Strategic Land-Use Planning in a Changing Climate—Adapting to the Spatial Dynamics of Risk in Ho Chi Minh City

Harry Storch and Nigel Downes

Abstract For Asian cities situated within mega-urban coastal regions, such as Ho Chi Minh City, there is a pressing need for adaptation to climate change to focus on minimising exposure and reducing vulnerability by increasing urban resilience to the future impacts of climate extremes. Scientifically predicted are the direct impacts of climate change on populations (i.e. by urban flooding) and the indirect effects through impacts on climate-sensitive urban sectors (i.e. housing, energy supply systems). Geographic context gives rise to the biophysical exposure, which includes factors such as topography, connectivity and urban structures, all of which can be mediated by spatial planning or construction technologies. Further the urban fabric underlies the patterns of social vulnerability, including issues such as population density, levels of income and education as well as institutional capacities. Here spatial planning measures to enhance adaptive capacity should be directed towards decreasing biophysical exposures and the social vulnerability from the viewpoint of place-based risk assessments. Key urban impact and vulnerability indicators vary considerably from settlement to settlement and even within settlements. The location, the built urban structures, the dominant building types, the social-economic characteristics and institutional capacities are all highly dynamic factors with an important spatio-temporal dimension that affects ultimately the overall exposure, vulnerability and environmental performance of a settlement. Rapid urbanisation driven by fast changes in socioeconomic development conditions are the key factors influencing the future levels in both exposure and vulnerability to climate extremes. Our impact assessment study highlights, that the influence of non-climatic stressors—like urbanisation as the spatial manifestation of socio-economic processes is still widely under acknowledged. Traditionally only snapshots of the current urban situations have been partially integrated into risk assessments, resulting often, for highly dynamic urban regions, in an overestimation of climate extremes as a stressor of risk. An urgent need has arisen to readdress and improve the scientific methods and datasets to examine these key non-climatic drivers of future urban risk and to assess their relative importance for risk propagation compared to primary changes

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in climate. The most significant issue here is the integration of the future dynamics of urban development processes.

The Spatial Dynamics of Risk in Ho Chi Minh City

The southern Vietnamese metropolis of Ho Chi Minh City (HCMC) represents one of the most dynamic examples of urban development and a megacity in the making. The city is precariously located on the banks of the Saigon River, 60 km inland from the South China Sea and northeast of the Mekong Delta, in an estuarine area of the Dong Nai River system. In a short space of time, the city has grown into Vietnam's most populous settlement, contributing a dominant share to the national economy. The official population of the city as of 2010 was 7.4 million, spread over a total administrative area of 2095 km^2 [5].

Over half of HCMC's population are concentrated in the 140 km^2 inner-city urban area with in an average population density of 260 inh/ha, and with highs of up to 800 inh/km^2 seen in many of the inner-city informal settlements (Fig. 1). The high-dense development of the inner city, additionally with coverage ratios of more than 60 % ground coverage and floor area ratios of 1.5 and above, is principally a manifestation of the necessary to adapt to the dominant flood risk situation of the city. Originally founded on relatively higher grounds, the city has densified through the infilling of open spaces or the redevelopment of existing buildings. However recently, great concern has been raised at the city's rapid expansion into the lower-lying and former wetland surroundings.

Elevation-Based Risk-Assessment for Urban Flooding

To assess the exposure to tidal-flooding and future SLR, our results provide an initial estimation of the exposure of HCMC to potential flooding from the current high tide level (1.5 m AMSL).The assessment results were based on the detailed mapping of the urban development of HCMC (Fig. 3). The scenario approach investigates how climate change is likely to influence HCMC's exposure to tidal flooding due to SLR (+1.0 m) up to the year 2100, alongside rapid urbanisation. Most of HCMC's area is distinctively low and flat. The terrain elevation varies from 0 to 32 m AMSL. It was calculated that 70 % of the whole urban area of HCMC is below 2 m AMSL.

