Exploring the spatial-temporal linkages of climate response and rapid urban growth in Ho Chi Minh City

1 Introduction and Problem Overview

In general, Asian cities located in deltaic regions tend to exhibit higher exposure levels to flood risk, primary as a result of their location, close to the coast, their low elevations and if located in tropical regions, the significant annual variations of weather extremes they incur. The challenge of a changing climate influences both the nature of these urban spaces and profoundly how they can function. According to the redefined role of urban environmental planning in times of climate change, spatial planning concerns the impact assessment of space and place as a basis for action or intervention. There is often a methodological void between regional climate change models and urban development scenarios which limits the effectiveness of impact assessments. To assess and illustrate the inter-linkages between dynamic urban development processes and the feedback on the urban environment itself, our research strategy is strongly focused on urban planning scenarios which link urban development and climate change and attempt to explore the main driving forces of future risk.

2 Geographic, Socio-Economic, Demographic Situation

As the largest financial and economic hub in Vietnam, Ho Chi Minh City (HCMC) accounts considerably to the strong economic growth rates of the entire country. HCMC own high rates of economic development enable to the city make a significant contribution to the national GDP; accounting for one third of the national GDP. Furthermore, with the largest port system and airport in Vietnam it acts as a southern transport hub and an international gateway to foreign countries.

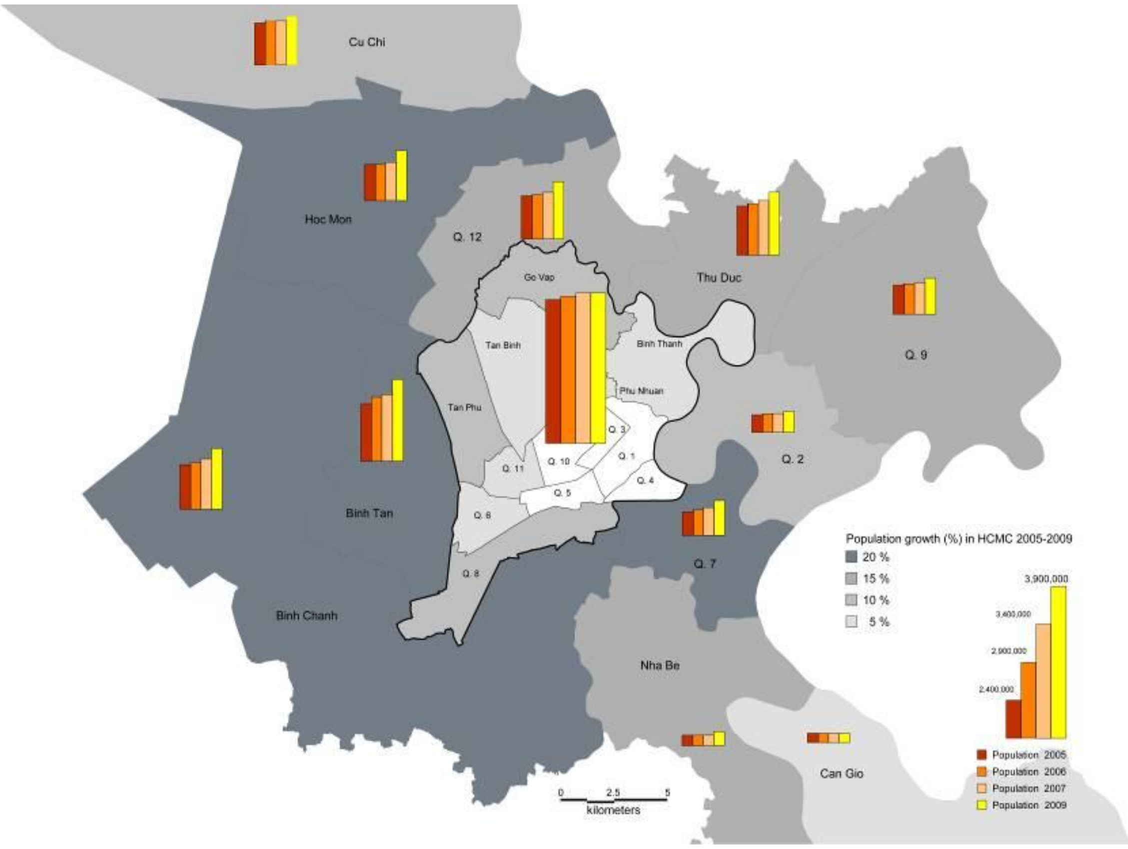

Figure 1: Population change in HCMC's districts 2005-2009.

