Cities 28 (2011) 517–526

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

A scenario-based approach to assess Ho Chi Minh City's urban development strategies against the impact of climate change

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ARTICLE INFO

Article history:
Available online 9 August 2011

Keywords:
Climate change
Adaptation
Urbanisation
Spatial planning
Ho Chi Minh City
Vietnam
Sea-level rise
Flood risk
Land-use

ABSTRACT

This paper presents an approach to quantifying current and future city-wide flood risks to Ho Chi Minh City. Here urban planning scenarios linking urban development and climate change explore the main driving forces of future risk. According to the redefined role of urban environmental planning in times of climate change, spatial planning needs to go beyond traditional planning approaches to bring together, draw upon and integrate individual policies for urban adaptation strategies for land-use planning. Our initial research results highlight that the spatiotemporal processes of urban development, together with climate change, are the central driving forces for climate-related impacts. The influence of planned urban developments to the year 2025 on future flood risk is seen to be significantly greater than that of projected sea-level rise to the year 2100. These results aid local decision making in an effort to better understand the nature of future climate change risks to the city and to identify the main driver of urban exposure.

Introduction

According to recent studies addressing the impacts of climate change, Vietnam remains ranked within the top rung of countries in terms of risk. In the first global review of population and urban settlement patterns in low elevation coastal zones (LECZ) undertaken by McGranahan, Balk, and Anderson (2007), Vietnam appeared amongst the top ten countries ranked in terms of both the total and the actual share of land and population located in low-lying coastal areas below 10 m above mean sea level (AMSL). A further comparative study by the World Bank (Dasgupta, Laplante, Meisner, Wheeler, & Yan, 2007), investigated the impacts of multiple sea-level rise (SLR) scenarios, ranging from 1 to 5 m for 84 coastal developing countries. Here Vietnam was ranked within the top five countries worldwide to be most affected by SLR. Moreover, the geographically extensive study on urban flood risk carried out by the Organisation for Economic Co-operation and Development (OECD) (Nicholls et al., 2008a), focused on the current and future exposure to coastal flooding of 136 key worldwide port cities. It too reaffirmed Vietnam's rank amongst the top five countries endangered, and ranked Ho Chi Minh City (HCMC) additionally amongst the top five cities in terms of the largest exposed population by the year 2070.

All studies identify Southeast Asia as the flood-prone region with the greatest need for urgent policy measures. Most of these global assessment studies themselves are mainly responding to urgent policy needs by identifying countries and urban areas that are the most vulnerable to climate change. Despite the limitations of the global datasets used, the results are frequently used by both national policy-makers and international donor organisations for the informed targeting of financial resources towards adaptation measures to be undertaken within Southeast Asia.

All the above mentioned comparative studies assess the exposure of coastal regions, countries or urban areas to sea-level rise; some include additional factors such as intensification of storm surges and land subsidence (Dasgupta, Laplante, Murray, & Wheeler, 2009; Nicholls, Wong, Burkett, Woodroffe, & Hay, 2008b; Nicholls et al., 2008a). This focus arises from a greater certainty about sea-level rise scenarios linked to future climate change in contrast to the uncertainties in many other climate impact variables (Hunt & Watkiss, 2011). For the quantitative assessment of exposed elements (land, population, GDP, urban areas) these studies are based on available spatially-disaggregated global datasets, while for the critical calculation of current and future projected inundation zones, elevation data from the Shuttle Radar Topography Mission (SRTM) is commonly used. The known accuracy problems of the SRTM databases in urban areas and forests where SRTM elevation is related to the height of the surface structures instead of the required ground elevation (Weydahl, Sagstues, Dick, & Ronning, 2007), strongly distorts the assessment results. A recent rapid assessment study outlining the extent of sea-level rise for Vietnam applying such datasets (Carew-Reid, 2007), documents the systematic and visible underestimation of impacts in urban areas and mangrove forests inherent in using SRTM data.

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doi:10.1016/j.cities.2011.07.002

Similar assessment problems concerning the usage of remotely sensed surface information for the calculation of the potential extent of inundated zones can be seen in the official SLR study for Vietnam (Ministry of Natural Resources and Environment, 2009). This is also highlighted in a recent report on climate risks in Asian Coastal Megacities (World Bank, 2010), where the detailed mapping of flooding and inundation zones for HCMC, based on large-scale digital terrain information (ADB, 2010), displays more realistic results. These examples from Vietnam emphasise that SRTM data should not be recommended for impact assessments at the national or urban level and should be used only to provide an initial estimate of the potential risks of SLR.

According to Nicholls et al. (2008b) coastal vulnerability assessments are exerting a strong focus on sea-level rise, while ignoring commonly the influence of non-climatic environmental change or socio-economic change. Therefore projections of future socio-economic change (population growth, land-use change and changes in asset value) should be used in combination with sea-level rise scenarios. For Vietnam's port cities, an integrated assessment (Nicholls et al., 2008a), shows that by 2070 the exposed population to coastal flooding will be seen to increase sixfold, while the underlying population growth as a dominant non-climatic driver is seen to be two-times more significant than the actual climate related drivers (SLR and subsidence). The main limitation of these studies is the focus on population and GDP as the dominant socio-economic indicators, thus ignoring the spatial dimension of urban growth. The basic assumption that future urban inhabitants "will have the same relative exposure to flood risk as current inhabitants" (Hanson et al., 2011), is a reduction of urbanisation to purely population densification occurring within the existing spatial urban boundaries. Rapid urbanisation in Southeast Asia is seen as predominantly a coastal phenomenon, while migration from rural areas to cities is an ongoing process and the further expansion of the existing urban boundaries into low-lying areas has to be assessed as an important driver of future urban risk in the fast emerging Asian megacities (ADB, 2010).