Figure 2, graphically represents the development trend of HCMC from 1989 till the year 2007. Since 2000, the urban expansion of HCMC has taken place in the low-lying peripheral and suburban areas [7]. These areas were already known to be prone to flooding in high-tide events. Natural streams, channels, lakes, wetlands and vegetation structures were replaced by impermeable surfaces causing increased surface run-off and increased the risk of urban flooding. Our results document that

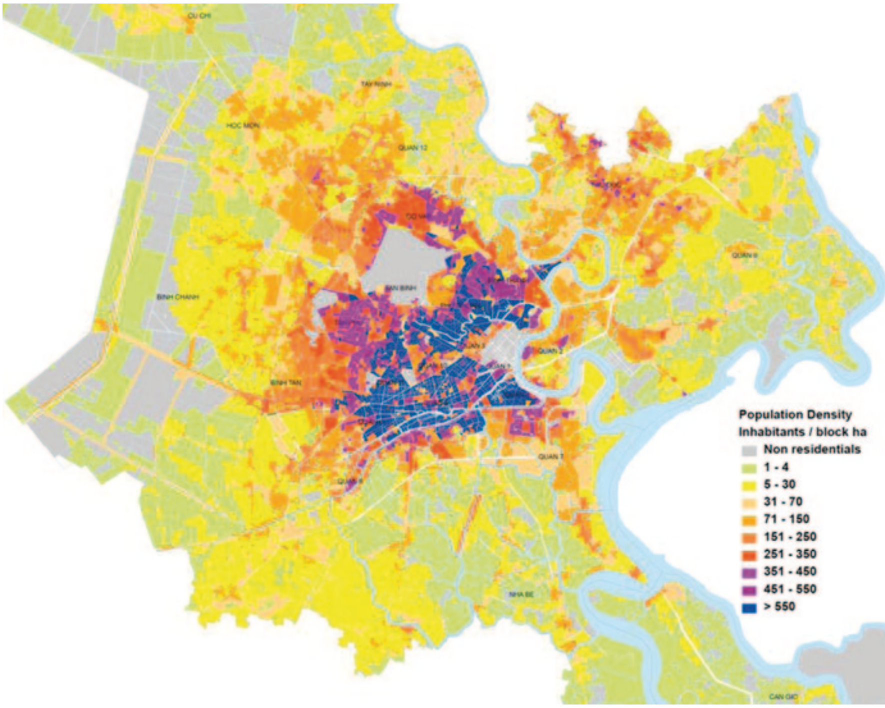

Fig. 1 The population density of HCMC in 2010

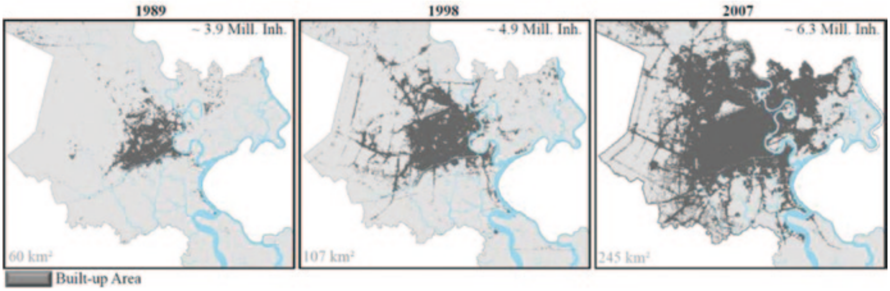

Fig. 2 The development of the built-up extent in HCMC from 1989 to 2007

HCMC, as a densely built-up area in a low lying region, is sensitive to climatic effects [12].

However our results also highlight that the vulnerabilities of lives and livelihood to climate-related environmental processes are primarily the result of the past inadequate and unsustainable urban planning practices [11]. To take into account future land-use changes, projected land-use changes were extracted from the official land-

