Session 2

Urban Metabolism in Asian Cities with Emphasis on Hong Kong

Albert Koenig

Associate Professor, The University of Hong Kong, China

1. Introduction

The Hong Kong Special Administrative Region (SAR) is a highly developed metropolitan region where technical and economic advances have made it possible to support 6.9 million people on about 110 km^2 of built up land, resulting in one of the most compact and most densely populated cities in the world (63.000/km^2). This population depends on a continual supply of materials, energy and information to function. Since the 1970s, Hong Kong has been transformed from a light industry center to a service-based economy, creating enormous economic wealth in this process as well as tremendous environmental quality problems. This paper highlights the economic and environmental transformation of Hong Kong by emphasizing the following aspects: development and transformation of the economy; material resource consumption and waste generation; environmental impacts of Hong Kong's economy beyond its borders; and its comparison with other Asian cities. In my view, a thorough understanding of the material foundations of modern urban society is a prerequisite to effectively address the issues of environmentally sustainable development.

2. Economic development and transformation of Hong Kong

Over the last decades, Hong Kong has witnessed dramatic economic developments, which may take centuries in other places. The following table highlights some economic and social indicators, which illustrate the structural shift in employment from the manufacturing to the service sector, thereby converting Hong Kong to a finance and logistics (transport and communication) center. Of those employed now, 82.4% are engaged in the services sector, while only 7.1% worked in the manufacturing sector. Since 1980, the contribution by the manufacturing sector to the GDP has shrunk from 23.7% to 5.7%. Hong Kong's transformation was accompanied by a relocation of its industry to mainland China, contributing to the rapid industrialization there.

	1966/71/80***	*1994*	*2000*
Population (million)	3.7	6.1	6.9
GDP: - total (billion US$)	2.5	132	165
- per capita (US$)	686	21 760	23 990
- contribution by manufacturing industry (%)	23.7**	11.4	5.7
Government budget (US$ billion)	0.35	18.6	
Value of total exports (US$ billion)	1	151	202
Cargo throughput: - port (million tons)	10	141	175
- airport (thousand tons)	22	1 291	2 241
Total employment (thousand)	1 520*	2 910	3 220
Number of manufacturing workers (thousand)	728*	446	229
Number of workers in service sector (thousand)	639*	2 214	2 490

3. Material resource consumption and waste generation

The enormous economic changes in Hong Kong since the 1970's, coupled with a large population increase, brought with them greater resource needs and unprecedented waste generation habits. The following table reflects the dramatic increases in total inputs, outputs and trends in selected material flows.

	million tonnes (Mt) per year			kg per capita per year		
Type of material	*1971*	*1997*	*% change*	*1971*	*1997*	*% change*
Total solid resources input	*11.5*	*46.5*	*+304*	*2 920*	*7 027*	*+141*
Food	2.4	5.0	+108	570	680	+20
Fossil fuel	4.0	13.0	+225	1 000	2 000	+100
(Industry)	1.4	2.3	+64	350	360	+3
Construction material	4.0	25.0	+525	1 000	3 800	+280
Other goods	1.0	3.5	+250	250	530	+112
Total water resources input	*1 692*	*10 236*	*+505*	*429 510*	*1 547 976*	*+260*
Freshwater	390	913	+134	99 010	137 976	+39
(Industry)	43	120		10 950	18 250	+67
Saltwater (flushing, cooling)	1 302	9 323	+616	330 500	1 410 000	+327
Total air resources input	*32.5*	*105*	*+223*	*8 250*	*15 870*	*+92*
Oxygen	6.5	23	+223	1 650	3 475	+92
Total solid waste output	*3.0*	*13.8*	*+360*	*762*	*2 086*	*+174*
(Industry)	n.a.	0.3	n.a.	n.a	39	n.a.
Total sewage output	288	677	+153	73 115	102 311	+40
BOD_5	0.13	0.20	+54	33	31	-6
(Industry)	0.04	0.03	-25	10	5	-47
Total air emissions						
CO_2	9.0	31.6	+250	2 285	4 776	+119
Air pollutants (particulates, SO_2, NOx, CO, VOC)	0.26	0.33	+27	65	50	-23
(Industry)	0.031	0.033	+6	8	5	-36
Ecological footprint	90 500km^2	290 500km^2	+221	2.3 ha/cap	4.2 ha/cap	+83

Between 1971 and 1997, the total consumption of material resources and generation of waste grew by 300% and 360%, respectively, while the population grew by only 50%. In 1997, only 41% of the resources consumed were of local origin, namely, 10% of food and 74% of construction materials - comprised mostly of aggregates and sand. In recent years, the material net input has not changed significantly, but the local contribution decreased even further, while all the waste remains in Hong Kong. The overall solid waste production amounted to approximately 30% of the input resources, with 66% as construction and/or demolition waste and 23% as municipal solid waste (MSW). Industrial waste contributed only 2% (less than 40kg per capita). Generally, industry's proportion in resource generation and waste generation dropped significantly over the years, especially when considering consumption of energy, generation of solid waste and emission of BOD_5 and air pollutants on a per capita basis. The per capita resource consumption and waste generation show the typical characteristics of a consumer city with a service-based economy, with almost no livestock, mining or industrial waste. But with Hong Kong's limited land, the annual waste generation per unit area is exceedingly high: 12 500 t km^{-2} for total land area, and almost 115 000 t km^{-2} for built-up areas, much higher than in any other city or region of the world.