The administrative region of HCMC accounts for 0.6% of the surface area and currently 6.6% of the population of the entire country. The total area of HCMC is about 2095 km², divided into 24 districts, which hosted in 2009 an official population of 7.2 million. The districts division includes 12 "urban" districts (districts 1 through 12), 7 rapidly urbanising districts (Go Vap, Tan Binh, Tan Phu, Binh Thanh, Phu Nhuan,Thu Duc, Binh Tan) and 5 mainly rural "outer" districts (Cu Chi, Hoc Mon, Binh Chanh, Nha Be and Can Gio). As of 2009, a population of 5.9 million resided in the 19 urban and rapidly urbanising districts, occupying an area of 494 km², with the rest divided between the rural districts. However, if the estimated 2 million migrants and people residing on a non-residential and seasonal basis are included, the actual population of HCMC might be more than 9 million. HCMC is currently undergoing rapid urbanisation to such an extent that by 2020 official estimates suggest population of approximately 10 million. In 2009, the inner districts of HCMC experienced a significant stagnation or decrease in population, while at the same time the surrounding periphery districts showed a sharp spike in population with often a gain of more than 20% (FIGURE 1).

3 Geographic Situation

HCMC is located on the banks of the Saigon River in southern Vietnam, 60 km from the South China Sea and northeast of the Mekong River Delta in an estuarine area of Dong Nai River system with high flow volume. The climate is tropical and generally hot and humid, with two distinctive seasons: The rainy season, from May to November, and the dry season, from December to April. The annual average rainfall is about 1.600 mm and the number of rainy days per year is about 160. The annual average temperature is 27ºC, ranging between 35-36ºC during the rainy and 24-25ºC during the dry season. (NGUYEN HUU NHAN 2006). HCMC is incised with a dense network of rivers and canals of around 8,000 kilometres in length and accounting for 16% of the total area. The water level is affected by a semi-diurnal tide that usually reaches highest value (1.5 meters AMSL) in September and October. Unfortunately the tidal peak period is usually coincident with the annual peak in rainfall. Here combined, heavy rainfall and high tides inundated many low-lying parts of the city (HO LONG PHI 2008).

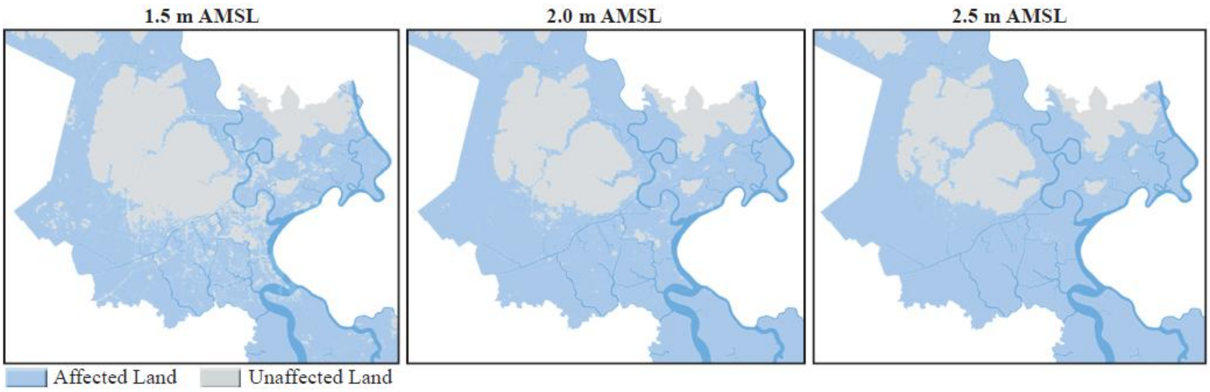

Figure 2: Inundation risk at max-tide level (1.5 m AMSL) and 2.0 – 2.5 m AMSL scenarios.

Most of HCMC's area is distinctively low and flat. The terrain elevation varies from 4-32 m above mean sea level (AMSL) in the north-northeast to southern coastal lowlands at 0-1 m or below AMSL. It was calculated that 70% of the whole urban area of HCMC is below 2 m AMSL. Furthermore, 98.8% percent of the southern rural districts of Nha Be and Can Gio are below 2 m AMSL, while in contrast, for the two northern rural districts Cu Chi and Hoc Mon, the figure is 38.3% (FIGURE 2).

