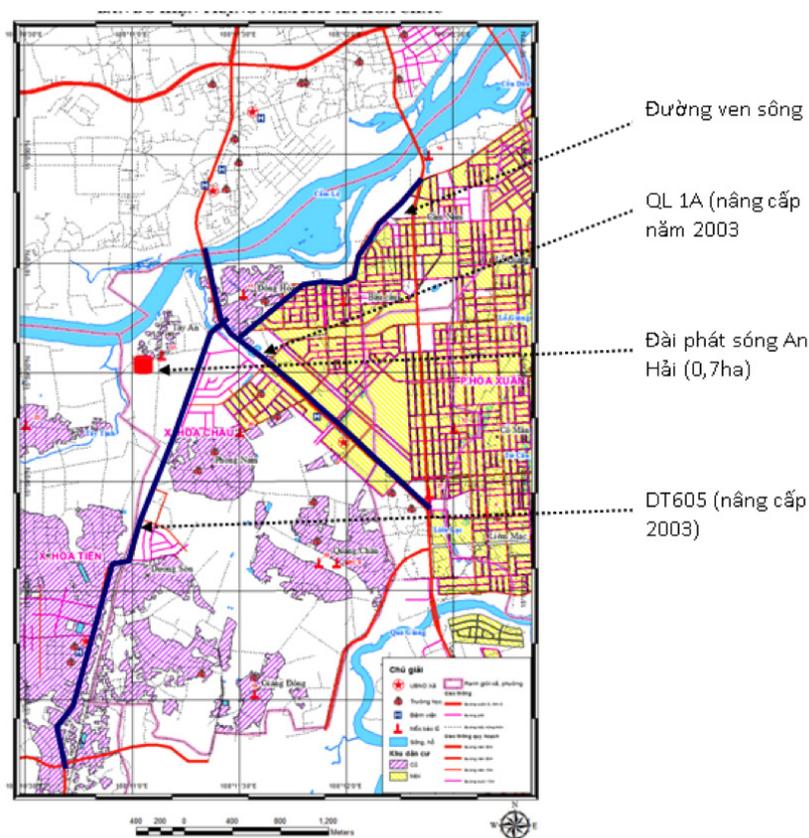
FIGURE 2
DIRECTION OF OVERLAND FLOOD FLOWS IN THE STUDY AREA (SURFACE TOPOGRAPHY IN 2007)



the ADB5 highway; raising the surface level in new urban areas; and building large structures in low-lying areas. In the 2007 flood, for example, floodwaters from the south and west were blocked by the upgraded road DT605, leading to deeper and more prolonged inundation in places like Tay An hamlet. The upgraded road provided a more secure evacuation route for local residents until the floodwaters rose so high that they overflowed the road itself, and began to wash out sections of road and bridge supports.

The ADB5 highway was built after the 2009 flood, running east-west a distance of about 5 km through Hoa Tien ward to provide better access across the river to Hoa Vang district centre and markets for local farmers. The road

FIGURE 3
MAJOR CONSTRUCTION IN FLOODPLAIN PRIOR TO 2007



has cut travel time significantly, and satisfied the access needs of local people. The lowest elevation of the roadway is 4.73 m, corresponding to a design flood probability of 5%. The elevation of the road was 2.5m higher than surrounding land. Since then La Bong, An Trach and Le Son 2 hamlet experience deeper inundation whereas flooding level in Cam Ne and Thach Bo hamlet on the north side of the new highway is lower than before. Local residents noticed the difference in seasonal flooding after the highway was built. For example, the flood in 2013 inundated several houses south of the highway for two days and took 5 days to drain, despite the high water flows lasting only a few hours.

The discussion between researchers and representatives from communities indicates that Bac An hamlet is one of the areas that are affected by floods induced by ADB5 highway. Mrs. Hiep' family who has lived in Bac An since 1992 suffers from flood almost every year. In 2013, river water was still low in the afternoon; but it rose very rapidly until 8pm. So she didn't have enough time to move her things and lost most of her household possessions. Since construction of the ADB5 road, she recognized that water rose very quickly in this area but drained slowly because the road blocked the waterways.

The entire area is part of the flood drainage of the Yen River, a branch of the Vu Gia. However, when designing the drainage system, the consultant calculated inadequate drainage aperture and unsuitable elevation of the center of the route so under flooding conditions the Vu Gia River overflows its banks upstream and water flows across the floodplain, piling up behind the highway embankment, which is at least 2 m above the surrounding plains, and creating a deep impoundment in upstream areas. By comparison, the Hoa Phuoc – Hoa Khuong road was also built in this area, connecting National Route 1A to Secondary road DT605. Along this short connection, the road was built with a total of 18 horizontal drainage culverts with a total cross-sectional area of 1856m². This road is designed for much better drainage than ADB5.

In addition to the road construction in Hoa Tien and Hoa Chau wards, comparison of two detailed plans for Hoa Xuan approved in 2002 and in 2013 also shows a significant change in urban development (see Fig 7 below). Earlier plans for Hoa Xuan ward and part of Hoa Chau showed large areas reserved for floodways and parks, but in the 2013 plan, which reflects actual construction and fill ranging from +3.6m to +4.7m, most of the area is identified for development. In fact, development in Hoa Xuan ward started in 2008 and the area has now been mostly filled and levelled for residential construction. Previously, this area was in the middle of a floodplain and directly affected by three different branches of the river system. Historic flood levels for a 20 year flood are approximately 3.7m (above sea level), while natural surface elevation is around 0.3 m or less.

The process of filling the low-lying areas in Hoa Xuan for construction has also altered the natural drainage system in the area. The adjacent area that has not been filled has been impacted with large areas of standing water and waterlogged soils, including Tay An hamlet.

Parts of Hoa Chau ward have also been urbanized and elevated since 2005. This has reduced flood risk for the raised areas, mostly along the main roads, but it has increased them for other areas. In the past, Hoa Chau ward, lying between several river channels, was typically flooded before Hoa Tien, which lay to the west on slightly higher ground upstream. Now the situation is reversed and in the 2007 and 2013 floods, Hoa Tien was flooded first. Throughout the floodplain, we can see a consistent pattern of new urbanization zones and infrastructure that is built to a higher elevation than the existing landscape, thus blocking floodwater flows and creating impoundments that deepen floods and slow drainage for those residents still living in the lowland rural areas.

But are the new residential areas safe at their higher elevations? So far, experience in the 2009 and 2013 floods suggests that these areas have not been damaged by these serious floods. Hoa Xuan in

FIGURE 4
URBAN DEVELOPMENT PLANS FOR HOA XUAN



Planning to 2020 (approved in 2002)



Planning to 2030 (approved in 2013)

particular has been equipped with large drainage systems and localized flood control measures, including several small lakes to regulate drainage canals, as well as 3 – 4 meters of fill. But this was originally a very low-lying area, and functioned as a natural flood retention zone, protecting the rest of Da Nang city and slowing river discharge during times of heavy flooding. Now that it has been filled, this has two results: 1) it increases the upstream water levels by constraining the river cross-section and flood retention, as demonstrated in the experience of local residents in Hoa Chau and Hoa Tien, described above; 2) it also speeds the transmission of high river flows to the central area of Da Nang and the river mouth. Under conditions of high tides, storm surge, or sea level rise, these floodwaters will be unable to drain to the sea, and this will lead to greater risk of flooding in the central city.

HUDSIM modeling results show that a flood similar to the one in November 2007 would likely result in inundation of 0.3 to 0.5m even in the filled areas such as Hoa Xuan. Particularly deep inundation of 1.5-2m will occur in the areas upstream and adjacent to roads in Hoa Tien and Hoa Chau. In addition, it should be pointed out that the 2007 flood was not the historical flood of record, and higher

flood levels should be anticipated in future as a result of climate change.

Another risk impacting people's lives is the challenge of transition from rural to urban livelihoods. The conversion of a large agricultural land base has changed the traditional occupations of the community. Local residents who lost their farmland received compensation, but some can only find unskilled wage labour in the urban sector. Low and unstable incomes mean that these poor households become even poorer. Some high value agricultural activities continue in the study area, such as organic vegetable and mushroom cultivation. Animal husbandry has also attracted some interest, but the changing flood patterns create high and uncertain risks for livestock owners. Unless there is better planning and predictability for the management of seasonal floods across this area, farmers will be reluctant to invest in more productive high-value agricultural technologies.

Planning practices in Da Nang

Planners have been generally aware of the risks of flooding in southern Da Nang. The city's original long-term master plan, approved in 2002, identified

most of Hoa Xuan and Hoa Chau as ecological reserves and park land because of their flood exposure and low elevations (see Fig 7 above). Some road construction projects in the floodplain have provided for adequate drainage, while others have not (see discussion above). Through extensive interviews and review of planning documentation, the study team tried to identify the details of the

planning and urban development decision-making process in Da Nang in order to identify how these planning and decision-making processes have influenced the flood outcomes reported above.

In general, the urban planning and development process follows similar steps in all three cities, which can be summarized in the Table below.

TABLE 2
SIMPLIFIED OVERVIEW OF STEPS IN URBAN PLANNING

Description of Activity	Components	Who is responsible
Preparation of Master Plan		
Define objectives and Collect relevant data	Review of policies, targets for Socio-economic Development Field studies on physical and natural conditions Other studies and research reports Establish basis for master planning	VIUP or provincial planning institute
Prepare alternative designs and select preferred plan scheme	Define options Prepare alternative design plans Finalize preferred option and prepare general maps	VIUP
Submit plan for political approval	Submit planning documents to provincial People's Committee Defend and review master plan Submit final master plan to Prime Minister's office for approval	City PC
Implementation – detailed area plans		
Define objectives and Collect data	Review of policies, targets based on master plan Field studies on physical and natural conditions Other studies and research reports	DoC and consultants
Prepare alternative designs and select preferred plan scheme	Define options Prepare alternative design plans Finalize preferred option and prepare general maps	Consultants
Submit plan for political approval	Submit planning documents to city People's Committee Defend and review plan Approved by Provincial People's Committee	DoC City PC
Detailed plans		
Provide information on detailed plan	Develop detailed neighbourhood plan (1/2000) Review detailed plan Approve detailed plan	Consultant DoC and other depts City PC
Control urban development based on the plans	Identify suitable sites for construction Call for investment, select developers Design program and construction plan (1/500) Design and negotiate options for architectural design Infrastructure construction Approve detailed site planning Monitor and adjust approved construction plan Allocate or lease land for construction Grant license for construction, inspect for violations of plan or of law on investment and construction Construction management	DoC Consultant (with Developer) City PC DoNRE DoC Developer

Urban master plans and climate risk considerations

In Da Nang, the initial Master Plan of 2002 was prepared by the Vietnam Institute for Urban and Rural Planning (VIUP), a national institute under the control of the Ministry of Construction. VIUP essentially acts as a consultant for the local government in preparing the plan.

After the first Master Plan was approved, VIUP continued to design 1/2000 detailed plans for most of the urban areas, including:

- Identified the primary areas for urban development in North-Western portion of Lien Chieu district, Southern part of Hoa Cuong, South-Western part of Cam Le, and other areas.
- Designed industrial zones of appropriate scale in Lien Chieu, Hoa Khanh, An Don, Hoa Cam. Designated specific areas for administrative center, culture and sports center, health center, education and training center, parks and recreational areas.
- Designed an interconnected system of urban infrastructure including the arterial road transport network through regional hubs and running North-South and East-West, proposed a network of bridges across Han river, and upgrading criteria for road system in residential areas.
- Designed and specified a system for wastewater drainage and treatment, consistent urban solid waste treatment, urban green spaces.
- Identified designated land for vehicle parking in public areas, riverside and coastal areas.

Implementation of the 2002 master plan was carried out by Da Nang city, led by the Department of Construction and other local agencies. Key activities included:

- Relocated about 120.000 households. 60% were relocated “on site”, meaning they were accommodated in new residential structures

close to original site, and 40% were moved to other areas. New housing provided was generally in low-rise apartment complexes with basic services.

- Almost all manufacturing facilities were relocated away from residential areas into designated industrial zones.
- Relocated hundreds of thousands of grave sites scattered in peri-urban areas and consolidated these into new large-scale cemeteries, as part of land clearing for urban development
- Over the last 10 years, built over 10,000 public apartment units.
- Converted hundreds of hectares of land previously reserved for military use, to urban development and infrastructure purposes.
- Cleared thousands of temporary and poor quality houses along the east bank of Han River; upgraded roads and built parks along both banks of the river, making landscape and recreational improvements; upgraded or built coastal roads to support more investment in tourism.
- Built a system of wastewater collection and wastewater treatment plants, greatly reducing the amount of untreated wastewater discharged directly into rivers and ocean. Developed a system of solid waste collection and treatment plants.

In 2013, a new urban master plan was prepared by the Da Nang Institute for Urban Planning, together with foreign technical experts. The Institute was specifically requested to update and revise the 2002 plan, to be consistent with social and economic development trends in the central region and the country as a whole.

The 2013 Master Plan for Da Nang shows strategic goals in socio-economic development towards regional linkages and sustainability. In the new plan, factors related to flooding and climate change

adaptation have been considered in the following ways:

- Consider that climate change, increase in temperature, sea level rise will directly affect riverside and coastal areas; therefore ground

level elevation must be considered and properly adjusted before development, especially in these areas.

- Specify standards of elevation corresponding to flood safety levels in certain areas, higher than those in the previous master plan.

