# Adapting Ho Chi Minh City for Climate Change. Urban Compactness: a Problem or Solution?

## 1 Ho Chi Minh City and Climate Change

Similar to other emerging mega-cities in South-East Asia, Ho Chi Minh City (HCMC) is undergoing a rapid process of urbanization accompanied by dramatically land use changes in the surrounding rural areas. It is characterised by urban structures of both planned and informal expansions of the urban morphology which are both degrading valuable natural areas in the hinterland, and are increasing the vulnerability of these areas to climate-related environmental changes or hazards. As densely built-up urban area in a flat low lying region, HCMC is historically a region 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. This combination accumulates to a high average level of physical and social vulnerability in most parts of HCMC.

Vulnerability analysis of these climate-related natural processes and the enhancement of adaptive capacities are major challenges, as the areas prone to potential climate-related impacts vary and overlay with respect to their spatial scope, time, and social environment. As the adverse impacts of climate change will affect the land use structures, the population and natural resources of HCMC, efficient planned adaptation responses must be grounded on site-specific designations within the decision-making processes of urban planning and development in HCMC.

### *1.1 Urban Environmental Governance*

Focusing at the local view suggests that addressing adaptation response to climate change should be a key component of urban sustainable development. The currently available experience indicates that a local approach to planning for change is likely to be the most effective. Urban authorities have been engaging with issues of sustainable development and attempting to translate global policies into local practice through urban development planning. Therefore local governments represent an important factor for the governance of global issues in their own right (BULKELEY & BETSILL 2005). Capacity building and community participation will be critical factors in ensuring an effective adaptation response. Adaptation is a process by which urban planning authorities seek to cope with the consequences of climate change, because without an adaptation framework the necessary future adjustment processes will be mainly triggered by disasters. The process of adaptation needs a planning framework to incorporating future climate risk into policy-making on urban-level. While the scientific-based understanding of climate change and its potential global impacts have become more detailed, the availability of practical guidance at the local-level for its adaptation has not kept pace. Because of the wide-ranging nature of the sources and consequences of global warming, institutional co-operation is vital in responding to the problem. Effective communication and co-ordination within and between relevant urban departments and institutions should be encouraged. Urban and regional adaptation planning requires coordination across all levels of government and the involvement of urban planners, scientists and community leaders.

The urban planning system in HCMC will be a key tool for adaptation in the face of changing climate. The quality of the planning system and its operation constitute an important dimension in institutional vulnerability (CAMPBELL 2006). The question is whether the current planning system in HCMC will be capable of accounting for climate change issues and whether it is efficient enough to implement the necessary measures. In HCMC the efficiency can already be drawn into question, as the already present-day climatic events cause hardship, even in areas recently developed.

## 2 Climate Change related Impacts on the Urban Environment of HCMC

The overall objective is to develop and incorporate adaptation into urban decision-making and planning processes with designation criteria and zones that will lead to an increase of resilience to climate-related physical and social vulnerabilities of the urban system of HCMC. Climate Change will likely change current climate conditions and lead to an ongoing sea-level rise and increase in extreme weather events such as heavy rainfall and heat waves etc. These climate related events cause a multitude of potential impacts and risks not only to natural areas but specifically to populations of densely built up metropolitan areas. In foreseeable future they may also cause indirect negative effects such as severe urban floods or disturbances of the energy supply or public transport systems in urban areas. The main task of assessing climate change related impacts in urban areas is to estimate the possible damages that might arise for human-influenced systems by climate change, including extreme weather events. In general there are two elements that define the potential risk: first, the probability of the occurrence of the events and second the “elements” at risk. Events to be included are heat waves, heavy rain, floods etc. "Elements” at risk are not only assets like houses, urban infrastructure services or economic losses, but also human health or livelihood. The goal of an *integrated regional vulnerability assessment* is to inform decision-makers and the general public about climate change risks, and to increase their capacity to implement necessary adaptation measures and to increase the resilience of the urban system of HCMC. The following questions will be explored for climate-related impacts on the urban environment of HCMC:

- Where and how does urban development change the land use pattern of the metropolitan area of HCMC, and to what extent does this affect the exposure or sensitivity of the urban environment to climate change related impacts?
- Which urban structure types can be distinguished, and what is the relation between their characteristics and the assessed level of vulnerability against climate change impacts?
- How adequate are the existing land use planning and urban-environmental management approaches to the relevant governance structures; to what extent do they contribute to an urban development that takes climate-related vulnerabilities into account?
- Which vulnerable areas can be identified in the context of the predominant impacts of climate change (including current variability and extremes) in HCMC (in the research fields of urban flooding, urban climate, energy and transport systems)?

An important first step to estimate the future vulnerable areas is to describe the observable impacts of current climate variability and weather extremes on the following four selected thematic fields of application: Urban Flooding, Urban Climate, Urban Energy and Urban Transport.

### *2.1 Urban Flooding*

Ho Chi Minh City is located 50 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 city is surrounded by marshes on the lower reaches of the Saigon River. The Saigon River, Dong Nai River, Nha Be River and Long Tau River flow through the city, and the rivers and canals form a complex network that is affected by tide (figure 1). The majority of the actual urbanized land is only 2 to 3 meters above sea level. This low elevation of the land and heavy rainfall makes the city susceptible to flooding induced by tidal fluctuations. From October to January when high tide reaches its peak, water level in rivers and canals rise as high as, or more than that the land elevation (NGUYEN HUU NHAN 2006, HO LONG PHI 2007).

Each year, HCMC suffers many serious floods, not only in rainy season from May to November, where monthly average rainfall is 250 mm, but also during the season with high tide from September to January.

There are three different types of floods in the HCMC-region tide-induced flood happening in areas with ground elevation lower than high tidal levels (<+2m), these areas taking up c. 60% total urban area;

- storm-induced flood in high-laying areas, but with old and degraded drainage system and inadequate sewer density and size;
- flood due to combined effect of tide, storm water and river water from upstream area.

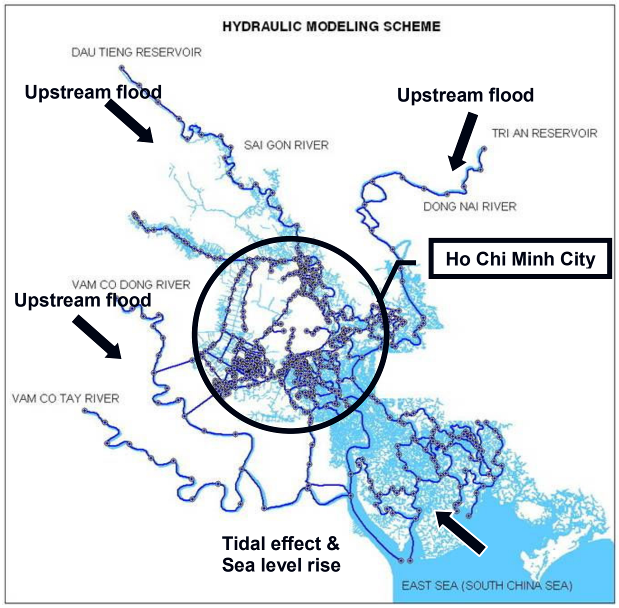


**Figure 1: Hydraulic Modelling Scheme of the HCMC-Region (Source: Ho Long Phi 2007).**

An additional cause of serious problem of urban flooding is the ongoing rapid urbanization process, which has changed the land-use pattern of the metropolitan region. 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 flow. The future urban expansion of HCMC will take place in peripheral and suburban areas, which will again increase the risk of urban flooding (see table 1).