4 Urban Development after the "Doi Moi" Policy Reform

HCMC's economy grew only slowly in the first decade following the end of the Vietnamese war and the reunification of the country in 1975. For the city this period can be considered as "zero urban growth". Economic and urban growth began to take placed after 1986, when the government adopted Renovation (Doi Moi) Policy and transformed Vietnam from a centrally planned to a globally-oriented market economy. Investment in private enterprises was encouraged, and the right to buy and sell land was established.

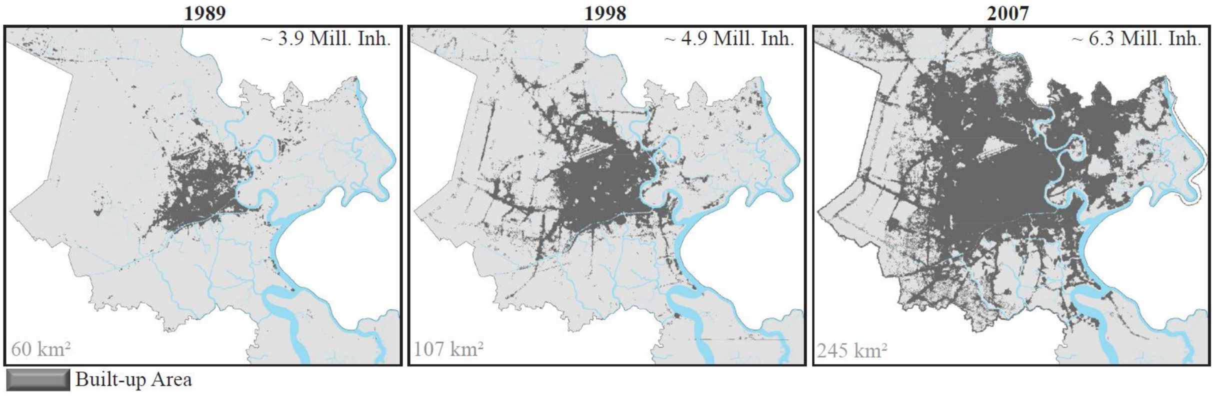

Figure 3: Development of Built-up areas in HCMC from 1989 to 2007

The transition of the economic system of Vietnamese cities (BOOTHROYD AND PHAM 2000), brought about major transformations in the physical and functionality of urban structures over the last decades. According to official statistics the population of the HCMC increased from 3.9 million in 1995 to more than 6 million in 2007 (FIGURE 3). As the first urban master plan of HCMC for the period up to 2020 was only finally approved in final form by the Prime Minister in 1998, the city's rapid development in the first decade after "Doi Moi" took place without adequate guidance and control. Up until 1998 urban development was an opportunistic and profit-driven process dominated by developers (HOUNG HA & WONG 1999). Much of the city's growth was seen on the periphery, particularly in the Tan Binh and Go Vap districts near the airport, north of the CBD and westwards towards Binh Tan district.

5 Historical Climate-related Risk in HCMC

Historically HCMC, as a densely built-up area in a low lying region, is sensitive to climatic effects. Due to its geographic location this flood-prone metropolitan area will always face natural hazards. However, vulnerabilities of lives and livelihood to climate-related environmental processes are primarily the result of inadequate and unsustainable urban planning practices associated with complex natural settings and societal structures. FIGURE 4 shows the inundation risk at current high-tide level in relation to the past urban development process from 1989 to 2007.