TABLE 3
COMPARISON OF HOW FLOODING, INUNDATION, AND CLIMATE CHANGE HAVE BEEN CONSIDERED IN DA NANG'S TWO URBAN MASTER PLANS

Factors	2002 Master Plan	2013 Revised Master Plan
Policy Guidance for Planners	Flood risk was addressed only at the site level through elevation standards. No technical guidance on how to integrate flood and climate risk into the master plan. There were no regulations on disaster risk reduction in planning.	Climate scenarios and flood models were considered in the plan. Legal documents at the national level now require local climate action plans and the consideration of climate change in planning, but there are no specific technical guidelines yet for how to implement these.
Scope	Disaster risk reduction and climate change adaptation were not considered in urban development planning and socio-economic development plan. Urban plans did not protect natural terrain, and it was standard practice to fill wetlands and flood plain areas. There was no reference to regional context (e.g. impacts on neighboring provinces from plan).	Climate impacts on future hydrology and flooding are considered in the plan through application of HUDSIM model. This resulted in changes to development plan in southern part of the city. Issues of flooding and inundation, sea level rise are considered in sector and detailed planning. Environmental Issues in urban and rural areas, riverside areas, coastal areas are identified and addressed in the plan. Regional issues still not clearly addressed.
Consultation	There was very limited consultation between technical units or different local government departments. The plan was prepared in isolation by experts. Master plan was not updated and revised every 5 years, as intended under national regulations. Detailed plans and site construction plans were implemented in isolation, not considering interactive impacts and contributing to flooding in nearby areas.	The planning process followed standard local practice for cross-sectoral consultation, with many opportunities for review and input from other agencies.. Analytical tools are used in developing detailed plans, including consultation with developers to resolve details of elevation, drainage, environment Detailed planning follows carefully the calculation and guidelines on flooding drainage in the master plan.
Public Information and Communication	Relevant information was not disseminated. Other departments and agencies, the public and developers didn't know much about the plan. There were no channels of communication to the community.	Public consultation followed guidelines for this purpose, which require public comment only for special, large-scale and sensitive schemes. Consultation did not specifically address changing flood risks or provide a clear mechanism for influencing either risk assessment or plan features. Communications with the community do not gain much attention or response.

- Select the minimum elevation for construction to be that of the river level during floods of probability 5%
- Some built-up areas of the central city cannot be filled, so in these areas partial filling and elevation of streets and thresholds is recommended

This revised master plan also specifically refers to environmental protection measures related to flood risk reduction in riverside and coastal areas.

The revision of the master plan in 2013 did not alter the fundamental strategic direction of urban growth, which remains focused on development in the low-lying southern areas and in the western industrial park zones. However, there is greater acknowledgement of the risks of flooding and climate change. This is in part the result of experience with the ACCCRN-funded HUDSIM model, which allowed the Department of Construction for the first time to model floodwater depths under different urban development, land elevation and infrastructure design scenarios. As a result of their experience with HUDSIM, DoC has reduced planned densities of residential and commercial construction in the new master plan for areas of western Hoa Chau and Hoa Tien.

However, the new master plan remains ambiguous in its approach to flood risk. For example, although national urban planning standards (QCXDVN 01:2008/BXD), require ground elevation to be at least as high as a 100-year flood (i.e. probability of 1%), Da Nang appeared to have no difficulty in gaining approval from the Prime Minister's office for a master plan with much lower elevation standards (20 year flood) in many areas of new construction.

Urban development, planning and flooding in southern Da Nang

In the 2002 urban master plan, Hoa Xuan was designated as an eco-urban area in the southern part of the city with most of the land set aside as

ecological reserve, parks and floodplain. But this plan was not implemented because of development pressure in this area, which is very close to the central city. Another attractive feature of the area for development was that it was sparsely inhabited, so relocation and resettlement costs would be lower. This combination of developer interest and support from the city government has led to the approval of 13 development projects with a total area of about 1000 ha in Hoa Xuan between 2002 and 2012. Of these, 6 residential development projects have been completed, 2 infrastructure projects are completed (sports complex and reserve lands along Cam Le river) and 5 projects are still underway in 2015. Hoa Xuan area has changed completely, with new traffic routes, new artificial lakes and landscaping, and massive filling of previous wetland and floodplain areas, raising the elevation by 3-4 m. Most of this development was inconsistent with the 2002 master plan, yet it has been consistently supported by city government authorities who place a lower value on flood risk than on economic growth and commercial profitability.

The residential areas along DT605 road across Hoa Chau and Hoa Tien have also emerged on the basis of the reconstruction of the old DT605 to serve the needs of residents resettled from other areas. Industrial development along National Route 1A in southern Da Nang responded to the improved accessibility for heavy vehicles using this route. The effects of this development on surface floodwater drainage have been discussed above. The important point to note is that drainage requirements have sometimes been neglected in the development of individual projects, and there does not appear to be a good oversight or coordination mechanisms that would ensure that new construction in this area provides for sufficient drainage.

The impacts of urban development in Hoa Xuan on flood patterns upstream have been recognized in the revised master plan. To address some of the drainage issues in the upper areas (the communes

of Hoa Tien and Hoa Chau), the revised master plan (2013) mentions some specific strategies:

- The master plan suggests some approaches for drainage in Hoa Tien as urbanization spreads along National Route 14B and DT605 Route.
- The plan suggests a 24 m wide flood channel to run under National Route 14B, connecting to the existing canal and draining into Yen river.
- A new 24 m wide drainage canal is recommended along Tay Tinh river, draining into Qua Giang river.
- Another 24 m drainage channel is suggested to drain the Hoa Nhon stone quarry into the Tuy Loan river.
- A flood drainage channel of 18-29 m wide is suggested for the areas along National Route 14B from the power station to Tuy Loan Bridge.

For the planning and design of road infrastructure projects, the study team conducted detailed interviews of technical staff in several ministries to compare the process of planning and construction of the ADB5 road in 2005-2010, and the Da Nang – Quang Ngai highway (under construction in 2014-2015). Both projects were externally funded – the first by ADB and the second by the World Bank. Both projects were managed and controlled nationally by the Ministry of Transport, and designed to their specifications. Land acquisition, resettlement, and construction management were delegated to the city government. In neither case was there any consultation with communities affected by the design. In the earlier ADB project, there was no opportunity for local government to provide input or advice on drainage and flood prevention measures, despite their concerns and the protests of local people during construction. The concerns of local residents and local government officials were borne out in the flooding of 2013, and after that event the city moved to install better drainage at its own expense.

In the case of the late World Bank highway project, the Da Nang provincial People's Committee was able to intervene with the Ministry to persuade the project management board to work with city government officials to review the design. The project management board agreed to run the HUDSIM flood model, which convinced them of the need for additional drainage culverts in the highway design to accommodate a 1% flood. However, there was still no consultation with the community and very limited information about the project provided to the public.

In order to address the flooding issue in the study area, urban planning and development should be more sensitive to the natural characteristics of this floodplain area. In particular, development in floodways and natural flood retention sites should be strictly limited to protect these areas, better accommodate floods and reduce damage from extreme flooding.

At the same time, design and construction standards should be reviewed to make allowances for high water flows in floodplain areas. This means that infrastructure such as roads should be avoided in these areas if possible to allow for overland flow of extreme flood levels. If infrastructure is essential, it must be designed to accommodate, rather than hamper, these occasional high water flows.

Further attention also needs to be given to management of upstream hydro reservoirs and to better weather forecasting for storms and heavy precipitation events. Reservoir managers need to receive at least 48 hours notice of possible heavy rains before those rains start, so that they can issue flood warnings and begin to lower reservoir levels safely in order to provide some measure of buffering for high runoff downstream. In addition, reservoir management practices will affect the calculations of flood levels and risks in the downstream areas. Planning based on historical flood conditions, including water levels, flow and rate of increase will be in appropriate under conditions of active management of the new

reservoirs, and safety factors and elevations will need to be adjusted accordingly.

Da Nang flood risk and urban planning – summary of case study

Urbanization and infrastructure development in the floodplain of the Vu Gia – Thu Bon river system has contributed to higher flood risk in the upstream areas of the floodplain. By raising the elevation of the land surface and building urban infrastructure, local government has reduced the natural capacity of the floodplain to absorb and slow floodwater discharge. The result is that in extreme events, floodwaters behave differently than they did in the past. Roads create barriers to overland flow, urbanization and land fill eliminate flood retention areas, and restrict or fill flood channels. The result is that flood risks are transferred from the newly developed areas to other areas: risk levels in upstream areas are higher, flooding in these areas may occur faster, water is deeper behind impoundments created by road networks, and flood inundation drains more slowly. At the same time, the infrastructure improvements also allow for more secure initial evacuation, until floodwaters reach the height of the roads, after which conditions become more dangerous than before because of the depth and speed of water flow. These urban development practices create new urban environments that would appear to be secure at the 5% flood design levels currently in use. However, it should be pointed out that current standards do not provide for future climate impacts and are likely to prove inadequate for flood protection even at the relatively low 20-year return period, much less for more extreme events.

A compounding issue is the management of upstream hydro reservoirs. This appears to be inadequate to handle complex multi-storm planning sequences, and under conditions of increasing rainfall intensity and small reservoirs, seems likely to aggravate flood conditions downstream by sudden large unplanned water releases.

Urban planning in Da Nang has begun to consider flooding and climate change as a factor influencing development plans. However, these considerations have not yet had a major influence on planning and development in peri-urban areas. Planning and urban development continues to be only loosely coordinated, and consideration of flood risks remains inadequate. At the same time, the growing experience with HUDSIM as a modelling and planning tool has begun to influence planning decisions in floodplain areas. The issues are increasingly recognized and emerging response options such as the following are gaining attention:

- restrictions on urban development in low-lying areas to avoid the need for fill or dikes to protect new urban construction. Large amounts of fill or new dikes in low-lying areas will restrict river flow and transfer flood risk to other locations.
- Preserve and expand floodway corridors, reducing structural impediments to surface flow in conditions of extreme water levels to speed drainage and reduce water levels.
- Revise estimates of flood levels based on historical data, to account for issues of sea level rise, increasing intensity of precipitation, sea level rise and upstream reservoir operations in extreme events. Detailed planning should be consistent with the broader regional context, including developments upstream and downstream of the site.
- In the context of climate change and sea level rise, leading to the increase in rainfall and flood levels, new adaptation measures to protect human life and property in the face of more frequent and severe flood events are needed.

CAN THO



The city of Can Tho is located in the centre of the Mekong Delta, on the Hau (Bassac) River. The city boundaries cover a large area of 1409 km², most of which is rural. The urban population is around 850,000, but growing rapidly due to rural-urban migration. The city is very low-lying, with a natural surface elevation from 0.5-1.5 m above mean sea level. Seasonal flooding is a characteristic of the Mekong Delta generally and of Can Tho. Rainy season runs from May to November with highest rainfalls recorded between August and October at the same time of high discharge from upstream, which annually creates “Mùa nước nổi” (water moving season). “Mùa nước nổi” provides rural livelihood benefits by restoring nutrients to flooded rice fields, flushing out aquaculture ponds and replenishing fish and aquatic species and their habitats. People in Can Tho City have adapted their lives to this phenomenon and feel confident they can deal with normal seasonal floods (DWF, 2011).

However in recent years, water levels of the Hau River have changed unpredictably and higher floods have occurred. Many parts of Ninh Kieu District are now flooded annually, including Hai Ba Trung ward, Cai Khe ward, An Hoa ward, An Khanh ward and An Binh ward. These seasonal flood events have severely impacted the living conditions and livelihoods of local people as well as economic development and the urban environment. Three sites were chosen on the periphery of Can Tho’s central Ninh Kieu district to study the problem of

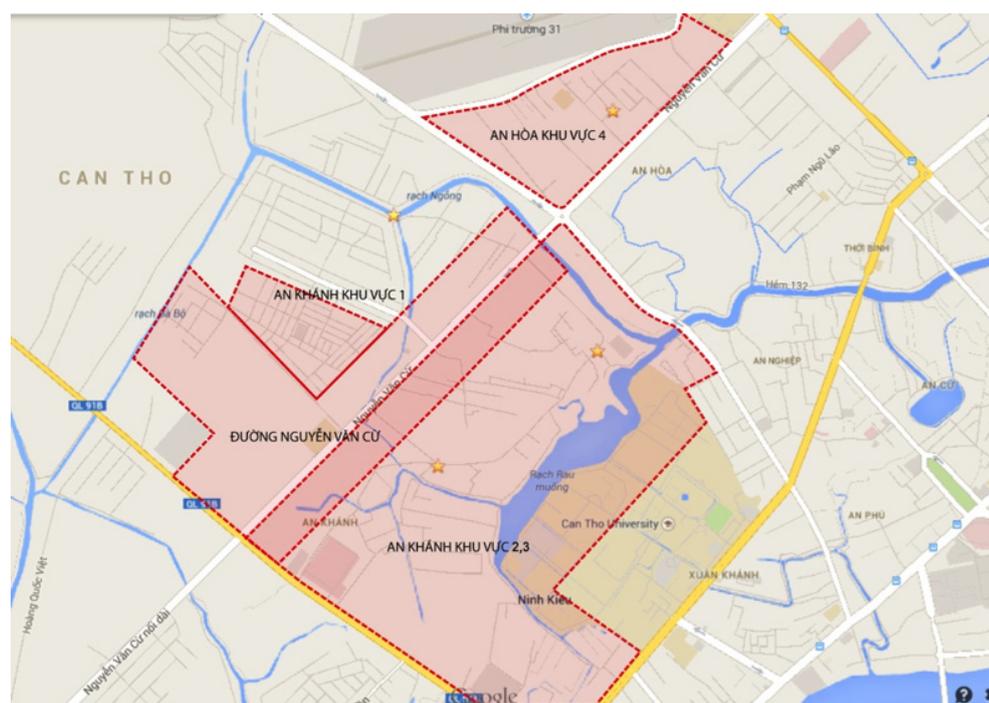
flooding and its causes in Can Tho. The sites were chosen because they reflect both planned and autonomous urban development neighbourhoods facing similar flood risk exposure in the same areas. The three sites are shown in Fig 5. They are all part of Ninh Kieu district, and located approximately 3 - 4 km from the centre of the city:

1. Mixed area of planned development and spontaneous development – Neighborhood 4 – An Hoa Ward (located northwest of Nguyen Van Cu Road, extending from Cach Mang Thang 8 Road to Mau Than Road).
2. Development area based on city plan – Neighborhood 1 – An Khanh Ward (located northwest of Nguyen Van Cu Road and Thoi Nhat neighborhood).
3. Area of spontaneous development – Neighborhoods 2, 3 – An Khanh Ward (located southeast of Nguyen Van Cu Road, extending to Bun Xang Lake).