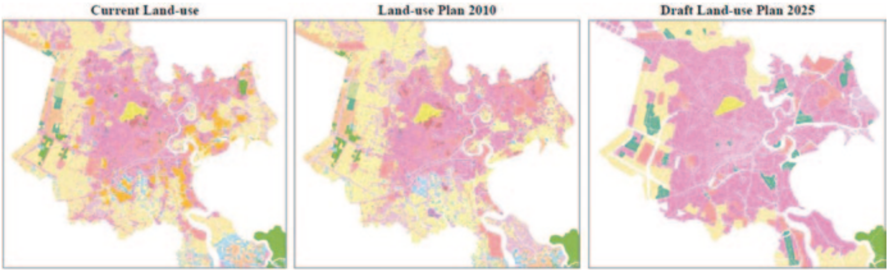

Fig. 3 The current land-use and official land-use plans for 2010 and up to 2025

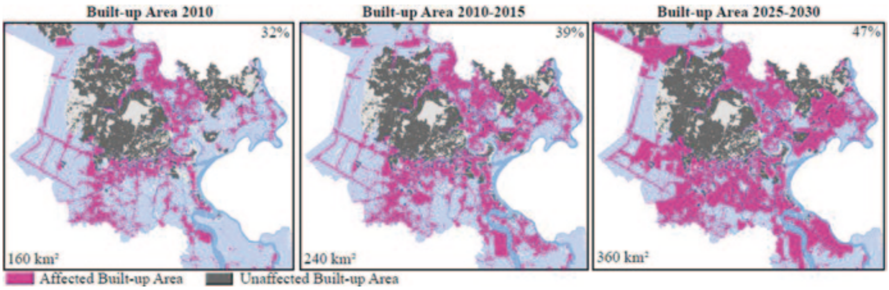

Fig. 4 The inundation risks for a max-tide water level of 1.5 m AMSL for HCMC's urban development scenarios

use plan up to the year 2010 and the draft version for the years up to 2025/2030, while, the current land-use was determined from the urban structure type classification for the entire HCMC urban area (Fig. 3).

For the purpose of this study built-up extent was defined as solely residential and industrial developments and derived from the aforementioned land-use plans (Fig. 3). The integration of the mapped built-up extents to the inundation risks at max-tide level, highlight that a significant proportion of the current built-up area (approximately 160 km^2 or 32 % of the total built-up 500 km^2) is exposed to potential inundation from a current max-tide water level of 1.5 m AMSL (Fig. 4). Implementing the draft land-use plans up to the year 2025/2030 would increase the total built up area to 750 km^2—an increase of 50 %, while at the current max-tide water level, the total built-up area at significant risk would increase twofold to around 360 km^2. However, when combining the effects of an extreme SLR of 1 m projected for 2100 [6] with the urban development scenarios, the total exposure can be seen to alarmingly grow to 450 km^2 (Fig. 5). This exposure would account to more than a threefold increase in relation to the current area at risk of present day tidal flooding.

Our assessments have highlighted that for exposure to tidal flooding, rapid urbanisation is proportionately more important for the emerging megacity HCMC, than projected SLR up to the year 2100 under a high-emission scenario [12]. Climate change was seen to contribute to less than one third of the total increase in

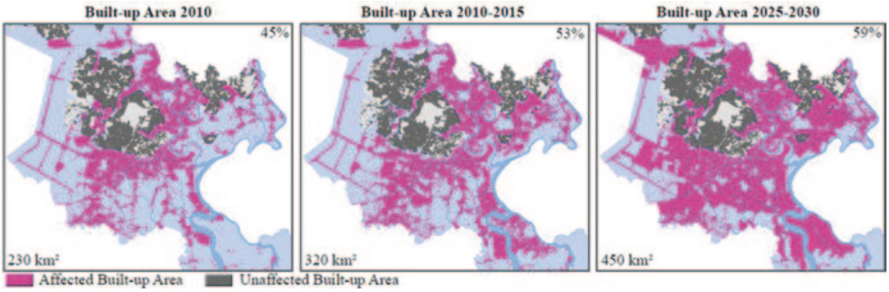

Fig. 5 The inundation risks form a current max-tide water level of 1.5 m and SLR 1 m (=2.5 m AMSL) for HCMC's urban development scenarios