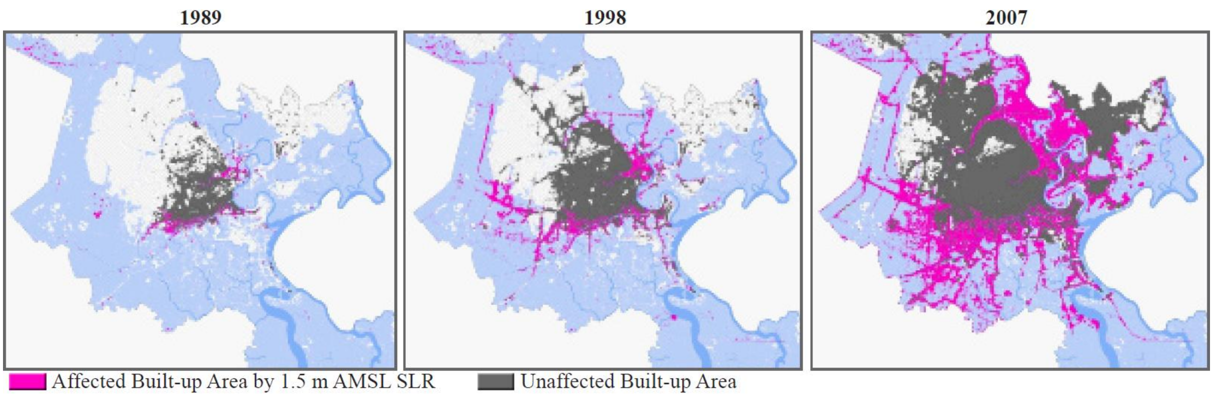

Figure 4: Potential Risk for Inundation at high-tide Level (1,5 m AMSL) for Built-up areas

Since the early 1990s, events of inundation within the city have been seen with increasing frequency (TRINH XUAN LAI 2005). In HCMC the number of flooded locations, the flooding frequency and its duration have increased continuously. More than 100 serious flooded locations have been reported following single heavy rainfall events (>100 mm) since 2004, causing not only prolonged traffic jams but numerous hazards. While some 20 inundated sites are reported monthly during high-tide periods (HO LONG PHI 2007). One major cause of this serious problem is the ongoing rapid urbanisation process. Since 2000, the urban expansion of HCMC has taken place in the low-lying peripheral and suburban areas. These areas are already known to be prone to flooding in high-tide events. Natural streams, channels, lakes, wetlands and vegetation structures that can maintain the urban water balance have been replaced by impermeable surfaces causing increased surface run-off and increased the risk of urban flooding

6 Administrative Implementation of Land-use Zoning

In March 2008 the People's Committee of HCMC approved a revised master plan designed to guide the urban development up to 2025. The most important agencies which determine overall land use, spatial zoning and environmental quality in HCMC are the Department of Natural Resources and Environment (DONRE), the Department of Architecture and Planning (DPA) and the Department of Construction (DOC). While DPA and DOC formulate the master plan (urban development plan), DONRE is responsible for drafting and updating of the land-use plan, which is developed from the master plan (NIKKEN SEKKEI 2007). The next update of the land-use plan will describe the medium-term development of the city until 2025. DONRE's land-use plan and DPA's and DOC's new master plan are the most influential spatial plans that will shape the nature of HCMC's urban development for the next decades (CAREW-REID 2009).