Methodology

In order to analyze the causes of the flood morphological changes in three case studies, we produced a spatial database to generate a flood risk simulation model. In addition, we engaged local government, examined local records and interviewed households in order to verify results from analyzing the spatial database. This research

FIGURE 5
STUDY SITES IN CAN THO



focused on severe flood events in 2011 and 2013, which caused heavy damage in the city. Our main methods were as follows:

- analyzing water discharge data from 1961-2014.
- analyzing data on rainfall and extreme rainfalls in Can Tho City and upstream.
- spatial analysis of case study sites from 2006-2014.

Description and causes of flooding in Can Tho

Flood season in the Mekong River delta is characterized by heavy and sometimes continuous rains throughout the basin from Can Tho all the way up the river to Cambodia, Thailand, Laos and China. In Can Tho, “mùa nước nổi” may be caused by water from different sources including (1) local rains in the delta; (2) discharge from the upper Mekong River to the East Sea; and (3) tidal flows from the East Sea inwards to the delta. Disastrous extreme floods, which are different from this seasonal and regular flooding, also occur mainly as a result of heavy upstream flows. For example, in

the years 1961, 1966 and 2000, water level recorded in Chau Doc station close to the Cambodia border was remarkably high. There were heavy floods throughout the delta in the year 2000. In Can Tho city, there was also flooding in both 2011 and 2013. We consider these Can Tho flood events in more detail below.

2011 Flooding

With the start of the storm season in May 2011, the lower Mekong Basin faced a series of tropical storms and heavy rainfalls through the end of August. Heavy rainfall continued in upstream areas in September, October and November. During this time, high flows reached the Mekong Delta in Vietnam. In Can Tho, floods in 2011 apparently were caused by a combination of this high water discharge from upstream and tidal flows from the sea. Therefore, the water level in the city fluctuated according to the tides. Floodwater reached a height of 2.15m which is ranked 2nd among the previous measured records (2.16m). In total, flood season was unusually long, lasting for 4 months, from late August to mid-December and included 9 tidal cycles over that period (see Table 4). While flooding at peak tides had been seen before, this pattern of

TABLE 4
FLOOD LEVELS IN 2011 - CAN THO (SOUTHERN REGIONAL HYDROMETEOROLOGICAL CENTER)

Tidal peak (m)	Date	Note
1.89	31/8	Exceed alarm level 2=1,8m
< 1.7	No flood alarm – below level 1	
2.11	29/9	Exceed alarm level 3=1,9m
1.71	12 - 14/10	2 days
2.15	27/10	Ranked 2nd among previous records
1.87	11/11	
1.96	26/11	
< 1.7	No flood alarm – below level 1	
1.81	26/12	

recurring floods at peak tides, including one that was near previous maximum water levels, was highly unusual.

On October 27, at around 3pm, water overflowed from drainage grates in lower alleys and natural waterways inside the city. Floodwater continued to flow onto the main roads and above Ninh Kieu Wharf. By 4.30pm, floodwater had covered most of the main roads in the city, backing up through storm sewers and drainage pipes onto the streets. In some roads, floodwater reached a height of 70-80cm. In the central city, this road flooding only lasted for about 3 hours and after that water gradually drained back down below road level. However, because it was so widespread this event had a negative impact on business and transport throughout the city, causing many businesses to close and travel to be disrupted during peak traffic times. And in some peri-urban areas the floodwaters did not drain so easily, causing sanitation and disruption issues for several days. While water levels during this season are normally high, this degree of flooding on the main streets of the city (and even more severe in other, lower areas) was very unusual.

2013 Flooding

In 2013, the flood season was normal in timing and water level, and there was no high-flow discharge in Mekong River. However, in Can Tho, floodwater rose unpredictably to a peak height of 2.13m which

is ranked 3rd among the previous measured records. The flood season in 2013 lasted for over 3 months, from early September to mid-December, including 6 tidal cycles.

From 18 - 21 October, high tide surged in Can Tho. The city hydrometeorological center warned residents that because of the combined effect of water discharge from upstream, tidal flow and Northeast monsoon, the daily tidal peak in city waterways would continue to rise. Local people described that water rose from 3pm to 5pm on October 20, inundating most of the city's roads and reached a depth of 1 m in some of the smaller alleys. Traffic was seriously disrupted by water on major intersections and roundabouts.

TABLE 5
TIDAL FLOODING IN 2013 IN CAN THO CITY (SOUTHERN REGIONAL HYDROMETEOROLOGICAL CENTER)

Tidal peak (m)	Date
1,82	21/9
2.04	7/10
2.13	20/10
2.02	4/11
1.82	19/11
1.95	4/12

Despite a year of normal seasonal floods, typical river flows, and no high localized rainfall, water level in Can Tho at the time of tidal peak still reached near-record levels, and exceeded alarm level 2 in all 6 tidal cycles at the end of 2013. In total, there were 50 days with more than 1.7m high daily peak floodwater level. These unprecedented regular floods resulted in many difficulties and obstructions for the living conditions of poor people in low-lying areas.

Causes of high water in Can Tho

Typically, floods may have many contributing factors. In the case of Can Tho, where localized flooding was in part a direct result of high water levels in rivers and canals in the city, we examine the factors contributing to those high water levels. There are several potential contributing factors to be considered: high localized rainfall, high upstream flows, tidal influences and land subsidence.

Localized rainfall can vary substantially over the flood season in Can Tho. The highest recorded daily rainfall of 211 mm took place on 9 June 2000, but this was unrelated to the flooding that year, which occurred three months later. For the flood events studied here, which affected the entire city, rainfall on the day of the event and cumulative rainfall in the previous three days were both insignificant in 2011 and in 2013. Localized rainfall played no role in contributing to these city-wide flood events.

Tan Chau and Chau Doc are upstream gauging stations located closest to the Vietnam – Cambodia border where the Mekong River flows into Vietnam. The highest water level in Can Tho City has tended to increase year after year although the flood peak in Tan Chau and Chau Doc station stayed stable or even lower than the previous year. Particularly, in Tan Chau and Chau Doc station, in 2011, 2013 and 2014, the flood peaks were lower than the flood peak in 2000, but the water level in Can Tho City was still higher than the water level in 2000.

In comparing the timing of highest annual water levels at Tan Chau, Chau Doc and Can Tho in 2000, 2011, and 2013, there is no correlation between either the timing or the height of water levels upstream and in Can Tho. Sometimes the peak water levels in Can Tho occurred before those upstream, other times the reverse, and often widely separated in time. So there is no specific relationship between upstream flows and the peak water levels in Can Tho, except that the peak levels always occur during flood season when the river levels are generally elevated.

Tidal influences seem to be most important in the timing and elevation of the peak water flows in Can Tho. For each of the years 2011, 2013 and 2014, the peak water level in the city coincided closely with the timing of the highest seasonal ocean tides. In 2012, peak water levels in the city were a couple of days after peak ocean tides. The complex interaction of high seasonal water flows in the river and variable tidal flows up the river from the ocean can lead to water “flushing” and tidal surges along the city’s river and canal systems.

A contributing factor to peak water levels in the city is land subsidence, caused by widespread over-extraction of groundwater throughout the delta. As water levels fall due to over-extraction in deep aquifers (more than 80 meters below the surface), the surrounding layers of sediment are compressed, causing land subsidence across the delta at rates of 1 – 4 cm/year (Erban et. al., 2014). This corresponds with measured increases in high water level in Can Tho in recent years of approximately 1.5 cm/year, of which approximately 0.4 cm can be attributed to sea level rise. The implication of continued subsidence at these rates will be an increase of water level of approximately 0.35-1.4 m due to subsidence alone by 2050.

Overall, we can conclude that higher water levels in Can Tho river channels and canals can be attributed to the combination of seasonal flood levels in the river with peak tides, all of which is exacerbated by subsidence and gradual sea level rise. With climate change, we can expect steady

FIGURE 6
CONSTRUCTION DENSITY IN AN HOA 4 NEIGHBOURHOOD IN 2006 (LEFT) AND 2014. THE FORMER CANAL ALONG NGUYEN VAN CU ROAD CAN BE SEEN AS A GREEN STRIP IN THE VIEW ON THE LEFT.

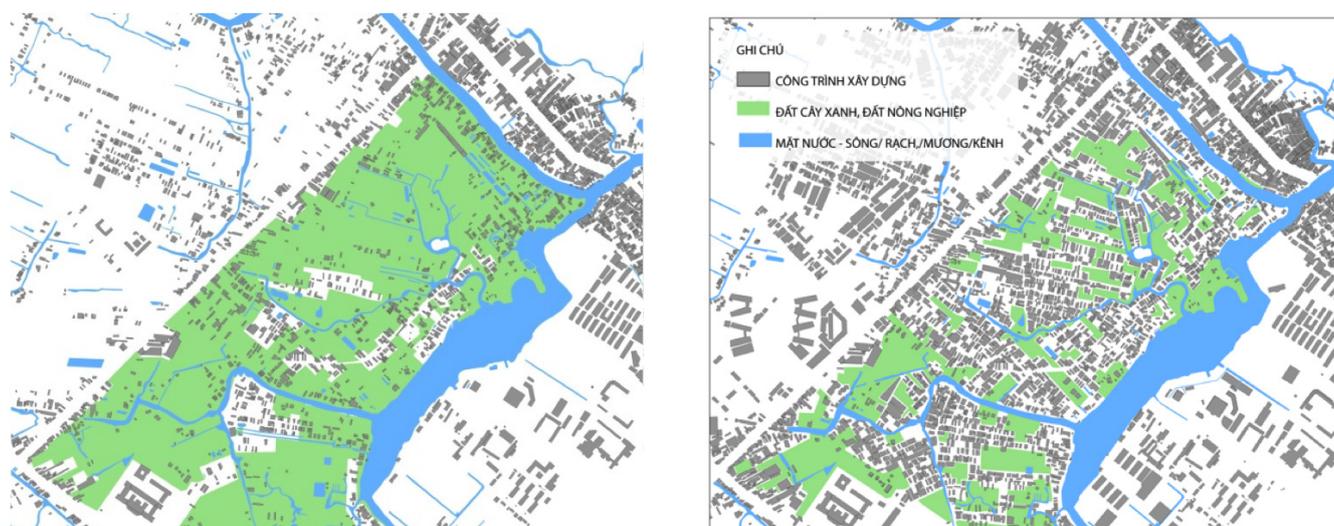


TABLE 6
LAND USE TRANSFORMATION IN AN HOA 4 NEIGHBOURHOOD

Land-use type	2004		2006		2014	
	Area (m ²)	Percentage (%)	Area (m ²)	Percentage (%)	Area (m ²)	Percentage (%)
Building	379,417	53.00	440,549	61.60	536,018	74.90
- Residential housing	158,538		247,113		306,035	
- Infrastructure, public building	220,879		193,436		229,983	
Vegetation (paddy field, orchard, etc.)	187,668	26.20	150,709	21.10	20,808	2.90
Water surface	92,639	12.90	68,019	9.50	30,598	4.30
Road surface	55,989	7.80	56,433	7.90	128,286	17.90
* Total	715,710	100.00	715,710	100.00	715,710	100.00

increase in sea level, and increasing variability in seasonal water flows in the river. The problem of high water levels in Can Tho will very likely get worse in the coming decades.

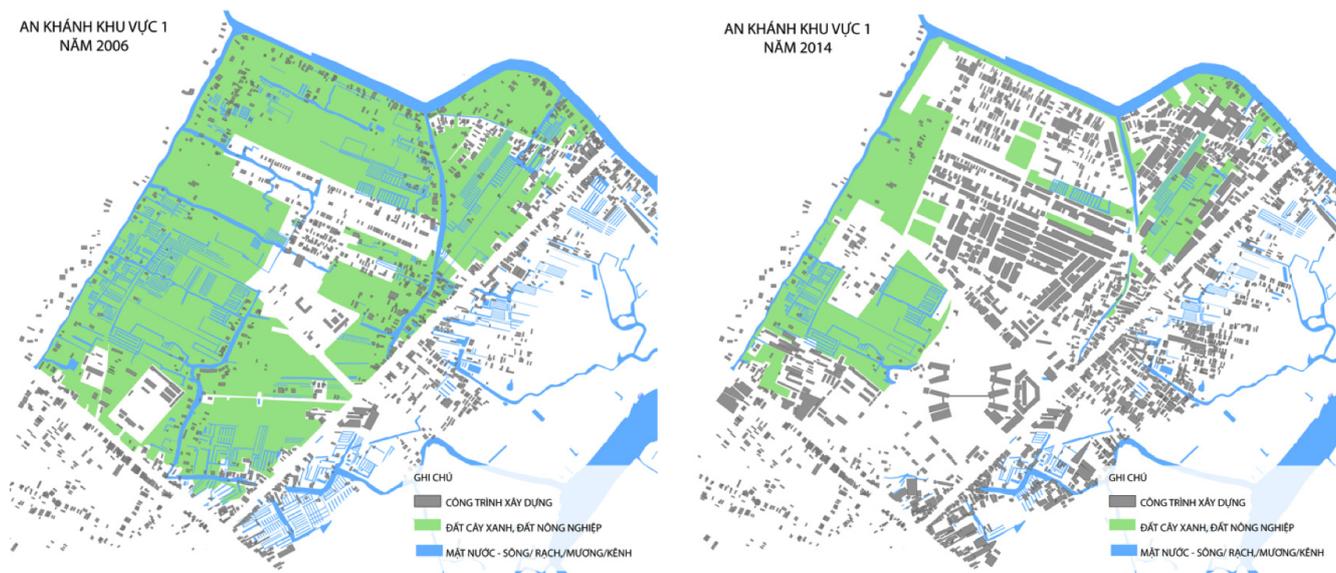
Urban development in case study sites

All three study sites are in newly developed areas on the edge of the central city district. Interviews and household surveys suggest that around 90% of current residents have settled in these areas since the year 2000.