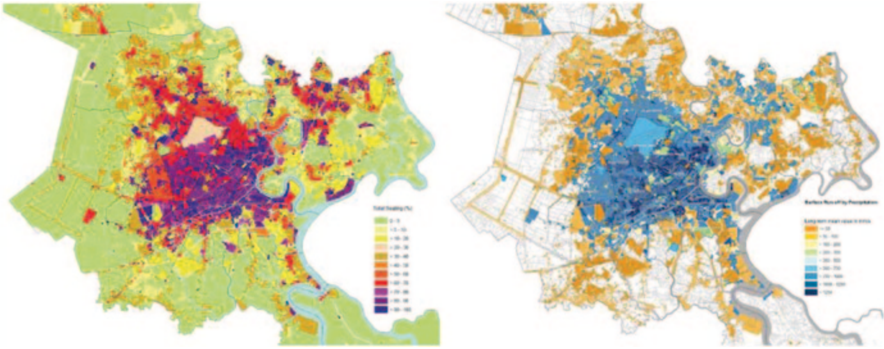

Fig. 6 The current imperviousness and modelled surface-runoff for HCMC in 2010

exposure of built-up areas, while the vast majority of exposure was seen to stem from the officially planned urbanisation up until 2025/2030.

The Impacts of Urbanisation on Stormwater Run-Off

In another step, to assess the impacts of urbanisation on the local hydrological system, a dedicated site specific risk assessment was carried out. One of the key environmental indicators for urban agglomerations is impervious surface coverage [2]. To determine the current impervious surface coverage of HCMC, the visual estimation from high resolution satellite imagery of the percentage of both built-up and non built-up sealed surfaces for each classified urban structure was undertaken [10]. An additional important consideration for the assessment of urban imperviousness is the varying proportions of different surface coatings for each urban structure. The results aggregated to the entire administrative area show that currently approximately 16% is imperviously covered (Fig. 6).

Additonally annual surface-runoff was modelled. Here a suitable water balance model was selected which would utilise the estimated impervious surface coverage values [9]. The results have shown that from a mean annual precipitation input of 1,572 mm, 225 mm or approximately 14 % is unable to infiltrate or evaporate and converts into surface run-off (Fig. 6). With the implementation of the future development plans up to 2025/2030, the impervious coverage will be seen to double over the entire urban area of HCMC. This action significantly doubles the amount of surface-runoff—a current major cause of urban flood problems.

Strategic Land-Use Planning in a Changing Climate

To support the potentials of urban land-use planning for adaptation in HCMC, the focus has to shift towards the evaluation of land conditions and urban development potentials in a more spatially explicit manner. In the development of planning recommendations to assist master plan adjustments for both land-use and urban development, recommendations need to be grounded in realistic land-use and urban development scenarios. These need to in turn consider both the underlying land conditions and suitability for development and additionally are required to integrate the pressing climate-related issues into HCMC's existing urban planning framework [5].

The main factors affecting urban development activities are natural factors, like naturally flood-prone area, topography and soil conditions (Fig. 7), and artificial factors, like urban services (water supply, drainage, roads), accessibility to urban centres and land prices. The current urban development situation in HCMC is characterised by a high population density in the existing urban core area, mostly by low-rise housing structures. This has led to an extreme inherent urban compactness (Figs. 1, 6 and 7), which ensures due to location a good accessibility and short commuting times for the residents. At the sometime, however, low-density sprawling into the peri-urban fringe—partly caused by illegal development is visible, resulting in an ineffective infrastructure provision. The current development trends—a continued concentration and densification within city centre and along the major transportation corridors—is highly impractical, yet is mainly driven by small private development projects on the level of the single building or street block. This trend is worrying from an environmental standpoint, as without planning interventions of some degree, such small scale yet high-density developments fail to provide adequately for open space provision and environmental services. The assessment of HCMC's urban development strategy highlights a lack of effective planning and plan enforcement mechanisms for guiding urban growth orientated to the basic underlying natural conditions, against a backdrop of strong market mechanisms that have recently dictated the current development activities.