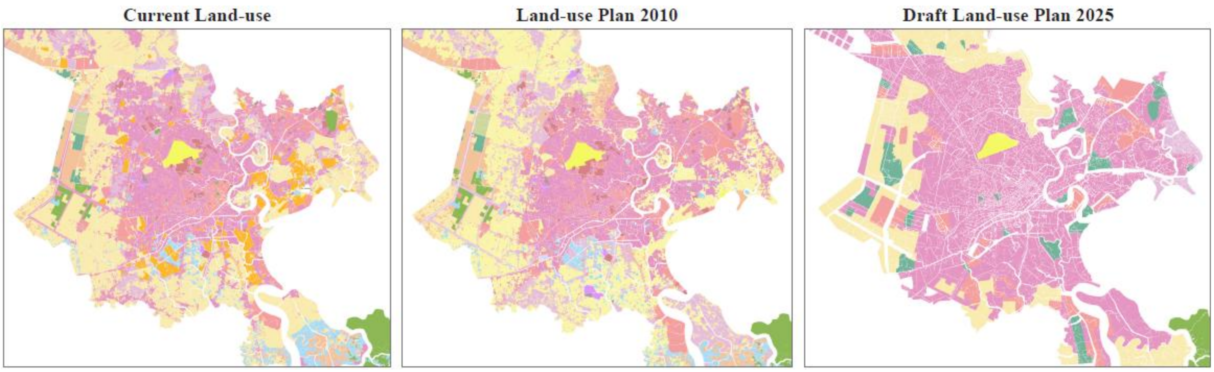

Figure 5: Current Land-use and official Land-use Plans for 2010 and up to 2025

According to DONRE, by the year 2025, on the basis of the current HCMC urban development master plan, the available agricultural land (121,000 ha in 2008, ca. 58% of the total area) will reduce to 83,000 ha, with 38,000 ha rezoned as construction land and becoming available for new developments (FIGURE 5). Alongside this ongoing urbanisation, comes the loss or deterioration of the valuable surrounding multi-functional green and open spaces, which are not only important for agricultural production but also for the regulation of both the urban climate and urban water balance (STORCH ET AL. 2011; RUJNER ET AL. 2010). During the mapping process for the actual use map, a total area of around 55 km^2 with visible construction activities could be identified (FIGURE 6). As the actual use map was determined on the basis of the visual interpretation of high resolution satellite imagery captured in the time period 2009-2010, many of the marked construction sites which are located in the urban fringe may have already been subsequently developed. The focal point and the dynamic building activities of current real estate projects in districts 2 (Thu Thiem), 7 (Phu My Hung) and 9 (below Thu Thuc) in the south and east of the city; which currently form the frontier of urban development, can be verified. In addition it is visible that the majority of the new construction sites are in accordance with the official land-use plans for 2010 and 2025.

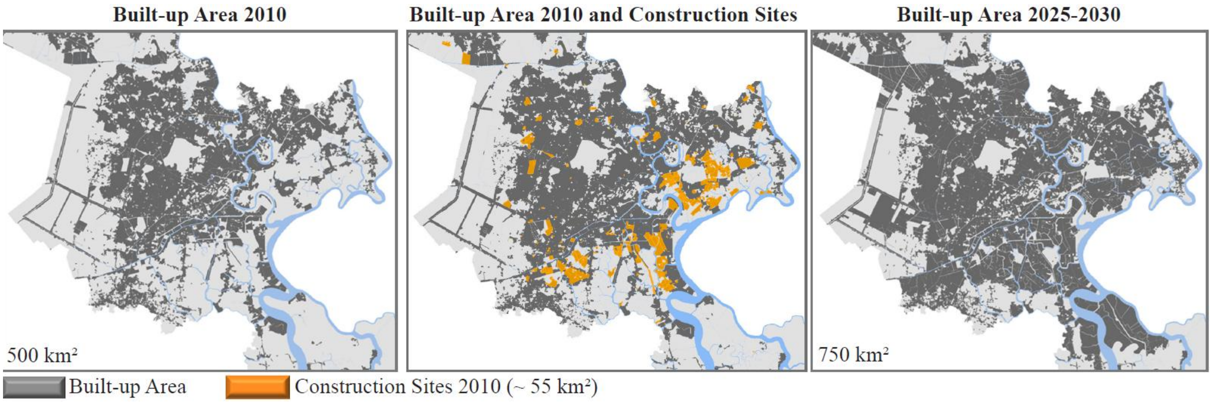

Figure 6: Construction Activities for new Residential and Industrial Areas detected in 2010

HCMC's urban movement seawards or towards the sea focuses on the south-eastern development direction, as highlighted in FIGURE 6. This development direction is stimulated more specifically by the further development of the new Hiep Phuoc port project in the southern Nha Be district. This will involve relocating the port, the re-development of the then old port areas that are situated somewhat closer and in the city centre and the socio-economic development of the city as a whole. However, these new developments will face enormous difficulties to effectively incorporate and adapt to the effects of climate change.

7 Assessing exposure to current tidal-flooding and future sea-level rise

Assessment of the future climate change risk of inundation, flooding and related vulnerabilities at the urban scale is an important first step in developing spatially-explicit adaptation strategies (FUCHS ET AL. 2011). The uncertainties involved in estimating future climate change related urban risks could be significantly reduced using the official urban development scenario of HCMC. The selected downscaling approach is based on a detailed mapping of the actual urban land-use and the future urban development of HCMC. In our assessment study (STORCH & DOWNES 2011), three spatially explicit core-indicators were considered: Firstly the built-up area (FIGURE 7) over three time-periods (current, 2010-2015 and up to 2025/30); secondary sea-level rise (FIGURE 2) (current max-tide and +1.0 meter SLR) and finally a digital terrain model (DTM) as a digital representation of ground surface topography built from official land surveying data. All three indicators were available at the necessary spatial resolution for the representation of the results at a scale of 1:25.000. Upon the block geometry of the official land use plan, the current land-use, plus future planning situations were portrayed. To demonstrate the amount of land exposed to inundation from various extreme flood levels, the assessment took the form of an elevation-based GIS analysis (HANSON ET AL. 2011).