An Hoa 4

This area is located to the north of Nguyen Van Cu Road, which is a major arterial in this part of the city, connecting two sections of highway 91, which runs along the Hau River upstream to An Giang and the Cambodia border, and downstream to connect to National Highway 1A just outside the city. The street runs southwest from the Hau river for about 10 kilometers. The original part of this road at the eastern end was built before 1975, and at that time was about 20 m wide, with small residential areas on each side and mostly temporary houses, gardens, orchards and drainage canals beyond. The

FIGURE 7
CHANGE IN BUILDING DENSITY IN AN KHANH 1 NEIGHBOURHOOD FROM 2006 (LEFT) TO 2014



road was built with fill excavated from a drainage canal that ran alongside the road along most of its length at the time. This drainage canal was used for storm runoff and domestic wastewater. Heavy rains and tidal floods would affect the water level in the canal, but would quickly drain northward to the Sao Canal, the major waterway in this district of the city. Until 2006, the elevation of the road was about 1.75-1.80 m, with surrounding areas slightly lower at 1.35-1.50 m. After 2002, the area started to grow quickly, with many new buildings erected and larger commercial and service complexes developed such as the Medical University, Can Tho Technical and Economic College, pharmaceutical factory, primary school and local government offices.

Starting in 2006, Nguyen Van Cu Road was widened to 34 m to help relieve traffic congestion, by filling in the canal running alongside the street. A new master plan was developed for Center III An Hoa – An Thoi urban area at a scale of 1:2000, and in late 2013 the road and commercial areas along the road were further upgraded, and a new drainage system installed. By that time the road elevation was increased to 2.3-2.4 m, while the average elevation of the surrounding area had changed little. The new commercial and public buildings were typically built at a foundation level of 2.0 – 2.1 m over this period. In the past 5 years, as this construction has been

implemented, flooding has become progressively worse in An Hoa 4 during heavy rains. Rainwater runs off roofs of the large commercial structures and off the road surface. The stormwater drains along Nguyen Van Cu are inadequate, and excess water drains mostly into the surrounding neighbourhood, where water levels can reach 40 cm in some streets. This floodwater drains slowly after the rain stops.

The older drainage system in the main streets of An Hoa 4 neighbourhood does not connect with the new storm drains installed in the elevated Nguyen Van Cu Road, because the newer system is built to a different design elevation and upgraded standard for trunk stormwater mains, so it is higher than the existing drains, rendering them almost useless for stormwater drainage.

An Khanh 1

This neighbourhood lies to the south and west of An Hoa 4, on the same side of Nguyen Van Cu Road. In 1994, Nguyen Van Cu was extended into this area of rice paddies, orchards and gardens. Average elevation of the surrounding area was about 1.2-1.4 m and most people lived along the existing network of waterways in low density rural housing. In order to build the road, some waterways connecting Sao Canal and Tu Ho Canal to Bun Xang Lake were

TABLE 7
LAND USE TRANSFORMATION IN AN HOA 4 NEIGHBOURHOOD

Land-use type	2002		2014	
	Area (m ²)	Percentage (%)	Area (m ²)	Percentage (%)
Building	379,417	53.00	440,549	61.60
- Residential housing	158,538		247,113	
- Infrastructure, public building	220,879		193,436	
Vegetation (paddy field, orchard, etc.)	187,668	26.20	150,709	21.10
Water surface	92,639	12.90	68,019	9.50
Road surface	55,989	7.80	56,433	7.90
* Total	715,710	100.00	715,710	100.00

filled. The elevation of Nguyen Van Cu Road was 1.75-1.85 m when this section was built. Until 2002, there was limited construction in this area. During times of heavy rain, water was not able to discharge easily to natural waterways in this area so drainage was limited and small floods occurred occasionally. High seasonal tides combined with floodwater flows in October also sometimes led to inundation of surrounding paddy fields and low-lying roads, but did not affect houses which were either at a higher elevation or protected by small embankments.

From 2002 to 2006, construction planning of the area along both sides of Nguyen Van Cu Road took place. Several residential resettlement areas were planned and built in different parts of An Khanh 1 and many commercial and residential blocks were built, including government offices. There was a sharp increase in the building density along with efforts to raise the ground elevation and fill small ditches and canals for the constructions of new buildings. The planned neighbourhood was being elevated to a level of 2.2 m, and concrete drainage pipes installed, so there were no problems with flooding through this period.

From 2006 to 2014, the number of office buildings and houses in the area increased dramatically. Another resettlement area was planned and built to accommodate residents relocated from large scale construction projects elsewhere in the city. In addition, residential accommodation was planned for residents resettled from the nearby 15-ha site of the new Medicine and Pharmacy University.

During this period, small localized floods occurred during heavy rains mainly as a result of poor solid waste management and lack of maintenance of storm drains and sewer system.

An Khanh 2 and 3

These neighbourhoods lie on the opposite side of Nguyen Van Cu Road, between the road and Bun Xang lake. This is a low-lying area (0.8-1.2 m in elevation) that had previously been mostly wetlands with limited agricultural activity. Parts of this area were included in detailed construction planning during 2002-2006, but unlike in An Khanh 1 the plans were never implemented. No formal drainage or road infrastructure was designed and built. Instead, residents moved in to this area autonomously and started to build their own houses. Excavations to obtain fill to raise foundation levels were ad hoc, and there was no consistent design elevation. After 2006, the commercial and institutional developments along Nguyen Van Cu raised the elevation of ground to the north. The city failed to develop a consistent urban construction plan for this area, but autonomous development continued at a rapid pace, even though urban infrastructure was limited and of low quality.

Flooding in An Khanh 2 and 3 has become a bigger problem. Floods occur both because of heavy rains and drainage from the higher commercial areas to the north, along Nguyen Van Cu road, but also due to tidal floods entering through the canal system to Bun Xang lake and raising the lake level. Drainage

FIGURE 8
CHANGES IN DENSITY OF DEVELOPMENT THROUGH AUTONOMOUS CONSTRUCTION IN AN KHANH 2 AND 3 FROM 2006 (LEFT) TO 2014

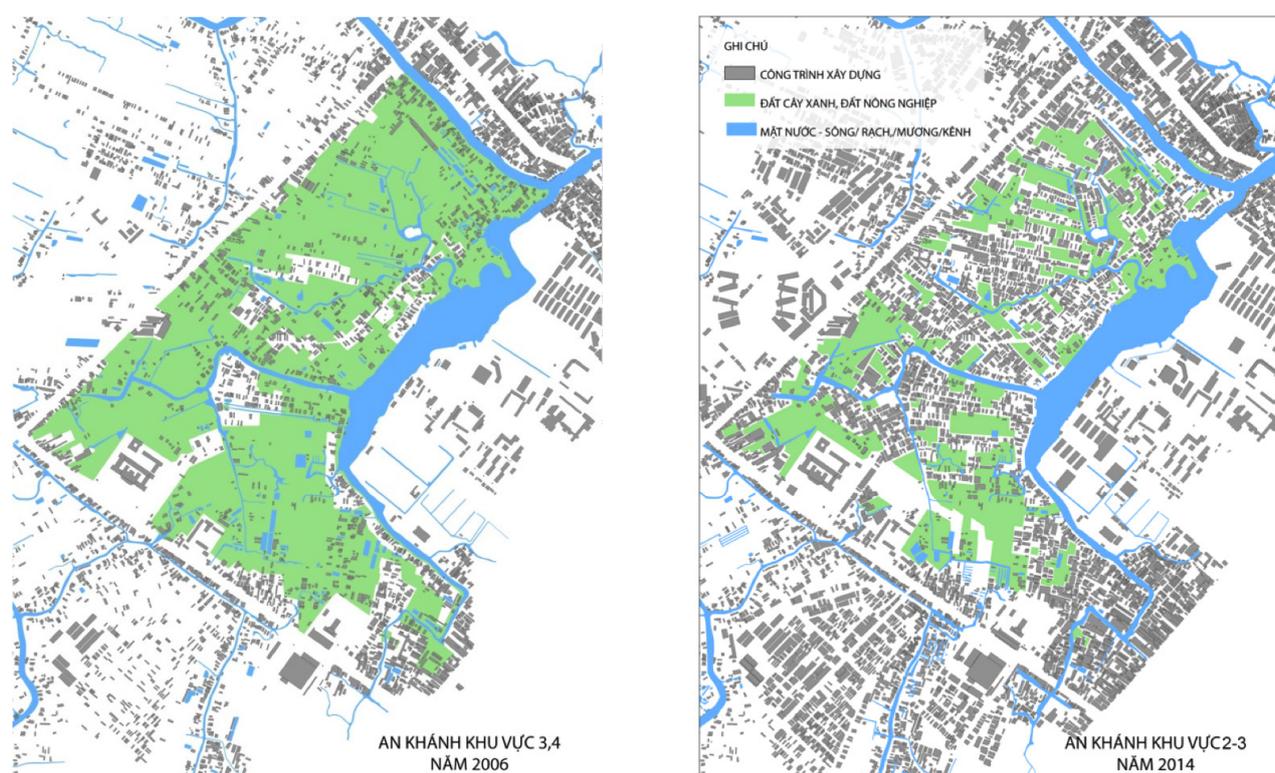


TABLE 8
LAND USE TRANSFORMATION IN AN KHANH 2 AND 3, 2006-2014

Land-use type	2006		2014	
	Area (m ²)	Percentage (%)	Area (m ²)	Percentage (%)
Building	508,813	22.90	1,124,655	50.60
- Residential housing	354,360		590,808	
- Infrastructure, public building	154,453		533,847	
Vegetation (paddy field, orchard...)	1,208,428	54.40	605,634	27.30
Water surface	298,322	13.40	285,274	12.80
Road surface	205,148	9.20	205,148	9.20
* Total	2,220,711	100.00	2,220,711	100.00

is very poor and the area remains flooded for long periods as a result.

Flood experience in case study sites and localized causes of flooding

An Hoa 4

In the year 2000, there was a natural waterway connecting what is now neighbourhood 4 of An Hoa

ward with the Sao Canal. At that time, it was not part of the city, and characterized mostly by fruit orchards and small drainage channels. During the flood season, some parts of the area were typically flooded twice a day because of the tidal cycle. Since 2000, the population has increased by about 15 times, and the area has become highly urbanized. New construction has emerged autonomously, without a coordinating plan, and small drainage

FIGURE 9
FLOODING CAUSED BY RAIN IN 256 ALLEY, AN HOA 4, 2014



ditches and canals have been filled in. A combined drainage / sewage system was installed very early, but it was too small and it no longer connects to the newer, larger sewage network installed along Nguyen Van Cu road, which was built to a different standard, so the drainage system does not function.

Uncoordinated residential construction in this area has taken the form of many new houses being built at a higher level than existing ones, forcing some residents to raise the floor level of their houses by up to 1 meter. Local residents agree that while the area is affected somewhat by tidal flooding, a bigger problem is heavy rain. There is inadequate drainage in the area, so rain backs up into the street. If heavy rains combine with high tides, flooding can last for up to 12 hours, disrupting residential traffic, requiring residents to relocate furnishings, creating unsanitary conditions and affecting public health and living conditions.

An Khanh 1

In neighbourhood 1 of An Khanh ward, many of the households were resettled and relocated to this area as a result of urban redevelopment in other parts of the city. Most of these residents have very small plots of land, or live in multi-storey buildings. However, this area was developed by the city according to an approved plan that included installation of combined stormwater and sanitary sewer drains. As a result, they have few problems with flooding.

An Khanh 2 and 3

Flooding is exacerbated by inconsistent ground elevation levels. Newer houses are typically built with higher ground level than older ones, using fill from local or outside sources. Most of the natural drainage channels in the area have been filled or blocked, and there is very limited drainage infrastructure, so drainage runs over the surface and collects in the lower areas of the neighbourhood before running into the lake and raising its level. Stagnant water collects in low areas around the neighbourhood, including those older residential properties that are lower in elevation than the more recently built ones.

In the absence of effective local government services or infrastructure, local residents adopt their own autonomous measures to try to control flooding, if they can afford these, such as:

- Raising floor levels on house (e.g. by adding masonry and concrete pad, e.g. Fig 10)
- Building embankment or flood wall around property
- Using sandbags to build temporary wall to divert floodwaters
- Pumping water out of garden
- As a last resort, raising furniture and electrical appliances inside the house to avoid flooding (Fig 11)

FIGURE 10
HOUSE WITH RAISED FLOOR



Nguyen Ngoc Huy, ISET

As of 2015, the local government (district and city level) had not implemented any plans to improve infrastructure or urban development in An Khanh, despite many complaints by local residents and familiarity with the problems. Local government solution to seasonal and tidal flooding has been to raise the level of main roads by up to 40-50 cm in the central city. This has meant that property owners along these streets are faced with the expense of raising the sidewalks and entryways of their own property, wherever possible, or designing steps or ramps and flood barriers if they cannot raise the threshold level. The local government does not pay for these costs because in its experience, it does not need to. If they raise the street level, individual property owners are more or less forced to invest their own funds to match the new level. In smaller side streets and alleys, the local government does not invest in infrastructure and encourages local residents to raise the elevation of these streets themselves, through collecting and applying used masonry and sand from building demolition and construction projects nearby. In some cases, the local government has invested in isolated drainage channel maintenance or construction of storm drains, but there is no overall coordinated network for these in An Khanh 2 and 3.