**Table 1 Natural land conditions for urban development in HCMC (JICA 2004)**

| Ho Chi Min City | Flood Prone (% of area) |
|---|---|
| Inner Core | 22 |
| Inner Fringe | 39 |
| Emerging Peripheral | 66 |
| Suburban | 77 |
| Rural | 58 |

Since the beginning in the 1990s events of inundation in the city have occurred with increasing frequency (TRINH XUAN LAI 2005). In HCMC the number of flooded locations, the flooding frequency and its duration have increased continuously (HO LONG PHI 2007):

- More than 100 serious flooded locations, including many in the city centre, were reported after one single heavy rainfall event (127 mm) on May 16 in 2004, causing prolonged traffic jams as thousands of motorcycles broke down.

- Some 20 inundated sites are reported monthly due to high tides.
- At some locations in HCMC land subsidence has been occurring at a significant rate, caused by overexploitation of groundwater and construction of high-rise buildings. Land subsidence is creating a similar effect as sea-level rise and may enhance the flooding situation when combined with rising water levels and more intense rainfall.

"Recent studies on the urban flooding problem in Ho Chi Minh City have proven that local impacts of climate change, rising water levels, land subsidence and urban sprawl are among the most direct causes of the flooding that caused millions of USD in losses damage each year" (HO LONG PHI 2007).

### *2.2 Urban Climate*

In the metropolitan region of HCMC the climate is generally hot and humid. There are two distinctive seasons: the rainy season, from May to November, and the dry season, from December to April. The annual average temperature is 27º C. The hottest month is April and the coolest is December. The insolation time is 5-9 hours per day. In HCMC the annual average rainfall is about 1,800 mm and the number of rainy days per year is about 160. The rainy season begins in late May and ends in late October, with most of the rainfall concentrated in June and September. The potential evaporation in the area amounts 120.4 mm per month with the highest in June (173.2 mm), while the mean annual relative humidity is 80%. The wind direction in the dry season is from East to Southeast and in the rainy season from West to Southwest. The average wind speed is about 2.5-3.5 m/s. The sea breeze effect is quite large and winds from East are strongest from 1400 to 2000 h (NGUYEN HUU NHAN 2006).

A regional climate change scenario (SEA START RC 2006) shows that the lower Mekong River basin region tends to get slightly warmer (1-2 ºC) under climate condition at CO2 concentration of 720ppm (2 times of current baseline). Summer time in the region will be significantly longer in the future. Hot days (maximum temperature over 33ºC) will increase by 2-3 weeks and the cool days (minimum temperature under 15ºC) will reduce also by 2-3 weeks throughout the region. A recent statistical analysis of the maximum temperature during rainfall seasons in HCMC has revealed that the temperature has been increasing over the past 20 years (HO LONG PHI 2007). This is a trend that may be comparable to climate changes induced by global warming.

Urbanization is an extreme case of land use change. Rapid and dense urban expansion in HCMC has direct impact at the local scale by changing the urban climate and indirect effects like modifying the urban water-cycle and increasing energy demands for indoor cooling. The clearest local indicator of climate changes due to urbanization is an urban-rural convective circulation known as urban heat island (UHI) effect. The additional impacts of future rises in temperature due to Climate Change, together with the observable increases in temperature due to urban heat-island effects make Asian cities more vulnerable to higher temperatures (KALNAY & CAI 2003, PATZ ET AL. 2005). The UHI-effect reveals the warming of the inner-core of HCMC that is significantly higher (up to 10 ºC) than typical temperatures in vegetated urban areas or the surrounding rural areas (TRAN THI VAN 2004, HO TONG MINH DINH ET AL. 2006, LE VAN TRUNG ET AL. 2006). This will lead to further increases in temperatures in the urban area of HCMC with negative implications for energy consumption and human discomfort. The energy consumption for cooling of buildings due to the effect of UHI increases more than 50% compared to that in rural areas (TONSUWONNONT 2006).