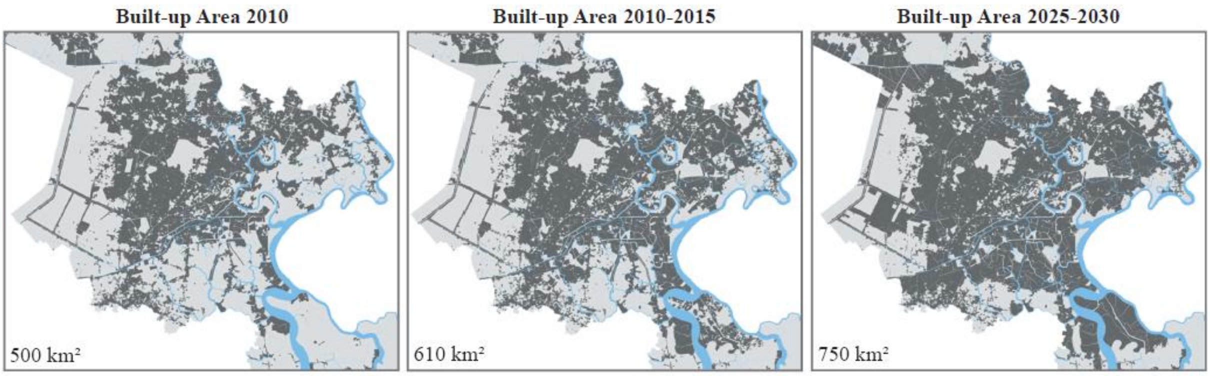

Figure 7: HCMC's Urban Development Scenario up to 2025/30

The current expanse of built-up land derived from satellite images and future urban development scenarios (built-up land) taken from the land-use plan up to the year 2010 and from the draft land use plans 2010-2015 to 2025/30 are portrayed in FIGURE 7. For the purpose of this study built-up land was defined as solely residential and industrial developments.

Risk of inundation at current high-tide level

In the first step the urban development scenario was mapped and combined with the current max-tide level for HCMC, which is 1.5 m AMSL. The resulting flood water extent level can be seen mapped in FIGURE 8.

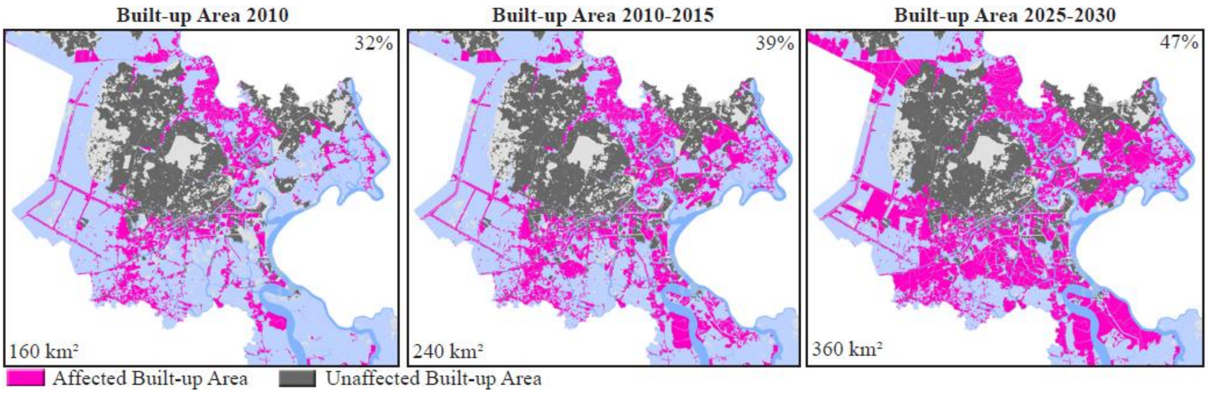

Figure 8: Inundation risks for the max-tide water level of 1.5m AMSL for HCMC's urban development scenarios

Integrating the mapped built-up areas, the results show that a significant proportion of the current built-up area (2010) is already exposed to flooding (FIGURE 8). Currently about 160 km^2 (32% of the total built-up 500 km^2) is exposed to potential inundation from the current max-tide water level of 1.5 m AMSL. This exposure is concentred in a few hot-spots, with the highest exposure mostly seen in low-lying areas recently developed during the last 10 years (2000-2010). Implementing the draft land-use plans up to the years 2010 and 2025/30 would subsequently increase the total built up area to 750 km^{2,} an increase of 50% (FIGURE 7). While at the current max-tide water level, the total built-up area seen exposed would increase twofold to around 360 km^2.