FIGURE 10
HOUSEHOLD FURNISHINGS RAISED OFF THE FLOOR TO PREVENT FLOOD DAMAGE



Vietnamnet

Urban planning, development and flooding in Can Tho

From the analysis of flooding in these study sites, we conclude that while city-wide flooding in Can Tho is linked to seasonal high tides during periods of high river flow, in these specific neighbourhoods flooding may also be the result of heavy rains and lack of drainage. So, for example the impacts from high water levels in 2011 and 2013 events were not significant in An Hoa or in An Khanh 1, but had major impact in An Khanh 2 and 3 from tidal water levels penetrating into the neighbourhood. On the other hand, An Hoa is heavily affected by rainfall, as are An Khanh 2 and 3.

There are commonalities and differences between these areas in the way that they have been planned and developed. In general, the process of developing and approving plans is similar to other cities:

- An urban master plan is undertaken by consultants at the direction of the provincial government. Prior to 2004, Can Tho city was under the administration of the province, so the original master plan was prepared by the provincial DoC, and approved by the Prime Minister's office (2002).
- Overall direction for planning comes from the city's People's Committee, but once detail plans are prepared the community is typically

consulted to provide feedback, according to the DoC. Notes from such consultation meetings are typically submitted to the People's Council to demonstrate community concerns

- Local concerns are usually not about technical issues such as drainage or infrastructure, but more about which households may be relocated as a result of development, and the terms of compensation and benefits
- While the urban master plan is approved by the provincial People's Committee and Prime Minister's Office, in Can Tho detail plans and construction plans can be approved by the DoC at the district level (this is different from other Da Nang, which requires provincial level approval)
- Prior to infrastructure construction or development approval, land use is formally amended from agriculture to urban uses (commercial / residential / industrial), and a detail plan is prepared at scale 1:2000 first, and then a construction / site plan at 1:500. In principle, detailed area plans and construction plans should follow the master plan. These plans provide for the staging of infrastructure construction, residential and commercial development and control site design, elevations and construction standards for infrastructure and buildings.

For example, when Nguyen Van Cu Road was expanded starting in 2006, the city acquired land along the road and had the opportunity to assemble agricultural land, reclassify it for urban use and then lease it for commercial development, or provide it to the national government to develop for public services (police, clinic, new Medical and Pharmacy University, etc.). In addition, the city government needed to resettle residents displaced by this development and by others in various parts of the city, so the adjacent site of An Khanh 1 was designated as a resettlement area. There was a detail plan and construction plans prepared for the land along Nguyen Van Cu and for An Khanh 1. All these areas were levelled to a new standard

elevation at the time, and roads and drainage infrastructure were installed to these standard levels for the new construction over the following years as they were built. An Khanh 1 is now a high density, fully-served community with relatively minor flood problems that stem mainly from inadequate drain size and poor drain maintenance.

Impacts of new construction not considered

The problem with this approach is that no attempt is made to connect the newly planned area to the existing areas around it. For example, the new drainage system installed when Nguyen Van Cu was widened and raised is physically incompatible with the old, existing drainage system in An Hoa 4. They are installed at different elevations and do not effectively connect, so the drains in An Hoa 4 (which were limited to begin with) are now almost useless. The new construction was planned to prevailing standards, as required under national legislation, but no consideration was given to the problems this created for adjacent urban areas. The drainage met the requirements for the new project and new standard, but construction of the road to this new standard resulted in the filling of the previous drainage canal and blocking drainage from the existing An Hoa 4 community. As a result, the road serves as a drainage barrier and runoff now flows into the surrounding community when it rains. While this was not the intent of the new standards, it is a clear result of how they were implemented.

And the problem does not end with completion of construction. Elevation standards continue to be revised with new flood experience. New projects now are built at even higher elevations.

In the same area, there are multiple standards for elevation historically. Standards have changed at least 3 times since 2000, and they still vary between different parts of the city. So there is often confusion about the correct elevation even in planned areas.

Furthermore, the standards specify only the minimum elevation. Developers or builders can

opt to fill their site even higher, as the new Medical and Pharmacy University did. Large public sector developments are reported by local officials and community members as some of the worst offenders in terms of blocking drainage channels, because of their size and because when they face budget constraints, drainage infrastructure is typically the first thing they cut. The formal planning system does not emphasize either drainage or flood retention functions, but instead relies on surface elevation as the key consideration in flood prevention. The result of this preoccupation with surface elevation is that drainage patterns become disrupted as new construction is higher than existing development, leading to unpredictable surface flows, especially from large sites, and flooding in lower areas. Raising the standard elevation for new construction does not solve the problem, it just shifts it somewhere else.

“Waiting for a plan”

A draft plan was also prepared for An Khanh 2 and 3, but it was never completed or implemented. No small-scale construction plan was prepared, and there was no investment in infrastructure or ground elevation in that area. In local terms, this area was “waiting for a plan”. Because the area is low-lying, there was no major private or public sector developer interested in investing here, so no pressure to complete a plan.

In principle, where there is no approved urban land uses, such as in An Khanh 2 and 3, no urban development should be permitted. But when an urban area such as this is generally designated for new urban land uses, but not yet planned, or even when it is still designated as agricultural land inside the urban boundary, residents who have agricultural use rights to the land (“red book”) can apply to the district DoNRE office to have their parcel re-classified as residential land to accommodate their existing residence. But they will charge a fee of VND 1.7 million/m² for this service (approx. \$US 80). So a small plot of 1000 m² would cost \$80,000 to convert. This is a huge expense, and would have to be financed by the owners. However,

it is recoverable through land sales, so it’s not difficult to finance.

And once classified as residential, it is perfectly legal to subdivide the land and transfer use rights to others on the private market. If they hold legal title (and sometimes even if they do not) the new owners can then get official approval to build a residence.

So while waiting for a plan, local land owners lost patience after 2006 and started to subdivide their agricultural land holdings, even though there was no formal construction plan or infrastructure services in the area. Land parcels were subdivided into plots as small as 30 m². There was an active speculative land market in the area and some plots changed hands dozens of times, with or without structures on them.

Even though there is no plan for the area, and no approved urban land use, it is therefore possible for residents to legally subdivide land and for new owners to obtain permission for construction (even though in principle this should not happen). It also happens that people just build a house with no title, and no formal construction approval or license (i.e. completely illegal). Construction is approved by the district level, but inspection is done by the ward, and there is poor communication between them, so the inspector cannot tell if a newly built house is legal or illegal. The difference in land price for a property with red book and one without (i.e. informal / illegal occupancy) is about 2 million VND/m². This reflects mainly the cost of obtaining DoNRE approval for conversion on a parcel-by-parcel basis as the risk of government expropriation or eviction from illegally occupied land is quite small.

New owners built houses without adequate access or drainage. No attention was paid to ground elevation, which was chosen largely based on personal priority and financial capacity. Some houses were built on the surface, some were elevated 40 cm, others were elevated as much as 1 m above the surrounding area. From 2006-2014

the area developed very quickly in this autonomous fashion. In general, as flooding became more severe over this period, newer houses tended to be built higher than older ones. Canals were blocked randomly, low walls and small berms or barriers were built by owners according to their financial capacity, and the drainage problems became worse. Uncoordinated autonomous flood responses led to more flooding in the narrow streets and lanes, leading to a vicious cycle of further investment in protective and diversionary measures, and worsening the situation for the poorest residents.

Can Tho flood risk and urban planning – Summary of the case study

Can Tho is a very low-lying and poorly drained city. It has historically been subject to seasonal flooding from high water flows in the lower Mekong River system, combined sometimes with heavy rains. In recent years, tidal flooding has played a more important role as a source of inundation, exacerbated by widespread land subsidence due to over-extraction of groundwater throughout the delta. But in our study areas, it is clear that planning and urban development processes play a major role in worsening flood risks for some residents.

The influence of urban planning and development practices takes several forms. Where detailed construction plans are completed for entire neighbourhoods and construction is staged and approved in line with the plans, with careful attention to drainage system investments, flood risks in those neighbourhoods are generally low. However, because planning and construction are driven by standards rather than by functional linkages to the surrounding area, new construction frequently increases flood risks for existing, older urban areas. Natural drainage and flood retention areas that previously served adjacent areas are filled, and new drainage systems are not designed to accommodate runoff from the adjacent urban area. The emphasis on ground elevation, instead of functional regional drainage, as a solution to

flooding only serves to increase the problem, as new construction creates or worsens drainage problems for other surrounding areas.

The planning problems point to a lack of coordination of detailed plans with broader regional and city-level infrastructure plans. Major public developments, such as universities or government buildings, are not required to protect or replace natural drainage systems. Neither is there a long-term, city-wide drainage plan and sufficient financing to gradually introduce improvements over a period of decades. The drainage problems cannot be solved by piecemeal measures such as raising ground or road elevation. These provide temporary local relief by shifting the problem somewhere else.

At the same time, some areas are developing informally because they have had no plans at all, and because construction regulations are not enforced. In these areas, there is no planning, yet neither are they protected from development. There is no clear prohibition to construction, but neither is there any guidance for where and how to build, nor is there any public investment in services. Construction proceeds but it is quasi-legal. Infrastructure services are inadequate or non-existent.

Can Tho faces increasing flood pressure from rising sea level, heavier local rainfalls and unpredictable seasonal flows in the lower Mekong River system, all due to climate change. But current systems of land management and urban planning are incapable even of coping with existing flood problems. There is not yet a consistent, city-wide drainage plan that can sensibly be implemented over time. And the drainage problems are getting worse because the city does not protect valuable natural flood channels, retention areas, and low-lying land from development.

HUE



Hue is one of the cities most affected by natural disasters in Vietnam. The city experiences two to three flood and inundation events a year, mostly in the rainy months from September to December. Residents in Hue are familiar with these incidents and are confident that they can adapt to these types of floods with their own experience. However, in recent years, floods and inundation have become complicated and unusual, causing considerable impacts on local livelihoods and urban life (M-BRACE, 2013).

There are three main causes of floods and inundation in Hue City. Firstly, Hue is located in the tropical monsoon climate area where maritime climate and continental climate meet, near the Pacific storm center. The city experiences storms and tropical lows with heavy rains and an annual rainfall averaging between 2,700mm to 2,800mm.

Secondly, Hue is located at a low elevation in the downstream area of the Huong River, which is a short and steep river subject to flash flooding. When river flood and high tide happen at the same time, drainage will be affected. As a result, Hue often has to face inundation in the inner city, suburban areas, and at the nearby coastal lagoons (M-BRACE, 2014).

Thirdly, urbanization and the construction of upstream reservoirs have resulted in major changes in the pattern of floods and inundation, and have significantly impacted the lives of community residents. The conversion of agricultural land

for new residential area development did not adequately address flood drainage. In addition, the construction of hydropower works upstream of the Huong river has also altered the flooding patterns and affects communities downstream. The drainage works were constructed without proper consideration of flood peaks and flood direction, leading to an increase in duration and depth of flood in low-lying areas, rice fields and vegetable fields.

This case study focuses on flooding in the area of An Van Duong, to the east of the current central city of Hue. An Van Duong is a large “new town” development intended to house up to 60,000 people in an area of 1,700 ha. It covers part of Hue City, Huong Thuy and Phu Vang districts. It was designed as a new modern urban area to include residential quarters and small scale production facilities, commercial centres, and sports and recreation centres with tourism and health resort services. The development was planned in four zones, each with a different functional specialization. The location is shown below in Fig 11.

The plan for An Van Duong was approved by the provincial People’s Council of Thua Thien Hue province in 2005, which led to investment by the provincial government in technical infrastructure and development, mainly through fill and land levelling. Prior to development, this area consisted of rice paddies at low elevation (0.1-1.5 m). During seasonal floods, the Huong River rises in the central city and water flows back up the small tributary channels in the floodplain. Historically,

FIGURE 11
LOCATION OF AN VAN DUONG NEW TOWN. CENTRAL HUE CITY LIES ALONG
THE HUONG RIVER IN THE CENTRE OF THE MAP



these flood waters would overflow into the low-lying agricultural fields outside the city to the north and east, and from these drain slowly into the lagoon. This agricultural area therefore served important flood drainage and retention functions before An Van Duong was built.

The Hue case study examines the experience of flooding in 2009 and 2013, describing the chronology of those floods and exploring the causal factors involved. The role of urban development in An Van Duong is clearly identified here. We also explore the planning process and decision-making that led to the construction of this new district, and identify how those steps contributed to increasing flood risk in other parts of the city.

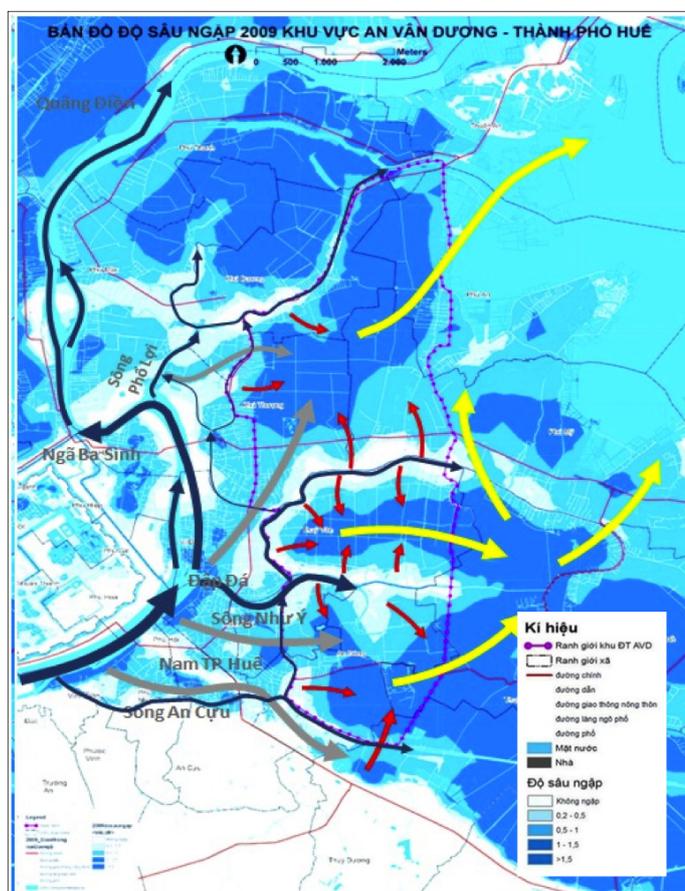
Methodology

Information related to the floods and flood paths, and hydrometeorological data were collected and

synthesized from the research of the M-BRACE and JICA projects. Information about urban infrastructure was collected from the Hue Planning Institute, the Department of Construction, and the New Urban Development Management Board, and from the project on Adjusting Hue City Master Plan funded by KOICA (JICA, 2011; KOICA, 2013). The current data of the research area were synthesized and analyzed with ArcGIS tool. The research team reviewed the buildings and infrastructure from 2006 for impact analysis. In particular, information about the elevation and the 2009 flood map of the M-BRACE project were used to identify priority areas for surveys and in-depth interviews.