Urban climate issues are a serious problem for human health and urban ecology (KATZSCHNER 1988), especially in Asian metropolitan regions. Urban environmental planning information systems can be suitable tools to analyse these problems related to urban climate. To consider aspects of urban climate within the planning process, spatial climatic information will be necessary (KUTTLER 2001). The assessment of the urban climate for adapted urban planning is an important task especially in fast growing cities in subtropical and tropical climates (BULKELEY & BETSILL 2005). Climate function maps can describe the urban climate in regard of thermal stress, climate comfort and ventilation. These parameters are closely linked with the urban design and should assist climate adapted urban planning. It is an important objective to investigate the impacts of different building structures on the urban climate. On the one hand it leads to an improved comfort for the inhabitants on the other hand it can reduce the $CO_2$ output and save costs by reducing the demand for air condition (ROAF ET AL. 2004, ARNFIELD 2005).

### *2.3 Urban Energy*

In 2004, Vietnam generated 39,7 billion kilowatt-hours (kWh) of electricity, of which 52% was hydropower. About 50% of the produced electricity is used in the household and service sector (Table 2). Although Vietnam's per capita electricity consumption is among the lowest in Asia, demand has risen in recent years, because Vietnam's economy has expanded rapidly (GDP-growth ~8% in 2004/05/06). An additional demand is attributed to the growing urban population and higher living standards (MONRE 2005).

**Table 2 Electricity consumption structure in Vietnam (MONRE 2005)**

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|
| Electric. Consume. Total (Bill. KWh) | 19,55 | 22,40 | 25,86 | 30,22 | 34,83 | 39,68 |
| Household and service (Bill. KWh) | 10,02 | 10,98 | 12,64 | 14,33 | 15,99 | 18,24 |
| Household and service (% of Total) | 51,10 | 49,00 | 49,10 | 47,40 | 45,90 | 46,00 |

Electricity demand in Vietnam is forecasted to grow by 15 percent per year until 2010 (MONRE 2005). Vietnam currently buys power from China to prevent shortages in the North, and plans to begin purchasing from Laos in 2008. In order to meet increased demand, construction of expansion is planned for 32 power plants before 2010 (LE CHI HIEP 2006). During a breakdown of a single power plant in June 2005, Vietnams National Electricity Dispatch Centres reduced the power delivery during peak demand hours in the morning and evening, because of high power consumption in the summer season. The electricity sector is investing in 25 power-plant projects; however Electricity of Vietnam (EVN) has warned that electricity shortages may still affect the country in the future (PEI 2005).

**Table 3 Electricity consumption of cooling/air-conditioning technology in VN (MONRE 2005)**

| | 2000 | 2005 | 2010 |
|---|---|---|---|
| Cooling capacity total (Bill. BTU/h) | 3-3.5 | 4.2-5.0 | 6-7 |
| Power capacity (MW) | 400 | 550-600 | 750-850 |
| Electricity demand (GWh) | 1200 | 1600-1800 | 2500-2800 |

HCMC's electricity consumption is about 25% of the total consumption of Viet Nam. The city has a projected power demand of 12 billion kilowatt-hours (kWh) a year by 2005 and 23 billion kWh a year by 2010. More frequent extreme climatic events and greater seasonal temperature variability will increase the energy demands for cooling buildings in summer. The more rapid increase in electricity requirements, however, estimated at a yearly increase of 15%, is attributed to the growing population and higher living standards. Thus, the effect of climate change on energy requirement may be marginal. But HCMC's power usage, like in the whole country (table 3), is greatly influenced by the climate, because with the penetration of domestic air-conditioning the demand for energy is increasingly temperature sensitive. In the first quarter of 2003, HCMC suffered extreme temperatures and power consumption increased by 20%. This condition caused episodes of power outage in the area. Electricity of Viet Nam saw this incident as another reason to raise generation capacity to meet growing electricity demand in the whole country (PEI 2005). Energy consumption in the household sector is strongly interrelated with the corresponding $CO_2$ emissions in production of space cooling, hot water, cooking, and use of electrical appliances. The climate-related indirect impacts on urban settlements include increased energy demand for space cooling. In order to calculate electricity consumption in the household sector realistically, the behaviour of private consumers in HCMC had to be taken into account.

