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Integrative analysis of urban systems

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Despite the growing recognition of the seriousness of urban environmental problems and their contributions to global environmental and social concerns, most people continue to study parts of cities rather than the wholes. Some study sectoral sub-systems such as transport, water pollution or housing. Others study neighbourhoods, such as particular slum communities. While specialisation is useful for detailed thinking, we need to see each urban issue in the context of how each city 'works' environmentally, economically, socially and politically. We need to take integrative approaches to the study of cities, and to understand how they function as systems.

Integrative analysis helps us to see beyond the presenting problems of an urban environment, whether they be pollution, social or economic issues, to their underlying causes, suggesting different opportunities for possible intervention. It helps us to conceptualise problems and issues differently, and hence what we might try to do about them. Focus on a single aspect of a city or its people, without understanding its context, risks making interventions which treat symptoms without their causes – a short-term solution, as the problem could quickly return, in the same or perhaps another form.

Why do we need integrative analyses of cities?

Cities can be viewed as systems involving people's interactions with the built environments they have created, and with one another. The built environments interact with the natural ecological processes of their sites, either accommodating to or resisting the original features of topography, soils, water processes and vegetation. For instance, the traditional form of Thai housing was a house on stilts, designed to cope with seasonal flooding and to use waterways for food and waste disposal. This was viable at low population density and before the advent of non-biodegradable packaging. Stormwater drains, and dykes built to divert floodwaters around a city, illustrate the use of engineering skills to resist, or at least re-channel, natural water processes.

Interventions in one part of any system inevitably affect other parts. In urban systems, we need to understand the likely impacts of planned interventions, especially unintended impacts. To do this we need to understand the features and dynamics of the total system, what affects what. If we do not take an integrative view of the issues we are trying to address, we risk making changes which displace problems into other parts of the system. An integrative, systems-based view can help us to reframe our problems, and see new opportunities for intervention.

A system is, of course, a human construct, an analytical artefact. We abstract systems for study from much more complex sets of interactions occurring in the 'real world'. Where we draw the boundaries of a system, what scale we select (neighbourhood or whole city), which parts of the system we focus on (poverty or pollution, perhaps), are all matters of our own choice. It is fine to focus on a particular aspect of a system, or a small scale, in order to understand it well, but we need to understand how this aspect fits into the rest of the system, or indeed web of potential systems. If we study a slum, how does it fit into the rest of the city system, in terms of its built environment and use of the natural environment, its people's lifestyles, and its economic and social roles? If we study a city, how does it relate to areas in its hinterland and nationally? What is its 'ecological footprint' (Rees 1992:121–29) in terms of use of imported resources and waste-absorbing spaces? How is it tied to rural areas in economic and policy terms, and how does this affect issues such as migration, cultural relations, the distribution of wealth? In turn, how does each urban–rural interactive system fit into global patterns of natural environment and economic and cultural systems?

What do we mean by integration?

Integration entails bringing parts into a whole. What we need to integrate depends on our theme and context. An integrated view of a city should include:

- relationships between people and environment, each affecting the other. People act on the physical environment, and the environment creates opportunities and constraints for their actions. Here 'people' must be considered both as individuals and domestic units, and as abstract institutional forces arising from the organisation of their society (such as 'the economy');
- scales, from the parts of the city to the larger systems of which the city is part, from local to larger spatial units, from individual through family, community, and institutional organisational aggregations; and,
- sectors such as transportation, water systems, air pollution, slums, and issues within these sectors (Ross et al. 1997).

International programmes promoting integrative studies

A few international programmes have tried to develop frameworks for the integrative analysis of urban systems, encouraging international comparative studies of cities. The UNESCO Man and the Biosphere (MAB) Programme was the first international venture to consider cities as ecological

systems. Its sub-programme on the integrative study of human settlements, established in 1973, seeks to advance knowledge and understanding of these complex systems as a basis for planning, management and decision making through research, demonstration projects and training. Key themes over the last decade have been the development of models of the relationship between urbanisation and environmental transformation, taking into account the rural areas around cities, empirical studies on demographic changes induced by urbanisation and their environmental consequences, demonstration projects aimed at reducing the pressure and impact exerted by cities on their hinterlands, and studies on the planning and management of green urban spaces (Celicia 1995). Stephen Boyden (1979) carried out much of the work of developing frameworks in association with UNESCO's Division of Ecological Sciences. Major studies have been conducted on Hong Kong, Lae in Papua New Guinea, Rome, Sao Paulo in Brazil, La Plata in Argentina, an urban growth corridor in Malaysia, Bangkok and in Seoul.

The implementation of Agenda 21, a set of principles for sustainability signed at the United Nations Commission on Environment and Development in 1992, has spawned international networking on the improvement of city environments, as 1,500 local governments in 50 countries have commenced Local Agenda 21 planning processes. Another widespread international programme is the WHO Healthy Cities Programme, which encourages towns and cities throughout the world to develop their urban environments as healthy places to live, according to a common health promotion framework which allows local diversity in strategies. While the focus is clearly health, the programme incorporates ecological perspectives in its emphasis on the contributions of environmental conditions to health. A megacities programme (Perlman 1987) commenced in 1987, with studies of Mexico City, Sao Paulo, Rio de Janeiro, Buenos Aires, New York and Los Angeles.

The projects conducted under these programmes have encountered a number of challenges, including finding sufficient funds to carry out a long-term, large interdisciplinary team project, and the challenge of studying a large and complex system. A number of the urban studies under MAB resorted to studying neighbourhoods within cities instead, viewed as a 'sample' of the whole city. Further, the teams have had difficulty with true integration. Most studies attempted integration at the end by drawing joint conclusions from somewhat separate research efforts. Few have attempted progressive integration.

