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Spatial Information Management for Megacity Research in Asia

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Abstract

Asia offers an appropriate setting for the analysis of many of the institutional forces and the urban dynamics that impact the interconnections between humans and their management of environmental resources in the megacities of today (Lo and Marcotullio 2001). This paper presents significant initial results of the urban sustainability assessment research of housing policies at the urban planning level in Ho Chi Minh City (HCMC). The objective is to develop an urban planning information system based on urban growth theory to assist a more integrated approach to the future sustainable development of housing and settlement structures to balance urban growth and redevelopment in HCMC. Although environmentally inefficient settlement development structures are resulting in an ongoing unsustainable use of land-resources, planning instruments have their limitations to promote the necessary structural changes in spatial development planning. Based on current urban growth research, this paper offers an overview of available indicators that can describe the efficiency of regional and urban spatial structures in relation to land use and land consumption. A special focus will be laid on methodological issues of urban sustainability indicators and their spatial representation by urban typologies for the establishment of an urban planning information system in HCMC.

1. Introduction - Megacity Research within the Metropolitan Area of HCMC

The transition of the economic system of Vietnamese cities and the interlinked development of the future megacity of HCMC has two interrelated perspectives: firstly urban growth, the evolving urban forms in the context of urbanisation, and secondly urban redevelopment within the inner urban area. Megacities of tomorrow like HCMC offer exceptional opportunities to analyse both the impacts of large-scale environmental resource problems and institutional responses to these impacts, as well as urban planning and management strategies to overcome the limits and failures in the management of environmental resources.

HCMC covers 2,000 sq km, divided into 24 districts hosting an official population of more than 6 million. The inner city has an average population density of around 10,000 people per sq km. HCMC is undergoing a rapid urbanisation such that by 2020 the 17 inner city districts are expected to have a population of approximately 6 million, while the suburban area will have roughly 4 million residents.

The demand of water and industry and households surpassed the current distribution capacities. The water quality in underground sources and river courses is highly degraded due to many sources of pollution (Van Duc and Gupta 2000). HCMC's infrastructure is overloaded and is unable to meet the needs of people living in highly dense urban areas. In HCMC, the public transport infrastructure can attract only around 10% of travel demand. The transportation infrastructure is poor and almost 90% of commuters use private forms of transport. The current urban transformation process requires that the urban planning information system be based on a sound understanding of the housing and settlement development processes.

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2. Spatial Indicators to Assess the Efficiency of Urban Land-use

Because these different principles of sustainability obviously have conflicting requirements (Satterthwaite 1999) an integrated urban planning strategy will try to balance these different requirements. The resulting planning decisions need to be regularly monitored and assessed against agreed-upon urban sustainability indicators. To enable sustainable livelihoods for all within the bounds of the environmentally possible, the spatial planning aspects of sustainable urban development require the development of settlement and housing structures that facilitate equitable access to public resources and service opportunities and the efficient sharing of finite natural resources and agriculturally productive space in the metropolitan region.

Settlement structure and its form of the built environment determine both the efficiency of resource uses and the quality of life of the inhabitants. Spatial development in metropolitan areas worldwide is characterised by the continuing use of mainly agricultural land, a finite resource, for settlement and traffic purposes. In contrast to similar problems in Europe, urbanised areas in Asia are affected primarily by growth in employment and population. In the field of spatial and urban planning research, the main impacts of an inefficient use of land for settlement development are described as a spatial development in which the spread of residential development across the rural landscape far outpaces population growth (Nechyba and Walsh 2004). The efficiency of the resulting regional and urban spatial structure that this spatial development process creates can be measured and analysed (Apel et al. 2000, Ewing et al. 2002, Flacke 2003) by the use of spatial and structural indicators. The sustainable use of land resources is an important indicator for the evaluation of settlement structures and transport infrastructures from the point of view of an efficient spatial development. Urban development planning of the last decades and the current discussion on regional planning are characterised by two contrasting and conflicting urban planning models (Apel et al. 2000):

- Network city - this widespread city is signified by the gradual dissolution of the traditional compact European urban structures.
- Compact city - this urban model is based on European urban culture and can be adapted to urban districts in polycentric, public transport-based regions.