Current urban development trends may be increasing the vulnerability of settlements to climate variablility and extrems. The urban-imposed threat to global sustainability has two fundamental dimensions: population growth and the ever-increasing per capita demand for floor-space, services, particularly material needs and energy. Emerging megacities in Asia like HCMC are characterized by a high population density and increasing electricity demand (HONGPENG LIU 2007). Settlements are complex systems and the impacts of climate change on settlements and their energy demand should be considered in the context of this complexity. The type, size and structure, location, socio-economic characteristics and institutional arrangements are key factors that affect vulnerability and adaptive capacity of a settlement. Designing buildings and urban areas in ways that buffer temperature changes or reduce energy demand will serve as an adaptation for climate change and temperature extremes.

### *2.4 Urban Transport*

In HCM City, existing land-use patterns and the resulting spatial structures limit the choice of transportation alternatives. Spatial structures with a high residential density, like in HCM City, cannot rely on private cars as the dominant transport system; low density use patterns in the developing suburbs cannot maintain an effective public transport system. The amount of land taken for traffic thus depends primarily on the accessibility and use of public transport systems. In the inner-city core of HCM City, the transport infrastructure occupies only 8% of the total urban area. Probably the greatest task of HCM City on its way to a global megacity is the reconstruction of the transportation network. In HCM City, the public transport infrastructure (see table 4) can attract less than 5% of travel demand. The transportation infrastructure is poor and more than 90% of commuters use private forms of transport (table 4). The dominance of motorcycles and the weakness of public transport have resulted in increasing emissions from private urban transport activities.

**Table 4 Urban transport in HCM City in 2005 (PC-HCMC et al. 2007)**

| **transport mode** | **total number** (registered) | **vehicle ownership** (% of total households) | **mode share** (in %) |
|---|---|---|---|
| bicycle | - | 17.2 | **19.0** |
| motorcycle | 2,400,000 | 98.0 | **73.9** |
| car | 253,000 | 3.2 | **1.0** |
| taxi | - | - | **1.2** |
| bus (public) | - | - | **3.7** |

The ownership of private motorised vehicles in Vietnamese cities reaches approximately the same levels as in European cities. Nevertheless there is a big difference in the composition of the vehicle fleet. While the European transport system relies mainly on private cars, the Vietnamese system is dominated by motorcycles (PFAFFENBICHLER ET AL. 2007).

The urban transport system in Vietnam is characterised by a very high share of motorcycle ownership and a declining share of the once very high level of bicycle use (table 4). More than 50% of all urban journeys or more than 80% of all motorised trips are made by motorcycle (BENKHELIFA 2006, DERSTROFF & ROSSMARK 2005). Most of the motorised two-wheelers in use in the Vietnamese cities have four-stroke motors (SCHIPPER ET AL. 2005).

Hence the situation concerning air pollution is better than in many cities in other Asian countries. The rapid economic growth of Ho Chi Minh City has led to significant changes in purchasing power and life style. It is expected that this continuing trend will led to uncontrolled traffic growth, congestion, saturation of urban space and air pollution (BENKHELIFA 2006). The main objective of urban transport planning is to assess the potential of different urban development and transport strategies to increase energy efficiency and reduce GHG-emissions.

## 3 Research Concept of Vulnerability and Adaptive Capacity

Vulnerability and adaptive capacity are two central concepts in climate change research as well as in a number of other research contexts related to the risk assessments of natural hazards. Vulnerability to climate change refers to the impacts to human-environment systems. Scientifically predicted are direct impacts of climate change on human beings (i.e. by urban flooding or heat waves), and indirect effects through impacts on climate-sensitive urban sectors (i.e. housing, energy system or drainage system).