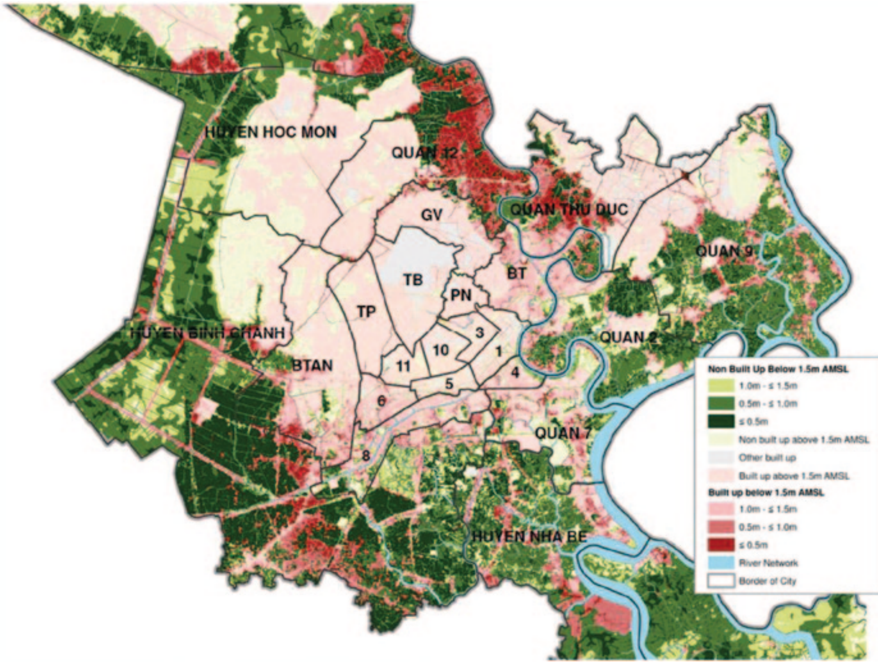

Fig. 7 HCMC's non built-up and built-up areas in flood-risk areas (areas below the current high-tidelevel of 1.5 m AMSL)

Development of Recommendations for Adaptation Planning

The rapid urban growth and expansion of cities into natural areas is not solely the problem of HCMC, but is a global phenomenon presenting an important challenge to both sustainability and adaptation planning [3]. Effective planning policies are required to stem the tide of increasing land-consumptive development in the high-risk flood-prone areas of HCMC. Here, without delay urban containment policies should be considered as a promising adaptation approach to address the current and unfolding spatial risk-patterns of HCMC.

Figure 7 highlights clearly that the current urban form and structure of HCMC is strongly influenced by and to some extent constrained by its underlying natural conditions. The few remaining open spaces surrounding the extremely dense core –mainly agricultural land–have an elevation below the current high-tide level of 1.5 m AMSL. These spaces currently act as a natural blue and green belt–akin to flood risk zoning by nature–and strongly influence the ongoing inner-city re-densification. Hence a genuine understanding the interrelationship between urban densification and adaptation processes to current flood risk can aid the guidance the spatial adaptation processes of HCMC in the uncertain times of rapid urban growth and climate change.

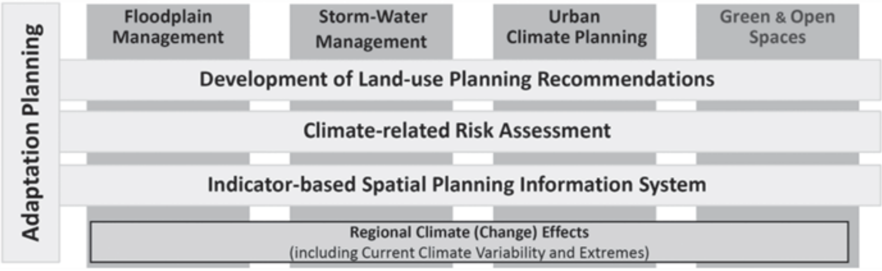

Fig. 8 The environmental planning tools and methods used for the integrated assessment of blue and green infrastructure for an adapted land-use planning in Ho Chi Minh City

Our developed planning recommendations for climate change adaptation focus on supporting the designation of natural flood-prone greenbelts (Fig. 7), the most restrictive form of urban containment policy. Utilising the existing flood-prone areas as greenbelts for current and future flood protection measures would additionally provide significant urban environmental benefits including recreational value, protection of open space, agricultural land, natural resources, all in additional to the highly important supporting ecosystem services for storm- and floodwater management. To be ultimately climate resilient, urban development planning need to reconcile these ecological services for adaptation planning. Supported by environmental planning methods and tools land-use planning can protect these environmental services in a systematic manner (Fig. 8).