Table 1:
Efficiency of land-use for urban development strategies
(compiled from: Apel et al. 2000, Ewing et al. 2002)

Indicator	**Network City**	**Compact City**
Residential density	The population is dispersed in low density development	High density of use, high residential density
Neighbourhood mix of uses	Rigidly separated uses (homes, shops, and workplaces)	Variety and mix of uses
Centeredness	Lack of well-defined activity centres (business, shopping)	Concentration of settlements, well-defined activity centres
Transportation choices	Poor access to public transportation choices: higher commuting rates and car ownership	Environmental-friendly public transportation choices, areas suitable for walking and cycling
Recycling of land	New developments mainly on greenfield sites	Redevelopment of brownfield sites and already built-up areas

Because efficiency indicators for residential land-use can be easily used to contrast and separate the two competing urban development models of the current spatial planning discussion (table 1), the efficiency of regional and urban development structures is a real, measurable phenomenon with real implications for indicator-based Sustainablity Assessment (SA) procedures incorporated in urban planning information systems.

2.1 Indicators and Information Requirements for an Urban Planning System

In HCMC, major deficits in the current regional planning framework to limit the environmental pressures associated with sprawl are a lack of spatially detailed data required to create indicators related to sprawl and land consumption and the resulting inappropriate zoning. Strengthening the regional planning competence requires an appropriate use of available data and a more precise and transparent zoning of future settlement areas (Runkel 1999). The current lack of usage and availability of efficiency indicators (Steinocher and Tötzer 2001) is limiting an appropriate the spatial assessment of environmental impacts of land-use changes. A pragmatic approach to the assessment of settlement developments involving core indicators should be used (Apel et al. 2000, Flacke 2003), because they can largely be derived from the above-mentioned available land-use und socio-demographic base data. In order to provide improved control of the efficiency of land-use at the regional planning level, requires the primary definition of the basic parameters of urban development based on efficiency indicators (Flacke 2003). Densification is the most important efficiency indicator for urban land-use patterns, because it reduces sprawl. Further, the dense structure of the compact city provides the necessary economies of scale for an efficient infrastructure, and provisions for certain types of public urban services and an efficient use of finite natural resources.

Yet in heavily under-serviced urban areas in developing counties, densification can be detrimental. In HCMC informal settlements are examples of areas of extremely high density living, but inadequate levels of service and infrastructure provision creating serious health problems and increased environmental impacts in these urban districts. In these under-serviced urban areas poverty reduction is the primary issue and the necessary establishment of acceptable living conditions induces an increase in resource consumption and energy production. Higher density is therefore not the only indicator for sustainable urban structures.

3. Spatialisation of Urban Sustainability Indicators

Sustainable urban development requires different strategies for different settlement types, because spatial planning concepts are very dependent on the particular local urban context. Different settlement types will have different implications for achieving sustainability of settlement and housing structures. Different discipline-specific methodological approaches to the 'urban environment' require a commonly accepted spatial working basis, which can ensure that the resulting heterogeneous investigations can be transdisciplinarily integrated by using an adequate spatially explicit classification.

Settlement and housing types in HCMC are not uniform. Because of the difficulties of separating settlement and housing typologies in HCMC they are used in an integrated manner, to accept the complex nature and continued transformation of urban typologies in HCMC. It is therefore not the primary goal to develop a general definition of settlement and housing typologies in HCMC. Rather, an analysis of the sustainability of urban typologies in a relatively representative model of different settlement and housing types is needed to assess the problems of different urban settlement and housing structures. Urban typologies can provide a tool for the structured and representative analysis of settlements in HCMC with its different components, of which housing is an important one.