The application of remote sensing technologies in Asian mega-urban regions to assess the environmental effects and dynamics of past changes in land-use patterns has recently begun to incorporate climate-related impacts (Tran, Uchihama, Ochi, & Yasuoka, 2006; Trung, 2009; Van, 2008; Van & Bao, 2007; Wu et al., 2006). However due to a lack of cooperation with administrative planning institutions the work has not had the all important practical influence. Therefore, even recent climate change impact assessments for HCMC (ADB, 2010; ICEM, 2009; World Bank, 2010), represent urban settlement areas only by population distribution mapped within sub-district administrative boundaries.

In contrast to the situation in Southeast Asia, and especially that of Vietnam, within Europe a large number of modelling approaches, ranging from system dynamics and land-use allocation models to agent-based models of individual (or group) behaviour, have been used to assess (urban) land-use change (Koomen, Rietveld, & de Nijs, 2008). Here urban growth modelling has a longer tradition in applications related to strategic impact assessment (SEA) and recent work has given the thematic field of climate change impact assessment more attention (Meyer, Rannow, & Loibl, 2010). Thus the current research work demonstrates the methodological advantages of assessing future urban land-use patterns for flood and SLR impacts, but has been primarily theoretical and lacking any practical planning relevance (Hansen, 2010). Even if the assessment presented here does not incorporate these modelling approaches per se, it is heavily inspired by the various state-of-the-art approaches taking place within real planning contexts (Bouwer, Bubeck, & Aerts, 2010; Dawson et al., 2011; de Moel, Aerts, & Koomen, 2011; Feyen, Barredo, & Dankers, 2008; Lonsdale et al., 2008; Mokrech et al., 2008; Wheater & Evans, 2009). These approaches are producing purposeful results from more integrated assessments of urban growth in these times of climate change, with the ultimate result of enhanced spatial planning decisions (Koomen, Koekoek, & Dijk, 2010; Mc Gahey & Sayers, 2008).

Our assessment considers the core scenarios that are required to support a more integrated assessment of coastal urban areas. Emphasis is placed on current and future urban land-use as the most relevant non-climate indicator. We estimate future potential exposure to coastal and tidal flooding by combining scenarios for urban development with sea-level rise projections.

Geographic area

Representing one of the most dynamic examples of rapid urban development of the last 20 years, the southern Vietnamese city of HCMC provides an example of an emerging coastal megacity exhibiting increasing exposure levels to climate risks. The urbanisation of HCMC has been intrinsically related to the process of industrialisation following the Doi Moi reforms of 1987. From 1986 to 2010 the population of HCMC approximately doubled from 3.78 million to a current level of 7.1 million. This figure, however, does not include the estimated additional 2 million unregistered migrants in the city. From 1997 to 2003, in response to this high urbanisation pressure, the HCMC government was forced to expand the urban boundary consecutively, leading to the establishment of six new urban districts. The resultant transformation of former rural agricultural land to built-up land increased the total urban area of HCMC from 142.15 km^2 to 494.00 km^2 in 2008. The new suburbs are the spatial manifestation of the drivers of industrialisation and housing development for factory workers, migrants and new members of the emerging middle class (Du & Fukushima, 2009).

Due to its location in a low elevation intra-tropical coastal zone, northeast of the Mekong Delta and 50 km inland from the South China Sea, HCMC experiences significant annual variations of climatic and weather extremes. Together with its large population, its economic assets and the dominant role it plays in the national economy, the city is considered a hotspot of vulnerability to the impacts of climate change (ADB, 2010; Carew-Reid, 2007; Dasgupta et al., 2007).

Climate change is already very evident in Vietnam with average temperature increasing by 0.5 °C and sea-level increasing by ca. 0.20 m over the last 50 years (MONRE, 2009). However while the precise extent of future climate changes are uncertain and difficult to predict, especially downscaled to the urban level, recent studies conclude that climate change and its effects for Vietnam are occurring at a faster rate than previously forecast. Local climate change will have profound impacts for HCMC, with the city being particularly at risk from heightened climate variability and rises in sea-level. The most significant impacts are identified as flood risk, thermal stress, energy security and water resources (Ho, 2007, 2008; ADB, 2010; Storch, Downes, Katzschner, & Thinh, 2011; Storch et al., 2009; Yusuf & Francisco, 2009). This paper focuses on the city's current and future exposures to flood risk.

Urban development trends and exposure to flood risks

In recent decades urban flooding in HCMC has become one of the most pressing issues. The city is already exposed to multiple flood risks. Only 55% of the current urban area of HCMC lies 1 m above mean sea-level and only 28% is above 2 m. This makes the city particularly vulnerable to inundation from even small changes in future sea-level.

A significant part of the city already experiences frequent flooding. There is severe disruption on a regular basis and multiple consequences (Storch et al., 2009). The occurrence of localised