Risk of inundation with an extreme sea-level rise

Through the statistical downscaling of global climate models, the sea-level rise changes for South Vietnam using IPPC high emission worst case scenarios (A1F1) have been predicted as an increase of 33.4 cm by 2050 and 101.7 cm in 2100 (TABLE 1).

Table 1: Sea level rise scenario's for Vietnam (in centimetres) (MONRE 2009)

IPPC Emission Scenarios			2020	2030	2040	2050	2060	2070	2080	2090	2100
		High	11.6	17.3	24.4	33.4	44.4	57.1	71.1	86.1	**101.7**
High	**A1F1**	Average	6.5	9.7	13.6	18.5	24.4	31.0	38.1	45.4	52.9
		Low	2.6	3.9	5.6	7.6	10.0	12.6	15.2	17.8	20.3

In the second step the urban development scenario was mapped and combined with an extreme SLR of 1.0 m corresponding to the IPPC high emission scenario A1F1 for ca. 2100. The resulting extreme flood water level of 2.5 m AMSL can be seen mapped in FIGURE 9.

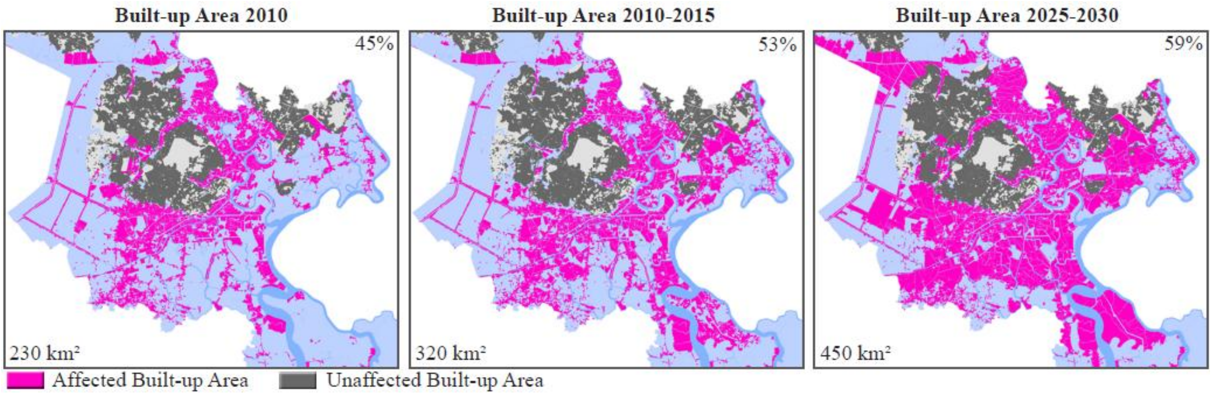

Figure 9: Inundation risks with current max-tide water level of 1.5 m and extreme SLR 1 m (=2.5 m AMSL) for HCMC's urban development scenario.

Assuming no further urban development, the occurrence of a max tide water level and an extreme climate change induced SLR of 1 m would increase the exposure of the current built-up area to 230 km^2 (45% of the current extent). When combining the effects of this SLR of 1 m with the urban development scenarios, the total exposure can be seen to dramatically grow to 450 km^2 (FIGURE 9). This exposure is than a nearly threefold increase in relation to the current area at risk of present day tidal flooding (FIGURE 8).

8 Summary and Outlook

This planning assessment study, linking urban development and sea-level rise scenarios, formulates a first estimation of the exposure of HCMC to potential flooding due to different high tide levels. The planning assessment study also investigates how climate change is likely to influence HCMC's exposure to coastal inundation due to rising sea-levels up to the year 2100, alongside rapid urbanisation and demographic growth. This risk assessment at the urban level, focussing on the projected land-use changes extracted from the official land-use plan up to the year 2010 and the draft version for the years up to 2025/30, provides a much more detailed analysis than earlier studies carried out on the global or national level (CAREW-REID 2009; HANSON ET AL. 2011). Our initial research results document that the spatiotemporal processes of urban development, alongside climate change, are the central driving forces for future risk.