3.1 Methodology - Data collection based on Housing Typologies

In general, data on the housing typologies will be gathered by examining actual study sites within the metropolitan area of HCMC. Prior to the selection of these study sites, the kinds of housing development inherent to each typology were identified. Four representative types, so called archetypes, of residential development were generally identified (table 2): Shophouse (tubehouse with small lot wide) patterns, villas structures, condominium (mid-rise multiple family apartment buildings) and high-rise apartment blocks (up to 20 storeys high). Based on these four housing archetypes, each of these types was conceptually divided into two subtypes to generate the housing typologies, with the exception of the shophouse structure, which was divided into seven subtypes to reflect the broad variety of these predominant settlement structures occurring in the inner-districts of HCMC. Following building-specific indicators were used to define the final housing typologies (table 2): Height (storeys), block size and shape, structure of the street-network, built-up ratio, location in the metropolitan area, housing mix and mixture of usage (multi-functionality). These housing typologies are used to define the study sites for the data collection procedures.

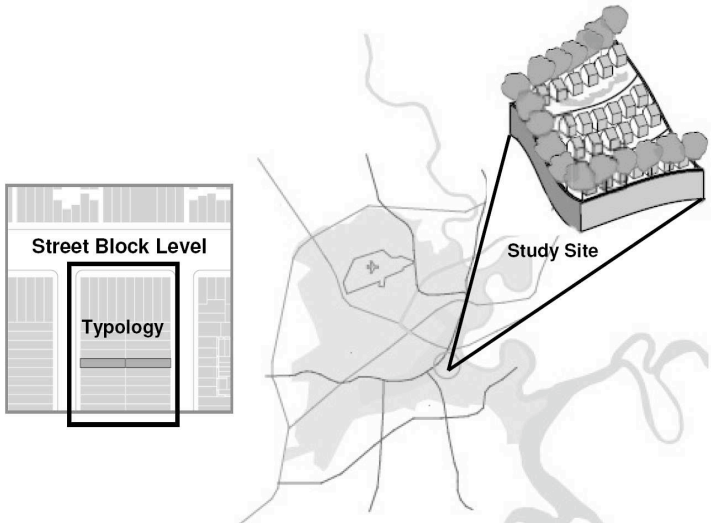

Figure 1: Housing Typologies – Selection of Study Sites

Each study site represents one housing typology found within the settlement pattern of HCMC. First, these study sites were spatially defined through examination of satellite images and later verified by ground recognizance (figure 1). Study Sites were selected following three primary criteria:

- archetypical representation of the housing typology;
- conformance of the shape and size of the street block arrangement to the overarching archetype; and
- correlation to pre-existing statistical and spatial data sources.

The final criterion was included to simplify the data collection process during the initial phase of the research programme, where all available data required for the multi-layered approach should only be aggregated to reflect the typology-driven accepted common spatial framework. Out of this process, a first requirement for thirteen study sites was realized (table 2).

Up to four study sites are selected for each of the housing typologies. Each study site is selected to represent one housing typology found within the neighbourhood pattern on district level. The physical boundaries of the housing typologies are defined by street blocks. The study site is embedded within the surrounding urban fabric of the neighborhood pattern.

Table 2:
Housing Typologies of selected Study Sites in HCMC (Storch and Eckert 2007 Tab.1)

Housing Typology	Description	Height (Storeys)	Block Size (Shape)	Street-Network	Built-up Ratio	Location	Housing Mix	Mixture of Usage
Shophouse								
Type A	Shophouses on the border (street-orientated) of a slum area	1-3	large	irregular	medium	Inner-City	medium	medium (shops in the outside borders)
Type B	Medium-sized blocks with a small inner connection only for pedestrians	2-4	medium	regular	high	Inner-City	low	high
Type C	Small-sized blocks, every plot is connected to a street	2-3	small	regular	medium	Inner-City	low	medium (basically residential use)
Type D	High-density tourist area with hotels, restaurants, agencies in shophouses	2-8	small	regular	very high	Inner-City	medium	high (basically commercial use, only some residential use)
Type E	Redevelopment site with shophouse typology for middle- to high income groups	5	small	regular	high	Inner-City, Redevelopment Area	low	medium (sometimes residential use only)
Type F	Orthogonal shophouse pattern in the periphery	1-2	medium	regular	medium	Outer Districts	low	medium
Type G	Linear street-orientated sprawl	1-2	no blocks	irregular	low	Outer Districts	medium	medium