The team also interviewed ward-level officials in charge of areas such as land administration, transportation infrastructure, water supply and drainage, agriculture and flood and storm prevention, and chiefs of the frequently flooded

FIGURE 12
SEPT 29, 2009 FLOOD FLOWS, WATER DEPTH (DARK BLUE IS DEEPER) AND DRAINAGE DIRECTION



villages. On this basis, the research team interviewed 25 households in the flooded areas to clarify and verify the information. The research team used information from the flood models, information from the community and ground elevation from the planning maps and topographical maps to draw cross sections to describe the cause of the changes in the flood patterns. Finally, the team conducted consultations with experts on the research results to review, evaluate and reconfirm the conclusions to improve their reliability and usefulness for managers.

Description of flood events

Flooding in 2009

From September 24–26, 2009, typhoon Ketsana intensified to level 13–14 on its way across the East Sea to the central coast of Vietnam. The typhoon caused heavy rain in a large area from Quang Binh to Quang Ngai province. About 400–600mm of

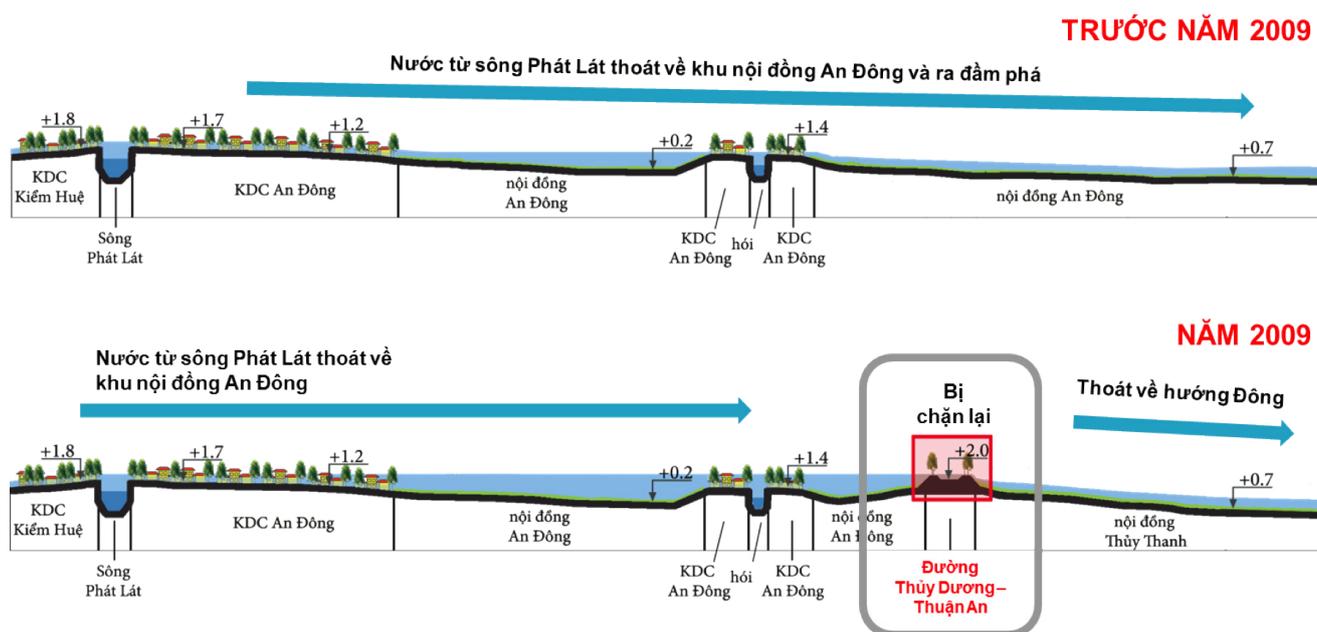
rainfall was recorded at locations from Quang Ngai to Thua Thien Hue province, and in the mountainous area of Thua Thien Hue province reached accumulations over 880 mm. Due to prolonged heavy rainfall, extreme flooding occurred on many rivers in Central Vietnam. By 7am on 29 September, water levels had reached or surpassed safety thresholds at several reservoirs and hydropower dams upstream, causing emergency water releases. The Huong River at Kim Long station reached 3.13 m that morning, or 0.13 m over warning level 3 (CFSC, 2009). The flood started to overflow the river at the city centre in the Southeast, gradually rising up the small tributary channels and overflowing the dikes and riverbanks along these channels throughout the city. By 8 pm, the recorded water level at the Kim Long station had reached 4.57 m, and water was flowing into many low-lying parts of the city, where it accumulated. The floodwaters disbursed to the east and north, flowing into the An Van Duong development site and from there across agricultural fields towards the lagoon (see Fig 12).

By the morning of Oct 1, 2009, when the typhoon had passed, many areas of the city were still deeply flooded, and rural villages downstream of the city, or between the city and the lagoon, remained isolated for several days.

Flooding in 2013

The 2013 flood was not caused by a prolonged period of heavy rain in the Huong watershed. Instead, it was caused mainly by heavy rain in the city itself. On Nov 7, 2013 super typhoon Haiyan (typhoon #14 in Vietnam) started to affect central Vietnam, causing heavy rains in the upstream areas and leading to reservoir releases from hydro dams. These did not cause flooding in the city, but did affect surrounding low-lying agricultural areas and ensured that the area surrounding the city was saturated with moisture. Then on Nov 14, the rainband from approaching typhoon #15 caused heavy

FIGURE 13
CROSS SECTION OF AN CUU CITY AND SURROUNDING AREA BEFORE 2009 AND DURING THE 2009 FLOOD, SHOWING HOW CONSTRUCTION BLOCKED THE PREVIOUS OVERLAND FLOW OF FLOODWATER.



precipitation along the coast. In Hue, it rained continuously and heavily throughout Nov 14 day and night, and on Nov 15 between 4 and 7 pm over 185 mm of rain was recorded in Hue city. The accumulation of rainfall led to extensive flooding of the city's street network to a depth of 30–50 cm, tying up afternoon traffic for hours. Flooding in the western part of the An Van Duong development zone reached depths of 0.5–1 m in many places, and persisted for more than two days.

Factors affecting flooding in An Van Duong

Part of the cause for flooding in 2009 was clearly related to emergency releases from upstream hydro reservoirs. In the basin of Binh Dien reservoir, the total rainfall from September 29 to October 1, 2009 was 564mm. The water level of Binh Dien reservoir before the flood on September 27, 2009 was +68m, and peaked at +81m at 19:00 on September 29. Two of the five control floodgates were not operating properly, and could not be set to variable flow rates. The three operating gates were not sufficient to lower reservoir levels under the heavy rainfall conditions that day. Therefore, when the water level of the reservoir reached a peak of 81m (8m higher than design crest level), the plant

had to fully open all five floodgates with a discharge flow of 4,500m³/s. In principle, the protocols for reservoir management should allow for gradual and controlled release of water, even under heavy rainfall, so as to modulate the downstream effects of flooding. However, due to the heavy and prolonged rains combined with the malfunctioning floodgates, the actual operation led to a sudden surge in downstream water level.

The development of An Van Duong new town also played a key role in contributing to localized flooding in that area. The process of raising agricultural land in the floodplain for urban development altered the elevation profile of An Van Duong as a natural flood retention areas and increased localized flooding in many residential areas here. From 2006 to 2009, in An Dong ward, the elevation was raised to +1.7m to + 2.3m to build the An Cuu City new urban area, part of southernmost Zone A of An Van Duong, directly to the east of the central city. The filling of agricultural land to develop An Cuu city was not matched with construction of improved drainage systems. This caused localized flooding in An Dong ward, because this region has lower elevation (from +1.0m to + 1.5m), as shown in Fig 13.

FIGURE 14
AN CUU CITY DEVELOPMENT AREA IN 2005 (LEFT) AND 2013 (RIGHT). HUE CENTRAL CITY IS TO THE LEFT



When An Cuu city was filled in the period 2005-2008, this prevented the normal overflow of flood waters from the An Cuu and Phat Lat rivers across the floodplain to the agricultural fields beyond the city. Instead, with an elevated urban district blocking previous drainage, the waters increased in depth and flowed slowly back through adjacent residential areas at the outskirts of the city. Drainage was further constrained by the road network constructed for An Cuu and An Van Duong areas, which lacked sufficient drainage culverts, so water was impounded and rose to higher levels in the nearby residential areas (see Fig 18). The existing residential areas surrounding An Cuu were flooded because of the blocked drainage and impoundments caused by the new fill and roadways. Neighbourhood roads, often the lowest elevation areas, were flooded to depths of up to 90 cm for several days in 2009, completely preventing access.

A key barrier was the north-south Thuy Duong – Thuan An road, which was built in the early phases of development of An Van Duong. This road was built to an average elevation 2 m higher than surrounding rice fields. Drainage culverts in the original road construction were completely inadequate to handle flood flows in 2009, or existing culverts were misplaced and not connected to a regional drainage system, so water backed up to the west of the roadway in fields and residential areas, instead of flowing across the low-lying paddy fields and draining east and northward into the lagoon. The effects in Zone A (south) areas of An Van Duong in 2009 can be shown in the cross-sections in Fig. 15.

Local residents to the west of the new road confirmed that prior to 2009, when they had flooding the water levels would rise and then recede quickly, but in the 2009 flood the water levels not only were much deeper, but they did not drain for several days. The new road network in the area had divided the low-lying field of An Dong – Xuan Phu (once the

FIGURE 15
WATER FLOW IN CROSS-SECTION 1B-1B NORTH OF AN CUU CITY, SHOWN IN THE PERIOD BEFORE 2005 AND IN 2009 FLOODS. THE EFFECT OF THE NEW THUY DUONG-THUAN AN ROAD CAN BE SEEN IN THE DEPTH OF WATER BACKED UP BEHIND THE ROAD

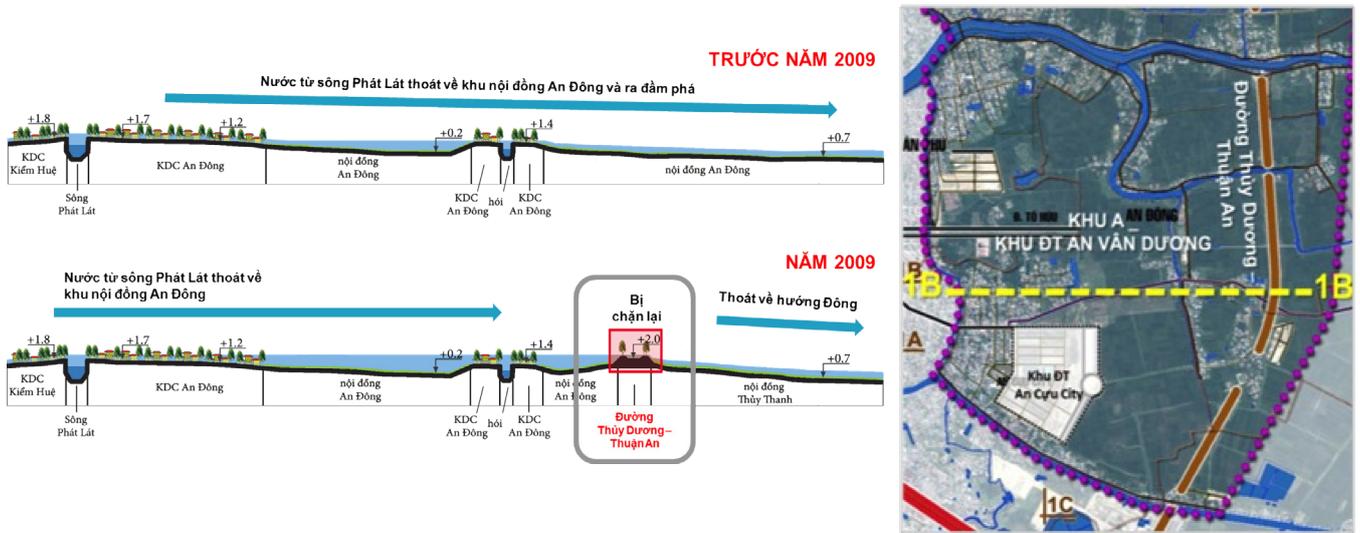


FIGURE 16
ROAD NETWORK AND NEW DEVELOPMENT AREAS (RED) CREATED DEEP WATER FLOOD CELLS (BLUE) IN 2009 FLOODING.



main floodway) into many smaller flood cells (Fig 16).

A similar situation arose in 2013, where the same areas flooded. Additional development had taken place by this time in the northern areas of An Van Duong, preventing overland flow towards the

lagoon to the north and east of the city. Even the newly developed area of An Cuu city experienced some flooding, because the new arterial roads surrounding the city were all built higher than the residential areas, which were flooded to a depth of 30 – 50 cm in 2013. In the neighbouring area of Tam hamlet in Xuan Phu ward, the flooding was at a

depth of 0.5-1.2 m, preventing access to the area for up to 5 days.