For high-dense urban patterns, a larger blue and green infrastructure is in general beneficial to adaptation, as it provides space for urban agriculture, natural spaces for retention and detention of storm and flood water management, and areas to generate and transit cool and fresh air, lowering and offsetting the energy demands for cooling in cities with tropical climates.

Supporting Administrative Integration and Implementation

Land-use planning is seen as having a key role to play in developing strategies to climate-proof HCMC [13]. As such, our research has not been carried out in isolation but from the outset was foremost intended to assist the Department of Natural Resources and Environment (DONRE) with administrative policy making (Fig. 9). In making informed decisions underpinned by the latest assessment techniques [1]. The results presented in this paper show the apparent gravity of the grave challenges faced by DONRE with respect to climate proofing future urban development.

Ultimately, DONRE has the task to determine the overall land-use, spatial zoning and environmental quality of HCMC. As such, DONRE possesses executive powers over one of the most important instruments for the adaptation of HCMC to climate change, the steering and management of land-use. To their credit, DONRE has become very conscious of its responsibility in relation to climate change re-

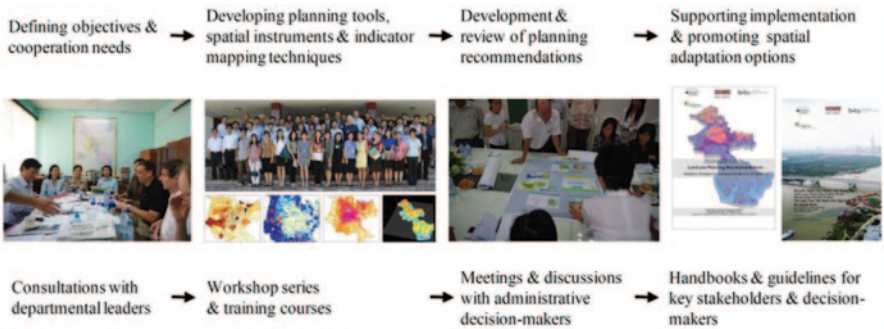

Fig. 9 The cooperation and joint research activities with DONRE in development and implementation of planning recommendations for adapting HCMC's land-use plan to climate change

sponses and the management of associated impacts. Externally, these matters have gained increasing acceptance and importance within the wider administrative structure of HCMC, while, internally they have reinforced the essential need to adapt their own planning [12]. Hever integrating climate change considerations into land-use planning in HCMC is inherently a complex decision-making problem, which requires the careful assessment of the current decision situation, related to place and space [13].

Summary and Conclusion

For high-dense Asian megacities, the complexity of risk and vulnerability requires high resolution spatial information in order to identify hazard patterns, vulnerabilities and risks at a scale that can provide guidance for urban land-use and development planning. Planning for risk and uncertainty for future urban growth will not just be a challenge for high flood prone areas; it will be a broader challenge impacting on the very nature and location of future urban development, particularly in planning for climate change [8]. Here land-use planning that takes into account disaster risks is the single most important adaptation measure for minimising future losses. The spatial planning framework and subsequent urban planning decisions, as currently applied, do not attach ample importance to the physical exposure and the rate of urban growth associated with the risk of disaster losses. Generally, urban governments are responsible and have a moral obligation for regulating either building or development in a way that reduces risks. Urbanisation does not necessarily have to lead to an increasing hazard portfolio and can, if managed properly, contribute towards risk reduction. However, there are a number of key characteristics of the urbanisation process that do directly contribute to the formation of risk [4]. Solely spatial and physical exposure alone does not explain nor directly lead to increased urban risk. If urban growth in risk-prone locations is directed by adapted land-use zoning and at the same time guided by adequate building standards, ensuring risk patterns can be effectively managed and mitigated.