Villas Structure								
Type A	Mainly original villa structure from the French influence	1-3	medium	regular	medium	Inner-City	medium	medium-high
Type B	Villa structure with an intense mix of other typologies	1-3	medium	regular	medi-um-high	Inner-City	rich	medium-high
Condominium								
Type A	High-density linear apartment blocks	5-6	small	regular	high	Inner-City	Low (plug-in in shophouse area)	medium (shops, services on ground floor)
Type B	Medium-density apartment blocks with designed public space and partly occupied by slum buildings	5-6	large, (linear row-structure)	irregular	medium	Outer Districts	medium	medium (shops, services on ground floor)
High-rise								
Type A	High-rise apartment buildings as plug-in in existing settlement structure	ca. 20	small	irregular	high	Inner-City	low	low
Type B	High-rise apartment buildings in the new development area (Saigon-South)	20-24	medium	regular	medium-high	New Development Area	low	medium (shops, supermarkets on ground floor)

Data collected from the Study Sites for the representing housing typology will be used to formulate scores for sustainability based on the multi-layered approach. The neighbourhood pattern is represented as a puzzle, in which the separate housing typology pieces fit together to form the complete picture of settlement developments in HCMC.

4. Spatial Sustainability Assessment based on Urban Typologies

The proposed concept represents an interpretative method to integrate the physical aspect of housing developments with the socio-economic and environmental-related information of built-up areas (figure 2), based on the concept of urban typologies. The typology-based approach allows a (scientific) trans-disciplinary identification of core indicators for the spatial information system (table 3). Because indicators used should reflect the housing-related sustainability issues that the urban typology is seeking to address, a layering of indicators is the most useful approach.

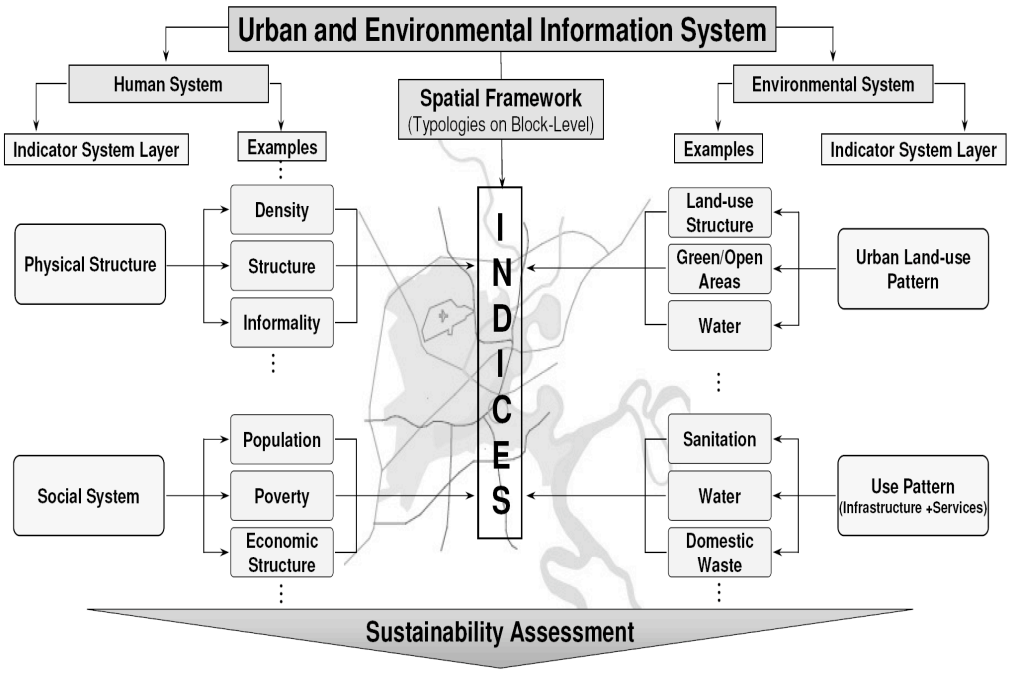

Figure 2: Spatial Information Management: Spatially Integrated Indicator Framework

It appears to be consensus that a useful urban typology must combine a range of different indicators. This has led to a multi-layered typological approach (figure 2) in which urban typologies (Flood 1997) highlighting the major aspects of sustainable urban development can be identified. The framing of these factors was based on a set of requirements drawn from international descriptions of the characteristics of a sustainable settlement as measured by the described indicator conceptions (table 3).