4. Environmental impact beyond Hong Kong's borders

The high consumption of renewable resources (e.g. food, timber, paper, etc.) required an ecological footprint of more than 250,000 km^2 of land (29%) and sea area (71%) in 1997, compared to 90,500 km^2 in 1971, exceeding the city area proper by more than a thousand times. Of the ecological footprint, almost all is located outside Hong Kong, with over 30% occurring in adjacent mainland China and 60% in other parts of the world. Compared to Hong Kong, inhabitants of Chinese cities require a 70% smaller ecological footprint. De-industrialization has shifted all pollutant discharges related to production of goods consumed in Hong Kong to areas elsewhere. For example, nitrogen discharges due to food production outside Hong Kong amount to the equivalent of 11.5 million people, of which more than 40% are discharged in the adjacent Pearl River Delta Region (PRDR) and return via the polluted Pearl river to Hong Kong waters. Similarly, the Hong Kong driven industrialization in the PRDR lead to a drastic increase in air pollutant emissions, so that in 1997 the PRDR contributed 86% of the 1,615,000 t of regional pollutants (RSP, NOx, SO2 and VOC) while Hong Kong's share amounted to only 14%. As a result, Hong Kong's air quality significantly deteriorates during unfavorable wind conditions. Moreover, due to less effective pollution controls, Hong Kong factories relocated to the PRDR are likely to emit more pollutants than before relocation. Hence the obvious reduction in local waste discharges due to the de-industrialization of Hong Kong is seriously compromised by growing water and air quality problems across the border and in Hong Kong. No

institutional arrangements exist to handle these new types of cross-border pollution problems.

5. Comparison with other Asian cities

How do other Asian cities compare to Hong Kong in terms of material resources input, waste generation and waste composition? No detailed data are available, but reasonable inferences can be made from available data on selected material consumption (e.g. iron and steel as well as paper and paperboard), energy consumption, generation and composition of MSW, GDP per capita as well as economic growth rates. It should be pointed out, however, that most Asian megacities such as Beijing, Shanghai, Bangkok, Manila, Jakarta and Kuala Lumpur have a city GDP per capita of between two to five times higher than their respective countries. Hence, the per capita material consumption in these cities may greatly exceed the average per capita consumption of their countries and serves as an important factor in attracting migrants from rural areas. Estimates of expected typical values for material consumption rates and municipal waste generation rates in selected Asian cities are presented in the following table.

City	Material consumption	Municipal solid waste generation
	kg per capita per year	
High-income countries: Hong Kong, Singapore, Tokyo, Taipei, Seoul	6,000 - 14,000	500 - 750
Middle-income countries: Bangkok, Kuala Lumpur	4,000 - 6,000	250 - 550
Low-income countries: Manila, Jakarta, Beijing, Shanghai	3,000 - 5,000	50 - 250
Rural areas in middle- and low-income countries	500 - 2,000	120 - 200

6. Sustainability issues

Compact cities with high population densities can achieve extremely efficient land, energy and material use, thus reducing urban sprawl and conserving land for recreational and agricultural purposes. However, the benefits of Hong Kong's compact urban system may be outweighed by the environmental costs through the exceedingly high unit waste discharges to the land, air and water within its city limits. These discharges are projected to increase in future and pose a most serious challenge to the environmental sustainability of the urban system. The real challenge, however, lies not in the efficient management of the urban system itself, but increasingly in managing the environmental impact of the generated wastes within and beyond the city boundaries. For example, (1) the best possible practices of waste reduction, recycling and incineration cannot lower by more

than 30% the quantity of waste material generated, and, (2) locating sufficient sites and space for waste and wastewater treatment facilities becomes increasingly difficult because of scarcity and high opportunity cost of land. Drastic changes in consumer behavior, urban planning and government policies will be needed to achieve sustainable material and waste management, e.g. a high degree of recycling of waste materials while minimizing generation of waste for final disposal.

Hong Kong's waste discharges and pollutant emissions correspond to the high 'domestic pollution' levels of an affluent post-industrial consumer society, exacerbated by high density, while industrial pollution has been relocated outside its city borders. However, the overall environmental detrimental impact of Hong Kong due to the stationary 'domestic pollution' locally and mobile industrial pollution elsewhere keeps on unabated. New environmental policies are required to address imbalances in local versus global sustainability.

Selected references

Baccini, P. and Brunner, P. H., *Metabolism of the Anthroposphere,* Springer-Verlag, Berlin, 1991.

Boyden, S., Millar, S., Newcombe, K. and O'Neill, B., *The Ecology of a City and its People: the Case of Hong Kong,* Australian National University Press, Canberra, 1981.

CSD, Census and Statistics Department of the Hong Kong SAR Government, http://www.info.gov.hk/csd.

EPD, Environmental Protection Department of the Hong Kong SAR Government, http://www.info.gov.hk/epd.

EPD, Environmental Protection Department, HKSARG, *Executive Summary Study of Air Quality in the Pearl River Delta Region,* CH2M HILL (China) Limited, Hong Kong, April 2002.

Koenig, A., The urban metabolism of Hong Kong: An extreme example in the Asian region, In: *Conference Proceedings POLMET '97 Pollution in the Metropolitan and Urban Environment: Sustainability in the 21st Century - The Challenge for Asian Cities,* The Hong Kong Institution of Engineers, Hong Kong, pp. 303-310, 1997.

Loh, C. Hong Kong SMEs: The primer. CLSA Emerging Markets, Hong Kong, April 2002.

Newcombe, K., Kalma, J. D. and Aston, A. R., "The Metabolism of a City: The Case of Hong Kong", Ambio, Vol. 7, No. 1, pp. 3-15, 1978.

Warren, K., and Koenig, A. "Ecosystem appropriation by Hong Kong and its implications for sustainable development", Journal of the International Society for Ecological Economics, Vol. 39/3, pp. 347-359, 2001.

Warren-Rhodes, K. and Koenig, A., "Escalating trends in the urban metabolism of Hong Kong: 1971-1997", Ambio, Vol. 30, No. 7, pp. 429-438, 2001.