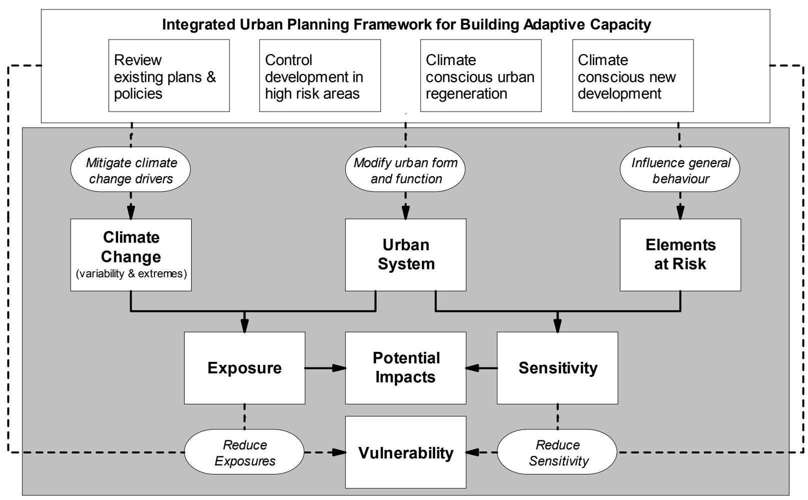


**Figure 2 Integrated Urban Planning Framework for Building Adaptive Capacity**

The proposed adaptation planning framework follows the basic definitions of the Intergovernmental Panel on Climate Change (IPPC), because the IPCC definition of vulnerability facilitates to describe the long-term vulnerability to social as well as biophysical systems (FÜSSEL 2007). The following definitions of central terms related to the assessment of vulnerability of IPCC (2001) are a basis for this research:

- Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of *climate change*, including *climate variability* and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its *sensitivity*, and its adaptive capacity.
- Adaptation: Adjustment in natural or *human systems* in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. In contrast, mitigation is the attempt to avoid or lessen climatic change (e.g. reduction of greenhouse gas (GHG) emissions).
- Adaptive capacity (in relation to climate change impacts): The ability of a system to adjust to *climate change* (including *climate variability* and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
- Sensitivity is the degree to which a system is affected, either adversely or beneficially, by *climate variability* or change.

- Elements at risk are variables of concern of the vulnerable system that are threatened by its exposure to the hazard. Climate change has a wide range of effects on a particular system or community (e.g. human lives and health, income and housing of a community).
- Exposure: The "degree of climate stress upon a particular unit of analysis; it may be represented as either long-term changes in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events" (IPCC 2001).
- Potential Impact is a function of (the change in) the *exposure* of a system to effects of climate change and of its *sensitivity.* The assessment of potential impacts does not take future adaptation measures into account.

In summary vulnerability according to IPCC is defined by three factors: the regional exposure factor, current sensitivity, and adaptive capacity. First, the geographic context gives rise to *biophysical exposure,* which includes factors such as topography and connectivity and can be mediated by technology. Second, the urban fabric of a society underlies patterns of *social sensitivity,* including issues such as population density, levels of income, education and risk awareness and institutional capacity. Combined in different places, biophysical exposure and social sensitivity constitute configurations of *place vulnerability* (CUTTER ET AL. 2003). In figure 2, measures to enhance the adaptive capacity should be directed towards decreasing exposures on biophysical and social sensitivity from the viewpoint of place vulnerability, taking into account the geographic context of the urban system determining these. The shift from risk research related to natural hazards to the more integrated view of vulnerability in climate change research has two important aspects. Firstly, vulnerability assessment is focusing on social and not only physical vulnerability. Secondly, it pays more attention to factors related to societal development, institutional organization and administrative decision-making (CUTTER 1996). Because the concept of vulnerability not only relates to the exposure of property and human or to the physical susceptibility of exposed elements, adaptive capacity is strongly related to development issues.