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References

1. Downes N, Storch H (2010) Adaptation response to climate change at the Urban level—spatial information needs for climate-related decision support in Mega-Urban regions. Report of the German-Vietnamese Workshop held on 9th July 2010 at IMHEN in Hanoi, Vietnam. Cottbus. http://www-docs.tu-cottbus.de/megacity-hcmc/public/04_Results/Ger_Vn_Workshop_Hanoi_2010/Workshop_Report_090710.pdf, accessed 25/11/2013
2. Downes N, Storch H, Rujner H, Schmidt M (2011) Spatial indicators for assessing climate risks and opportunities within the Urban environment of Ho Chi Minh City, Vietnam. In: Isocarp (eds) E-Proceedings of 47th ISOCARP Congress 2011 "Liveable Cities Urbanising World, Meeting the challenge" Wuhan China, Case Study Platform www.isocarp.net and Congress CD, p 13. ISOCARP, The Hague
3. Fünfgeld H (2011) Introduction: approaches to climate change adaptation in cities. In: Otto-Zimmermann K (ed) Resilient cities: cities and adaptation to climate change, Proceedings of the Global Forum 2010, Local Sustain 1:399–400.Springer, Berlin. doi:10.1007/978-94-007-0785-6_40
4. Heinrichs D, Aggarwal R, Barton J, Bharucha E, Butsch C, Fragkias M, Johnston P, Kraas F, Krellenberg K, Vogel J, Lampis A, Ooi GL (2011) Adapting cities to climate change: opportunities and constraints. In: Hoornweg D, Freire M, Lee MJ, Bhada-Tata P, Yuen B (eds) Cities and climate change: responding to an urgent agenda. Publication from the Fifth Urban Research Symposium, World Bank
5. Labaeye A, Brugmann J, Nguyen Van P, Bao T, Ly Khanh Tam T, Nguyen Anh T, Storch H, Schinkel S (2012) Reality check: Ho Chi Minh city, Vietnam. In: Otto-Zimmermann K (ed) Resilient cities 2. Local Sustain 2:367–376, Springer, Berlin. doi:10.1007/978-94-007-4223-9_38
6. MoNRE (Ministry of Natural Resources and Environment) (2009) Climate change, Sea Level Rise Scenarios for Vietnam, Hanoi
7. Nguyen-Thanh S, Chi-Farn C, Cheng-Ru C, Li-Yu C, Bui-Xuan T (2012) Urban growth mapping from landsat data using linear mixture model in Ho Chi Minh city, Vietnam. J Appl Remote Sens 6(1). doi:10.1117/1.JRS.6.063543
8. Preston B, Kay R (2010) Managing climate risks in human settlements. In: Jubb I, Holper PN, Cai WJ (eds) Greenhouse 2009 Conference. pp 183–196
9. Rujner H (2011) GIS-based coupling of the water balance model ABIMO with Urban structure types of Ho Chi Minh City. In: German Academic Exchange Service (DAAD) (ed) (2011): "Future Megacities in Balance" Young Researchers Symposium in Essen, 9.–10. Oktober 2010, pp 58–63, Dok & Mat vol 66
10. 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 (eds) Angewandte

Geoinformatik 2010, Beiträge zum 22. AGIT-Symposium, Salzburg. Wichmann, Heidelberg, pp 545–551
11. Storch H (2007) GIS-based sustainability assessment of housing and settlement structures within the metropolitan area of Ho Chi Minh city. In: Zeil P, Kienberger S (eds) Geoinformation for development. Bridging the divide through partnerships, Wichmann, Heidelberg, pp 65–75
12. Storch H, Downes NK (2011) A scenario-based approach to assess Ho Chi Minh city's Urban development strategies against the impact of climate change. J Cities 28(6):517–526. doi:10.1016/j.cities.2011.07.002 (Special Issue: Low Carbon Cities)
13. Storch H, Downes N, Katzschner L, Thinh NX (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 Sustain 1:349–363. Springer, Berlin. doi:10.1007/978-94-007-0785-6_35