In 2013, the provincial road 10A was upgraded and elevated to +2.1m, blocking the drainage of the entire residential area south of the provincial road 10A, including Ngoc Anh, Chiet Bi and Duong Mong villages. Floods frequently affect the local roads in low-lying villages like Ngoc Anh and Chiet Bi. During the 2013 flood event, these roads were under 0.5–1.0m of floodwater for up to 5 days, causing major disruptions to people's daily lives. Meanwhile in other parts of the city, the flood only lasted 1–2 days, and in the city center it was only one evening of November 15, 2013. The same story was repeated in many other areas nearby.

In summary, we can see that while upstream reservoir management failures were a contributing factor in the 2009 flood, for both 2009 and 2013 the urban development practices in An Van Duong had a major impact on nearby residential areas. Fill and levelling of ground elevation, with new construction at different levels than existing residential areas, contributed to blocking the historical floodways, causing flood levels to be higher and drainage to be much slower once the area flooded. The problems were exacerbated by road construction, which was designed at a higher elevation even than the new urban areas, and with insufficient drainage. The key issue in these failures of urban development is that even 8 years after the start of construction in An Van Duong, the drainage system was not functional. Drainage under the new roads was inadequate, drains in different parts of the new development area did not connect with each other to form a coherent drainage network, drains and pipes are of varying sizes and standards, and existing drains are poorly maintained, so they do not function properly. These observations lead to the question of how and why planning decisions in this area were made.

Planning practices in Hue / An Van Duong

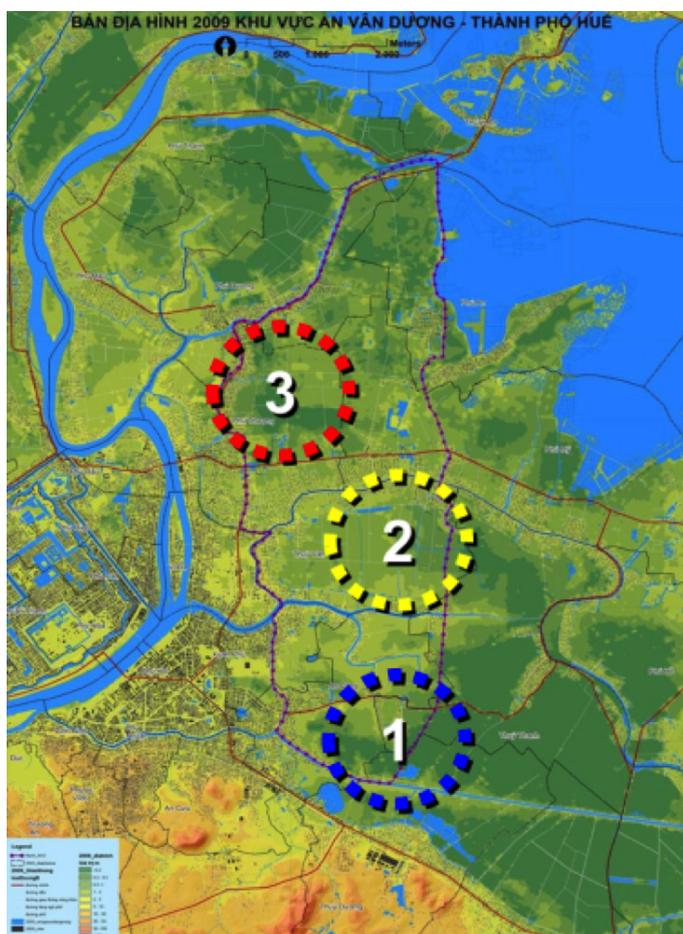
The selection of An Van Duong as the main growth direction for Hue city was not without controversy. When the master plan for An Van Duong was

approved by the provincial People's Committee in 2005, it was already understood that this area was very low-lying, and that Hue city was highly vulnerable to flooding. Concerns were expressed by many professional experts and community leaders about flood risk in this area. However, the selection of this site for urban development reflected an emerging belief at the time that Hue would be protected from further floods by new upstream dams and reservoirs. Hue was badly damaged in the 1999 flood of the Huong River, but after that time, the city government was assured that new upstream dams and reservoirs would protect it from future flooding (an assurance that proved in 2009 to be false). So with this assumption of increased flood security, provincial officials could move forward with plans for urban development in an area that was highly accessible and adjacent to the existing urban core, but very low in elevation.

The topography of the area is shown below in Fig. 17, which illustrates three basins (previously paddy fields) divided by existing floodplain channels and roads. During historical floods, these areas would frequently be inundated to a depth of around 2 m. The small hamlets and residential areas along roads in this area would be built at an elevation of 1.5-2.1 m so less affected by the flooding. When the Huong River flooded, water would rise in the floodplain channels until it overflowed the banks of these streams. Because of natural sedimentation and construction of banks, roads and dikes along the streams, their banks are normally higher than the surrounding landscape, so once they overflow, the water will run overland in the general direction of the lagoon to the north-east. This pattern of water flow was very familiar to local residents, but because flooding was shallow and drainage was rapid, it was not seen as a serious inconvenience.

The master plan for An Van Duong was prepared by VIUP, under the authority of the Ministry of Construction, acting as consultants to the provincial Department of Construction in Thua Thien Hue province, over the period 2003-2005. After the approval of the general plan for the entire

FIGURE 17
TOPOGRAPHIC CHARACTER OF AN VAN DUONG
PRIOR TO DEVELOPMENT, SHOWING 3 PADDY RICE
PRODUCTION BASINS BETWEEN THE CITY AND THE
LAGOON



area by People's Council and People's Committee in 2005, detailed planning was undertaken in 2006 at a scale of 1:2000 for areas A, B and C, starting in the southern-most part of the new development, closest to the centre of Hue city, by the consulting firm VINACONEX, under the supervision of the Department of Construction. The detailed construction plan for Zone A was approved in 2007 by the provincial People's Committee, with Zone B and C following in 2009. Planning for Zone E, on the east side of Thuy Duong – Thuan An road, has been started but was not complete in 2015, and planning for Zone D at the northern end of the development has not been started yet.

Given the well-known vulnerability of Hue city to high rainfall and flooding, drainage and flood

considerations were fundamental to the planning effort. Plan documents suggest that the development of the area should protect existing floodways and ground elevation should be carefully controlled to avoid blocking drainage. The regional drainage network should have been the first infrastructure constructed, to ensure that as other parts of the urban area were built, they would be protected from flood damage.

In the planning program for the An Van Duong area, ground elevations, road elevations and bridge spans over flood drainage areas were carefully specified and specific elevations fixed in the plan. A drainage plan called for preserving existing flood channels and actually increasing the area of drainage ponds, canals and green areas to absorb water. Drains and sewer networks were specified to connect to existing storm drains and sewer mains in the city.

The initial investment in land levelling, servicing and infrastructure development was made by the provincial Department of Construction. They were the investor / client for the planning consultant at this stage. This investment was premised on the idea that such infrastructure investments would make the area more attractive to developers, and costs of completing the infrastructure could be covered from land sales to private developers.

However, in construction, many of the details of drainage and bridge heights were adjusted or postponed to a later stage. Parks and ponds intended as part of the drainage system, and for flood retention, in the new development area have not actually been built yet, so do not function as planned. Flood channels were filled and blocked by roads. Culverts, bridges and drainage areas were not installed in order to save funds when construction costs increased and the pace of land sales and development slowed. Drainage systems that were installed have not been connected to drains in many

cases, because of improper staging of construction, where unnecessary infrastructure (such as Thuy Duong – Thuan An road) was built well before it was needed to serve the development, resulting in needless expenditure and discontinuities in infrastructure construction. The sewage and drainage system remains incomplete because a water treatment plant has not yet been built. As demand for private development and construction in the area failed to materialize, there was no way for the local government to continue its infrastructure investments and construction of roadways and drainage infrastructure remain incomplete.

The incomplete infrastructure and inadequate drainage provisions were a major factor in severe localized flooding in 2009 and 2013. But the flood experience also contributes to the problem. Now that the area's flood vulnerability is widely known, developers are less interested in purchasing land in the area, and construction has slowed further. In addition, any developers who do build in the area seek approval to raise the ground elevation even further to prevent damage to their new construction. This only makes the problems worse for surrounding areas.

The planning for this new urban area was premised on an initial assumption that the area would serve a population of 25,000 by 2010 and 60,000 by 2020. This target was driven mostly by the desire of the provincial government to have Hue attain the status of national level city (Level 1), which required achieving certain minimum population and infrastructure thresholds. Increasing the rank of the city confers economic benefits in the form of greater political authority, authorization for larger city staff and greater fiscal transfers from the central State budget. But at the time Hue's urban population was only around 300,000 and was not growing rapidly. And there were targets for growth in other parts of the city as well, not just An Van Duong. So the population target had little to do with actual migration or population growth levels, or demand for housing. It reflected the planning mentality of the provincial government,

where governments set arbitrary targets for development rather than analyze actual trends. With an economic slowdown around 2010, the growth targets for An Van Duong proved hopelessly optimistic. To date, only 13% of the area has been developed, and most of the basic infrastructure remains unfinished due to lack of funds.

Urban planning, development and flooding in Hue

When plans for An Van Duong were prepared, the flood risks were generally understood. Hue had just recovered from one of the largest floods in its history (1999). Flooding in this area was no surprise, and planning guidelines provided for extensive flood retention and for flood channels and drainage to the lagoon, as well as for artificial drainage systems linked to this network of rivers and flood channels. However, once construction started and the Department of Construction found that there was limited interest from developers in land sales to help recover their development costs, they began to cut corners in an attempt to save time and money. Infrastructure was not completed, drainage investments were postponed, and plans were revised to suit the interests of the few developers prepared to invest in the area.

Part of the problem is that construction and development in An Van Duong was not properly staged. The construction plan called for an initial phase of development that would see construction in each of zones A, B, C and D. Instead of concentrating infrastructure investment in one small area until it was fully developed, this strategy required spreading infrastructure investment over the whole site, particularly development of all major road networks at the beginning of the project, leading to great expense and low efficiency. No effort was made at the outset to determine investor and developer interest in this area, which was widely known locally to be vulnerable to floods and so less attractive for investment. So with little investor interest and an over-extended construction plan, the province quickly ran short of funds and reduced expenditures on drainage in particular.

Without adequate drainage, the newly raised construction areas in An Van Duong served as barriers to flood runoff from high water in the Huong River. The flood in 2009 should have served as a warning and a reminder of the urgency of drainage investments, but instead the disaster was repeated 4 years later, when even more people were affected as the population had increased in the peri-urban area. Drainage was still inadequate in the area, and drainage plans had not been implemented. Roadways blocked flood channels, instead of providing bridges and culverts to allow floodwater flows, creating a pattern of flood cells where water collected to depths of up to 2 m before slowly draining. Runoff from higher elevation roads and development areas flowed down into neighbouring residential communities, collecting in roads and houses and then stagnating there for days.

Hue flood risk and urban planning – Summary of the case study

Hue experienced unusually heavy floods in 2009 and again in 2013. The flooding was most severe in the peri-urban areas to the east of the central city, and some neighbourhoods were inaccessible by road for several days. There were several contributing factors to the severity of the floods, which took place after heavy rains. In the case of the 2009 flood high water flows on the Huong River were partly a result of emergency reservoir releases upstream because of malfunctioning floodgates on a major dam. In 2013, the floods were mostly due to very heavy localized rains. But in both cases, local flooding in the peri-urban area was a direct result of new construction of roads, infrastructure and land elevation raising in An Van Duong.

In Hue, the planning process was driven not by a need to accommodate actual growth, but by a policy objective of achieving the top rank of national level city, because of the political and financial benefits this provides. The site was chosen for its proximity to the central city, on the assumption of reduced flood risk because of upstream dams, with

little consideration of the regional context and the constraints imposed by site topography, relative to other potential development areas. The general plan for An Van Duong, and the subsequent detailed plans (1:2000) included many appropriate drainage measures and designs intended to compensate for the poor location of the site. But the project was much larger than required, and development was spread all over the site at the beginning instead of being carefully staged to allow gradual built-out and cost recovery. As a result, road construction and fill to raise land levels took place throughout the site in a haphazard pattern, and there was insufficient financing to implement the complete drainage plan at the beginning of the project. The result was that the construction in the area itself contributed to worsening the flooding for existing and new residents.

These lessons of urban planning and drainage are apparently not yet learned by the provincial government. In 2012, with Korean funding and technical assistance, an update was made to Hue's urban master plan. In this update, the international consultants recommended that the development of An Van Duong be scaled down, more space in this area be created for drainage channels, and that the northern area of An Van Duong (Zone D) be protected from development completely, to allow for a green belt and floodway connecting the river and the lagoon. When the province submitted its proposed plan to the Prime Minister's office for approval, it kept most of the recommendations of the international consultants, but did not protect Zone D. Instead they suggested this area be raised in elevation for the construction of low density housing, an option that will almost certainly lead to more flooding upstream in the city.

SYNTHESIS AND CONCLUSIONS OF CASE STUDIES: URBAN PLANNING AND FLOOD RISK

Planning system

Government officials in Vietnam give little formal attention to the process of planning. Guidelines for urban planning emphasize the technical considerations that should be included, for example by specifying the ground elevation for future development, rather than the mechanisms for incorporating different kinds of knowledge and sectoral interests, or criteria for making trade-offs and determining priorities consistent with long-term socio-economic development goals. Most physical development plans are undertaken by technical consultants, who are often part of national or provincial planning institutes, rather than city staff. All planning requires trade-offs and priority-setting, but in Vietnam this process is opaque, so the rationale and criteria for decision-making are generally not explicit. Until recently, most plans consisted mainly of maps at different scales, with land use and construction details indicated on the map. The rationale and criteria for planning choices were not generally explained as part of the plan document.