## 4 Adaptation Planning Framework

The concept of Vulnerability and Adaptive Capacity aims to provide the basis for an integrated assessment of climate-related impacts and possible adaptation options in the urban environment of HCMC. Vulnerability Assessment and Adaptation Planning has the overall objective to take over competencies of regional spatial planning by combining requirements of spatial planning and sector planning with relevant legal, environmental and social objectives with the aim of an adaptation of land use to climate change. Each sector planning analyses conflicts of climate change and assesses designations and measures on their suitability for adaptation to climate change. The comprehensive instrument of spatial planning has the task to compromise between the land use demands from the different sectors and to integrate these in the weighting process. For this purpose a conflict analysis of all proposed designations and measures of all sectoral planning activities in HCMC will be carried out (STORCH ET AL. 2007). In the following overall assessment of potential contents of the spatial planning system, which shall be implemented with priority for climate adaptation purposes, vulnerability assessment will function as essential decision-making tool and process. Criteria will be selected in a joint procedure with the aim to achieve results on urgent and important future designations and measures of regional spatial planning, requirements for adaptations in legislation and strategies for the participation and information of affected settlement areas and social groups. Vulnerability Assessment will contribute to identifying, developing and advocating spatial land use planning mechanisms to help the adaptation of urban development and land use to climate change and current climate-related impacts on the urban environment of HCMC (STORCH & ECKERT 2007). Strategic Environmental Assessment is a valuable process and response instrument to transfer scientifically well understood and documented core problems of climate change (urban flooding and urban climate) into adapted planning systems and to select criteria to assess these in the context of comprehensive urban planning systems.

**Table 5 Designation criteria and measures for adaptation to climate change**

| Environmental Media | Urban Planning Objective | Environmental State in Urban Planning | Environmental Impacts | Adaptation Response Measures |
|---|---|---|---|---|
| Human Health | Protection of population against floods | Settlements in retention areas of rivers or close to coast | - Increasing water levels causing flooding<br>- Increased urban flooding from overflow of storm drains | - Resettlement<br>- Designation of retention and infiltration areas |
| | Protection of population against pollution | Cities, settlements close to highly polluted areas (accumulations) | - Air pollution | - Buffer zones<br>- Afforestation |
| | Protection of population against urban heat islands | Cities of high settlement density | - Air pollution<br>- land consumption<br>- fragmentation of fresh air corridors | - Designation of sanitation areas (desealing etc.)<br>- Designation of climate protection areas (cold air protection areas and fresh air corridors) |
| | Protection of population against diseases | Especially urban and recreation areas | - increasingly viable disease vectors | - Public awareness rising<br>- Prevention |
| | Provision of recreational areas | Green spaces and public recreation areas | - Air pollution<br>- Decrease of groundwater level<br>- Dehydration of waters | - Creation of restriction zones and inner-urban greenspaces |
| Fauna<br>Flora<br>Biodiversity | Protection of natural rural areas and inner-urban green spaces | Protected areas | - Air pollution<br>- land consumption<br>- Decrease of groundwater level | - Creation of restriction zones and inner-urban greenspaces |
| Water | Remediation of rivers and retention areas | River catchment areas | - Decrease of groundwater level<br>- Dehydration of lakes and rivers | - Designation of retention and infiltration areas |
| | Remediation of groundwater regime and wetlands | Wetlands, grasslands, agricultural areas | - Decrease of groundwater level | - Designation of retention and infiltration areas |
| Air and Climate | Reduction of $CO_2$ and other greenhouse gas emissions | Urban and transportation areas | - Air pollution | - Land use designations for greenhouse gas reduction, capture and storage |

The overall objective is to derive adaptation options for urban land use planning in HCMC as a response to climate change. Viable adaptation options for urban development spatial in HCMC could be:

- Objective-led control of demand for urban land uses and preservation of more natural rural areas of importance for climate protection
- Introduction of designations for climate relevant large-scale un-fragmented cold air generation areas, fresh air exchange corridors, wetland restoration areas, water river retention areas, buffer zones for $CO_2$ and water capture and storage and others
- Proposal of regional environmental quality standards limiting land consumption and land-use stresses especially in urban areas of high density