It is noteworthy to mention that the urban development activities seaward and towards the sea in low-lying risk prone areas only commenced at the turn of the century. An example project includes the Saigon South New Town (known locally as Phu My Hung), an urban development project backed by a Taiwanese real estate developer, which is built on valuable wetlands south of the Te Canal in District 7. A further example is the decision to expand the existing the CBD on the east bank of the Saigon River over the river into District 2 on the opposite bank. Again this new site, known as Thu Thiem, was formally wetlands, but unlike South Saigon, due to the ineffectiveness of the existing urban master plan, which provided no detailed guidance and was only weakly implementation, the area was previously densely populated. The conversion of these two wetland areas and the loss of their critical functions in both buffering and storing rain waters and surface runoff and releasing them slowly back into the surrounding water bodies has significantly increased the inundation risk for built-up areas.

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References

Boothroyd, P. and Pham Xuan Nam (Eds.) (2000) “Socioeconomic Renovation in Viet Nam: The Origin, Evolution and Impact of Doi Moi”..:*International Development Research Centre, Institute of South East Asia Studies*. Ottawa, Singapore.

Carew-Reid, J. (2009) “Climate Change Adaptation in HCMC Vietnam”. In: Vietnamese Institute for Urban and Rural Planning and Ministry of Construction (ed.): International Symposium for the Hanoi Capital Construction Master Plan to 2030 and Vision to 2050 (brochure). pp. 109-135.

Fuchs, R., Conran, M. and Louis, E. (2011) “Climate Change and Asia's Coastal Urban Cities: Can they Meet the Challenge?” *Environment and Urbanization Asia* 2011 2: 13, DOI: 10.1177/097542531000200103

Hanson S, Nicholls R, Ranger N, Hallegatte S, Corfee-Morlot J, Herweijer C, Chateau J (2011) “A global ranking of port cities with high exposure to climate extremes”. *Climatic Change* 104(1), pp. 89–111.

Ho Long Phi (2008) “Impacts of Climate Changes and Urbanisation on Urban Inundation in Ho Chi Minh City”. *Proceedings of the 11th International Conference on Urban Drainage*, Edinburgh, Scotland, UK, 2008

Houng Ha, Wong, T.C. (1999) “Economic Reforms and the New Master Plan of Ho Chi Minh City,Vietnam: Implementation Issues and Policy Recommendations”, *GeoJournal 49*, Special Issue: Urban Development, Environment and Planning in Asia: Challenges for the 21st Century, pp. 301-309.

MONRE (Ministry of Natural Resources and Environment) (2009) “Climate Change, Sea Level Rise Scenarios for Vietnam, Ministry of Natural Resources and Environment”. Hanoi, Vietnam p 33

Nguyen Huu Nhan (2006) “The Environment in Ho Chi Minh City Harbours”. In: Wolanski, E.: “The Environment in Asia Pacific Harbours”, Amsterdam: Springer Netherlands, pp. 261-291.

Nikken Sekkei (2007): “The Study on the Adjustment of HCMC Master Plan up to 2025”. Final Report. Urban Planning Institute: Ho Chi Minh City, Vietnam.

Rujner, H., Goedecke, M., Storch, H., Moon, K., Downes, N. (2010) „GIS-basierte Kopplung des Abflussbildungsmodells ABIMO mit dem stadtstrukturellen Planungsinformationssystem von Ho Chi Minh City (Vietnam)“. In: Strobl, J., Blaschke, T., Griesebner, G. (Hrsg.) *Angewandte Geoinformatik 2010*, Beiträge zum 22. AGIT-Symposium, Salzburg, Heidelberg: Wichmann, pp. 545-551.

Storch, H., Downes, N., Katzschner, L., Thinh, N.X. (2011): “Building Resilience to Climate Change Through Adaptive Land Use Planning in Ho Chi Minh City, Vietnam”. In: Otto-Zimmermann, K. (Ed.) Resilient Cities: Cities and Adaptation to Climate Change, Proceedings of the Global Forum 2010, *Local Sustainability* 1, Berlin: Springer,pp. 349-363.

Storch, H., Downes, N.K. (2011): “A scenario-based approach to assess Ho Chi Minh City’s urban development strategies against the impact of climate change.” *J. Cities*, doi:10.1016/j.cities.2011.07.002

Trinh Xuan Lai (2005) “Comprehensive Approaches to Develop and Maintain Drainage/Sewerage Systems in Urban Areas of Vietnam”, Workshop-Paper: Hands-on Workshop on Sanitation and Wastewater Management ADB Headquarters, Manila: 19-20 September 2005, Asian Development Bank.

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