Furthermore, a plan is normally seen as an official document that guides the actions of the agency that prepared it. Plans of all kinds are routinely undertaken as a way to seek political approval for departmental action, and to provide a context for short-term budget and work assignments. However, plans undertaken by one agency, such as the Department of Construction for urban development, are typically not legally binding on other agencies, such as the Department of Transportation,

because of their different mandates. Only the executive level of local government (the Provincial People's Committee) can direct the factors to be considered by other departments. Approval by the PPC of an urban master plan is therefore important in providing long-term guidance for urban development and for strategic decisions on infrastructure investment, most of which are under the control of the Department of Construction, but is only one of the inputs considered by other departments or by senior government agencies in the planning of their own projects. Project design and implementation may be influenced by separate departmental or ministerial guidelines that are unrelated to local planning priorities.

Projects and plans undertaken at a higher level of government are also not subject to the review of lower levels. So a national project, such as a road planned and designed by the Ministry of Transportation, is not subject to local review. In Da Nang, researchers were told that the local government requested a review of the impacts of the ADB5 highway (which in principle is required anyway), but they were rebuffed by the national ministry, who said, in effect, "it's only a road."

Therefore, at every level there are unresolved contradictions between infrastructure planning, design and construction and local urban plans. Flood drainage is the main loser in these contradictions. Despite extensive experience with floods, the approach of segregating planning responsibilities by sector, jurisdiction and level of government virtually precludes coordination.

Political economy is always an issue in urban planning, because the enormous rents from land conversion create incentives to use power for personal or corporate benefit. This is true anywhere, but it is especially problematic in Vietnam because the planning system is not transparent. Decisions about the choice of new urban development sites are made by a small number of people without clear rationale. There is broad scope for discretion in modifying detail plans so that they are no longer consistent with nationally approved master plans. Planning decisions always require choices and setting priorities, which is the responsibility of legitimate political leaders. But when the criteria and rationale for decisions are not clear to a public observer, there may be suspicion of undue influence or benefit. The case studies show examples of how detailed plans have been modified to suit development interests; but also of how planning decisions based on political interests, such as the desire to meet criteria for a higher city rank, can over-rule the interests of private developers and lead to costly outcomes. Finally, the lack of resources for planning and the inconsistent enforcement of land use and planning regulations can lead to much higher future costs for urban development and servicing.

Many urban development companies in Vietnam are private corporations that are owned by the local government. This does not mean that their operations are intended to support public policy objectives. Rather, because government controls much of the financing and approvals process for urban development, these private companies were structured by local governments after land reforms in the early 1990's in order to take advantage of the enormous rents available from urban land development. They behave in most respects as profit-maximizing private entities, despite being government owned. But because developers influence the details of construction planning and detailed site planning, and because of the historical linkages between the executives of government-owned development corporations and local government officials, it is difficult to

determine a clear distinction between the private interests of developers and the public interests of local government. Indeed, local governments (as in other countries) frequently see their political and fiscal interests as aligned with the profit-making interests of developers. Urban development generates direct revenue to local governments through land transactions, creates employment in the low skill construction industry and raises the status of the city, enabling it to make a case for a higher national rank and larger budget from the State. Local governments therefore have strong economic incentives to support development proposals.

Ground elevation and flood management

The standard approach to construction throughout Vietnam has always dealt with flooding, which is a familiar fact of life in many areas of the country. The practice has been to raise the ground level in areas subject to flooding before building new structures or infrastructure. Although more difficult, it is also common to raise the elevation even after construction. Ground floors of multi-storey structures are often built with high ceilings, which allow for raising the floor level if needed.

Local governments take advice from the Hydro-Meteorological Department on estimated maximum flood heights and set ground elevation standards accordingly in planning for new urban areas. These levels are typically set at the 20-30 year historical event (3 – 5% probability), but may be altered periodically based on experience.

However, in the planning process no formal consideration is given to the actual elevation of existing adjacent residential areas. In order for surface runoff to be effective as designed, existing urban areas must be at the same elevation as the new ones. But of course they are generally lower, as we have seen in case studies from both Hue and Da Nang.

The result of this structural approach is that flood risks are redistributed but not eliminated. When low-lying land is filled for construction, even if it is filled above the estimated flood height, the fill itself changes floodwater flow and depth. Unless improved drainage channels and flood ways are provided, this will increase the water depth and displace water to create more flood problems in some other location nearby. With rapid urbanization and changes to construction elevations, these displacement effects are often not recognized by local government or residents until a major flood event catches them by surprise.

These unexpected changes in water flow and depth when new urban development areas are filled mean that traditional flood management and accommodation practices by local residents are no longer effective. Floods become unpredictable, so early warning mechanisms and official flood predictions also become unreliable and residents are unsure how to identify and respond to potential threats. Floodwater depth and velocity increases as a result of impoundments. Riverbank erosion in the remaining unfilled channels is higher because of the greater depth and flow passing through them. Roads that were not previously inundated are now unexpectedly flooded, hindering evacuation and emergency response.

On the other hand, in areas that are developed autonomously by individual property owners, ground elevations and drainage conditions are not regulated through planning controls at all. In these cases, many separate individual improvements to protect from flooding will often prevent proper drainage and worsen the problem, as seen in Can Tho. This approach is also fundamentally inequitable: the poorest and most vulnerable become more vulnerable when autonomous adaptation measures are undertaken by nearby households who can afford them.

These autonomous responses to flooding are only temporary measures. As flooding becomes more severe, and local government fails to implement effective drainage measures, individual households raise their properties or build diversion walls. These

Costs of urban flooding

The losses of human life, injury and property damage from urban flooding are clear. Compared to rural areas hit by natural disaster, urban areas provide more emergency services and better infrastructure to protect from floods. But we can also see from this study that some urban development practices actually increase the risks of flooding. Because of the high densities, high level of investment and the many commercial businesses in urban areas, the damage from flooding is usually larger than in rural areas. In cities, there are many losses that are hard to quantify but very important to the urban economy:

- loss of household income due to inability to get to place of employment or due to closure of businesses
- loss of business income due to closure, logistical failures, power failures and on-site damage
- investment to upgrade houses or raise foundations (for those who can afford)
- damage to city infrastructure and services: increases direct costs to local government
- loss of property value: as flood area expands, commercial value of property affected is reduced
- loss of city reputation and investor confidence

Vietnam's cities would like to present themselves as modern, efficient and secure places to invest. Every major urban flood makes it more difficult to achieve this reputation.

impede drainage and make the flooding even worse, so after a time more walls and fill are needed. This becomes an endless cycle of expense for property owners and does not solve the problem of how to safely manage the water.

A final problem with the method of developing standard elevations for new urban construction is that the historical probabilities used to set safe ground elevations are not a useful guide to the future. Climate change means that extreme rainfall and hydrological events are increasing in intensity and frequency, so the margin of safety provided by the specified elevation of fill is actually less than expected, and declining every year. The problem of flood safe urban development in Vietnam has been presented as mostly a question of establishing the “right” elevation for new construction. Our conclusion is that this approach is fundamentally flawed and insufficient to address urban flood risk.

Contradictions in planning

Another problem discovered in our case studies is that even when high quality master plans are prepared and approved, they are not always used to guide more detailed planning or to control investment. Even after master plans are approved, detailed implementation planning may be modified to serve the needs of developers in building large projects. There seems to be no requirement for detailed planning to be consistent with the approved master plans. Plans can be changed at the request of developers, or at the decision of local government leaders. We can see this kind of change in Hue as the development staging of An Van Duong was altered to encourage investment; and in Da Nang as Hoa Xuan ward was developed in the floodplain despite master plan guidance to protect this area from development.

City leaders do take master plans into consideration in making development decisions. However, other factors often intervene to create a higher priority than flood prevention. In particular, plans are often modified to accommodate the interests of large land owners or developers who are prepared to

make major investments. This is partly because local governments are reliant on the income generated from land sales for a large share of their revenue. This puts them in an inherent conflict of interest: on one hand they are responsible for public security, safety and flood prevention so they should avoid urban development that will increase flood risk. But on the other hand, they also have to generate revenue for local government services and have few options to do this. Short term financial interests often prevail, leaving residents and businesses to bear the long term costs of flooding.

Lack of coordination

One of the purposes of planning is to provide guidance to coordinate many different kinds of investment by different sectors: transport, education, power supply, water supply and drainage. But urban plans do not seem to serve this purpose in the cities studied. The inconsistencies apply at all levels: national guidelines and standards for flood protection and ground elevation are routinely ignored, or exceptions are provided, in local plans. National level projects, such as highways, do not require local review and approval, and pay insufficient attention to local planning requirements, so they end up causing damage by disrupting local drainage patterns. Direction provided in master plans or detailed plans is not always followed in regulating detailed infrastructure investment. As a result, urban development can be fragmentary and inconsistent with construction activities. In particular, we see examples in all three cities of urban development being approved by local authorities in areas that were set aside for flood protection, or road construction that is not coordinated with drainage investments, resulting in prevention of drainage and increased inundation in urban communities. This lack of coordination is not only between technical units at the city / provincial level, but also between provincial and national authorities.

Lack of investment in drainage

The lack of public investment in drainage causes major damage to private properties, homes and businesses. In some cases, even when drainage infrastructure was built, it was ineffective because of poor construction, inconsistent alignment with existing drains, or lack of suitable valves and gates. Because there is very limited consultation about planning and infrastructure investment priorities with property owners or residents, and limited public information about infrastructure investment plans, individual owners do not know what the local government will do about the problem and are forced to invest their own funds to try to find a solution. These autonomous solutions are costly, and make the problems worse for those who cannot afford to invest in costly improvements to their own houses. Often, the resulting water flow is not rational or desirable from a public perspective (e.g. may divert water away from drainage canal), making solutions more costly for all.

In new urban development areas, new infrastructure and landfill are very expensive. In order to recover costs, the local government must be able to sell land to developers. So the key challenge becomes one of financing: how to build sufficient infrastructure to attract developer interest, but not so much that future investments are constrained by lack of funds. In the cities we examined, this balance was not achieved. Local governments tended to assume that they could sell as much land as they wished. When major investments in road infrastructure did not lead to land sales, the local government ran out of funds for drainage infrastructure, and so became vulnerable to inundation in heavy rains or flood conditions. Then when flooding inevitably occurs, developers lose interest in building and the value of the property falls.

Other causes of urban floods

In all three cities examined in this study, the urban areas were exposed to severe flooding influences. In some cases, the source of the flooding was heavy localized rains that could not drain because of high

water levels already. In other cases, water levels in rivers were affected by upstream hydro-electric reservoirs forced to release stored water as heavy rainfall in the watershed rapidly raised the levels of the reservoirs past safe maximums. In Can Tho, the flooding problem is closely tied to seasonal high tides that affect water levels in the city's main rivers and canals.

Conclusion

Climate change will increase the threats that Vietnamese cities face from flooding. Extreme rainfall will likely be more intense. Sea level will rise, raising the level of estuaries and rivers. Dams and reservoirs will become more difficult to manage under extreme conditions. Cities must be prepared for more water. But these case studies show that mechanisms for planning and managing urban development are already inadequate even for current conditions. Development is directed to areas of high flood risk, planning and construction detail is driven by standards rather than by functionality, there is no attention to regional context and the impact of development on surrounding areas, drainage measures are typically included in plans but often neglected in construction. Some areas of cities are being built autonomously with no planning or services at all. These conditions will lead to increased flood risk and property damage, reducing the economic output of urban areas.

REFERENCES

- Development Workshop France (DWF). 2011. *Survey on Perception of Risks in Can Tho City. Can Tho City: Building Urban Resilience in Disaster and Climate Risk Management*. Hue, Vietnam: DWF. <http://www.dwf.org/en/media/2556>
- Erban, L., S. Gorelick and H. Zebker. 2014. *Groundwater extraction, subsidence and sea level rise in the Mekong Delta, Vietnam*. *Environ. Res. Lett.* 9 (2014) 084010 (6pp)
- Korea International Cooperation Agency (KOICA). 2013. *Summary narrative of Hue City master plan adjustment until 2030 with vision to 2050*, funded by KOICA.
- Vietnam Ministry of Construction (2014). Annual report on urban development in Vietnam, Hanoi Vietnam.
- Optiz-Stapleton, S., & Hawley, K.. 2013. *Da Nang: Extreme rainfall and climate change*. Boulder, CO: Institute for Social and Environmental Transition-International. <http://i-s-e-t.org/resources/policy-tech-reports/tech-report-danang.html>
- Project Management Board of Mekong-Building Climate Resilient Asian Cities project in Thua Thien Hue (M-BRACE). 2013. Climate Vulnerability Assessment of Hue city, funded by USAID.
- Project Management Board of Mekong-Building Climate Resilient Asian Cities (M-BRACE). 2014. Assessing flood risks and drainage capacity of Hue City under urban development in consideration of climate change impacts, funded by USAID.
- Public announcement no. 985/PCLB by Thua Thien Hue Committee for Flood and Storm Control (CFSC). 2009.
- Tran, P., Tran, D.. 2014. *Building climate resilience from results of Hydrology and Urban development simulation model project*. Da Nang, Vietnam: Institute for Social and Environmental Transition-Vietnam and Da Nang Department of Construction. <http://i-s-e-t.org/resources/working-papers/results-hydrology-danang.html>
- Tran, T.L.A. 2016. *Climate Change Challenges and Solutions to Improve Climate Change Adaptation Capacity of Cities in Vietnam*. Presentation at the Interim Workshop on National Urban Development Strategy, Apr 20, 2016. Hanoi.
- Working group for Flood Management Planning and JICA expert team (JICA). 2011. Integrated Flood Management Plan (IFMP) for Huong river basin of Thua Thien Hue Province until 2020, funded by JICA.
- World Bank. 2015. *East Asia's Changing Urban Landscape: Measuring a Decade of Spatial Growth. Urban Development Series*. Washington, D.C., World Bank. http://www.worldbank.org/content/dam/Worldbank/Publications/Urban%20Development/EAP_Urban_Expansion_full_report_web.pdf

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