The data collection is based on two sources: a GIS survey of pre-existing statistical data aggregated on street block level and ground reconnaissance. The indicator-related data collection was chosen on the basis of the four layers establishing the multi-dimensional housing typologies: housing structure, urban land-use pattern, housing-related infrastructure services and socio-demographic characteristics. The main task of the multi-layered typology approach is to illuminate the connection between patterns of housing development and the sustainability of the metropolitan region of HCMC. The layered approach of housing typologies helps to indicate how successful each typology is in achieving these goals. This multi-layered approach reflects that the livelihood of the neighbourhoods in general is dependent on the combined effect of a range of sustainability-related factors, rather than the presence or absence of single aspects of urban sustainability. To assess the sustainability of urban settlement developments, four different layers must be analysed (figure 2):

- The physical structure – how the settlement with its form of the built environment is related with the different parts of the city, responds to the topographic situation and is integrated within the natural environment.

- The urban environmental land-use patterns – spatial environmental sensitivity indicators offer the capacity to assist the identification of areas where housing-related development impacts require careful consideration (Bouland and Hunhammar 1999).
- The use patterns – are described by the public provision of urban infrastructure and services, which defines the way the settlement uses its resources and the impacts on the urban and regional natural environment.
- The social system – how the settlement provides opportunities for an acceptable quality of life to their residents.

Clearly, the structure and arrangement of housing areas are factors influencing urban sustainability. Recognition of this connection makes it possible to re-evaluate the housing development pattern as a fundamental determinant in the formation of urban sustainability, because, if replicated on multiple sites, the housing development pattern becomes an integral part of the urban fabric of HCMC. The sustainability of each housing development helps to determine the ultimate sustainability of the urban region. Urban sustainability is strongly influenced by the choices that are made about the housing types to build.

Table 3:
Multi-layered Urban Sustainability Indicator Framework

Human System		***Environmental System***	
Physical Structure		***Urban Land Use***	
Compactness (Density + Structure)	**Floor area, Height (storeys)**	Land resource	**Land use structure**
	Built-up ratio,	Green area	**Green area (trees, grass, waters)**
	Block size and shape	Community space	**Community space**
	Structure of the street-network	Green areas	**Distribution of green areas**
	Location in the metropolitan area	Underground water	**Quality of underground water**
	Multi-functionality / mixture of usage		**Intensity of exploitation**
Informality	**Informal Settlement rate**	Surface water	**Quality of surface water**
Accessibility	**Low income people accessibility to housing**		
Social System		***Use Pattern (Infrastructure and Services)***	
Density	**Population density**	Sanitation (Accessibility)	**Clean water supply**
Population change	**Migration/ Natural growth rate**		**Sewage system**
Economic structure	**Income**		**Waste collection system**
Poverty	**Population living below poverty line**	Water pollution	**Volume/ Treatment of wastewater**
Unemployment	**Unemployment rate**	Disposal/Collection	**Domestic waste generation/collection**
		Treatment	**Volume of treated waste**
		Transportation modes	**Efficiency of public transportation**
		Energy	**Consumption of energy**

5. Discussion and Conclusions

The concept of multi-layered urban typology looks at the housing development as a regional building block. Rather than examining the effects of housing developments on single aspects of sustainability independently, possible combinations of these aspects are explored. The goal of the data collection is to determine the relative sustainability of each housing typology. Although all of the defined housing typologies are pre-existing in HCMC, the purpose of the multi-layered approach is to describe how each would function as new developments in the metropolitan area of HCMC. The results of the investigation of multi-layered housing typologies will be applied in the Sustainability Assessment of new housing developments, where urban planning administrations may combine different housing typologies to explore the implications of the resulting settlement pattern on the creation of a sustainable urban development region. The strong spatial focus on urban typology facilitates the analyses of different housing-related environmental resource management strategies. It is important to reflect on the role of urban typologies in bringing clarity to urban planning policy and implementation.

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