Within the interdisciplinary approach the overall objectives are to determine adequate adaptation measures for spatial planning on urban level by minimising the significance of core conflicts of human health and climate. Sector planning objectives and designation zones shall be analysed on the basis of their importance for climate change and shall be compiled in a clearly arranged way. As the implementation of sectoral policies has much stronger spatial consequences on urban land uses and developments than comprehensive land use planning policies, their position in adapting to climate change must be strengthened and their integration level assessed. Therefore the consideration of all climate relevant issues in the weighting process of urban planning systems shall be analysed and assessed. The iterative link of spatial planning to sector planning mainly consists of objectives that are compromised with and integrated during the spatial planning weighting process. A permanent communication and cooperation with all relevant stakeholders is therefore crucial for the success of an integrated adaptation planning framework. Essential contributions of sector planning to urban planning must be identified. All relevant results on the state of the art in HCMC concerning designation criteria and measures for the prevention of and adaptation to climate change from all sector planning activities will then be compiled in a systematic way (see table 5).

In an interdisciplinary approach assessment criteria and methodology shall be selected with the aim to assess contents and objectives of the regional land use planning system for their adequacy and efficiency in adaptation to climate change. The assessment method shall first of all be embedded into the existent urban planning system, in order to stay flexible under the uncertainty of forecast for site-specific adverse effects of climate change. Revisions and amendments of the selected indicators and criteria will be possible in the future. The tasks of vulnerability assessment methods shall lead to the following results and deliverances in the course of the research project:

- a compilation of current core impacts and conflicts of urban developments with climate protection and change (state of the art).
- an interrelation scheme with identified current potentials of environmental and urban planning policies, strategic environmental assessment and social impact assessment.
- an assessment methodology evaluating all climate-relevant spatial objectives and designations including those integrated from sector planning.
- a priority list of derived adaptation scenarios and measures for the urban planning system of HCMC at urban level as a response to climate change.
- a comprehensive guideline for future implementation of environmental climate protection and adaptation policies on urban planning level.

During the integration of sector planning into spatial planning in the weighting process, climate concerns and their transparency for the different planning authorities of HCMC shall be strengthened. The implementation of adaptation measures for climate change into urban development planning requires beside environmental policy, legal and planning regulations public participation and consideration of social impacts. Therefore objectives for an integration of the adaptation planning system into administrative and environmental governance processes in HCMC shall be formulated as an important future step.

**Summary and Outlook**

The spatial form of urban areas must be considered for adaptation planning. Asian cities are getting more and more dispersed, increasing their land areas without taking into account the natural conditions. This urban expansion processes are at the root of many urban hazards, especially urban floods (MESSNER & MEYER 2006). The later identification of risk areas and the resettlement of populations from these urban areas is a complex process which involves social, technical and financial questions not easily managed. As long as the current model of urbanization in Asian megacities continues to ignore the environmental constraints, no planned adaptation to climate change is possible. The current patterns of urban development, expansion and land use must be re-examined, because the generated dispersed urban forms are reflections of processes which reproduce climate change related risks in new contexts, amplifying their intensity and increasing the numbers of vulnerable urban areas and population. Asian cities will play a specific role in adaptation research related to Climate Change. With population increasingly concentrated in urban spaces, and considering their dense nature and diverse urban forms and disrespect for the natural site conditions and climate phenomena, cities are among the spaces of greatest vulnerability to Climate Change. Ho Chi Minh City constitutes a hotspot where Climate Change related natural hazards are intensified, also congregating social and economic risks, whether or not they are produced at the urban scale. Emerging megacities, like HCMC, therefore, constitute a specific focus for adaptation measures guided by spatial planning science, since they are and will increasingly be the principal spaces of vulnerability.

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