Bangkok Man and the Biosphere Programme study

This paper illustrates one way of making an integrative analysis of a city system, from a UNESCO MAB Programme study of Bangkok (Poungsomlee and Ross 1992, Ross et al. 1997). The aims of our project were to study the impacts of modernisation and urbanisation on the people and biophysical environment of Bangkok, using an integrative method; to develop an integrative framework and methodology that could be applied

in future environmental management and policy making; and to explore societal processes through which improvements in ecological sustainability and human health might be brought about (Poungsomlee and Ross 1992:3). Bangkok's path of modernisation has focused economic development almost exclusively on Bangkok, which has grown as a 'primate city' 50 times larger than the next most substantial urban centre. This is related to uncontrolled urban growth, both in terms of the spread of the city and successive changes to land uses within it. There has been little formal planning, and little infrastructure has been provided to cope with the environmental problems created by the uncontrolled growth. For instance, a sewerage system only commenced in the early 1990s, although the population of the city is estimated at between seven and ten million people (Ross and Poungsomlee 1995).

As a starting point, the study focuses on the impacts of Bangkok's environmental problems: traffic and transportation; land use change, such as the rapid conversion of agricultural land, and displacement of low income communities through 'urban renewal'; flooding; water pollution; air pollution; noise; solid waste disposal and toxic substances (Poungsomlee and Ross 1992). It examines the interactions between the environmental problems and people's perceptions or interpretations of each problem and ensuing behaviour.

Relationships between people and the environment

Our research team views the shaping and reshaping of Bangkok's environment as a continual process in which both political decision makers, in a position to form and implement grand plans, and households operating on a more modest scale of influence, have gradually transformed the floodplain ecosystem of the Chao Phraya river system into a highly built-up environment.

The natural ecosystem consists of a floodplain, barely a metre over sea level. The land is subject to flooding and to subsidence, since the groundwater has been extracted in large quantities as a water source. Until recent engineering developments made high-rise building possible, the city was forced to expand outwards rather than upwards, owing to the lack of a firm geological base (Ross 1995).

In the first century of Bangkok's development as the capital city of Thailand, political decision makers created a political and religious city core, with the Royal Palace and temples, and dug numerous canals to augment the natural stream system of the floodplain. This created a highly efficient network of drainage channels and transport routes. This water-based configuration was gradually transformed after the decision to 'modernise' and 'Westernise' the city by creating a road network, requested by foreign diplomats in the 1860s. Many canals were filled in to provide this road network, interfering with the drainage system. For the most part, however, the city grew with little influence from formal planning and government investment. While the king

designated areas for particular ethnic groups to live (Smithies 1986), the people developed these local areas according to a vernacular pattern of building houses along canals, then along small lanes between canals. Redevelopment continues to follow the urban and agricultural land parcels originally created.

This century, particularly since the conversion to a constitutional monarchy in 1933, formal planning initiatives have been infrequent. The city has continued to grow in a vernacular style, as particular households and investors build housing and businesses according to the land and economic opportunities available to them. While some main roads have been built, particularly as part of national economic development initiatives since World War II, most of the road network has expanded inefficiently from the informally-built network of lanes. Ad hoc encroachment on canals has interfered with the drainage system further, adding to water pollution. Sewerage infrastructure was completely neglected until the early 1990s, with household and factory wastes discharged untreated into the canals.

The city's built environment is unusual in that there are many agricultural areas within the city boundaries (as well as many built-up areas beyond the boundaries). These have remained owing to the irregular pattern of land development, and provide the useful ecological and social services of providing green spaces and land capable of absorbing water (Ross 1995). Two of the large agricultural areas are now protected, rather unsuccessfully owing to loopholes in the law, as 'green belts'.

The result of two centuries of transformation of the natural environment is a city now more in competition than in harmony with natural ecological processes, and consequently beset with environmental problems. Some of these problems, especially water pollution and transport problems, could have been alleviated with systematic provision of infrastructure, but were not, due to peculiarities of the decision making system and economic priorities in the second half of this century.

In contemporary terms, we need to consider two broad domains of people-environment interactions. At the small scale, we need to consider the way that individuals, and households, perhaps also communities, shape and use urban space through their behaviour patterns. While each household's influence is small, the activities of up to ten million people can have major cumulative effects. At a societal scale, with a larger geographical potential for influence, we consider the influences of political decision making.

Behaviour patterns

Understanding behaviour patterns is important for two main reasons. Similar patterns on the part of many individuals have potentially large cumulative effects, to the advantage or detriment of others. Further, policy interventions will work or fail according to their acceptability to the public. If one understands people's motivations and behaviour patterns, one has more hope of designing workable policies. For

instance, most analyses of Bangkok's notorious traffic problems have concentrated on the nature of the road system, and the speeds of vehicle movement, to the total neglect of people's personal motivations and decisions in using the system – their behaviour patterns (Punpuing 1996).

People's behaviour patterns in their use of Bangkok's built environment contribute to the problems. In some cases, households and small businesses have no option but to pollute: in cases where there is no sewerage infrastructure, household, restaurant and small-scale industry wastes are discharged directly into the canals. Where people do have options, political and economic incentive structures in Thailand have tended to reward environmentally damaging behaviour. Until regulations and monitoring were tightened up in 1992, it was common for factories to avoid running their waste water plants because of the running costs. Traffic conditions are a clear example of the contribution of behaviour patterns. As people became frustrated with slow travel times and the discomforts of public transport, they strove to own their own cars. The economic conditions of the 1980s boom, fostering the growth of the middle class, provided opportunities for more people to do so. The increasing number of cars on the road, however, clogged the traffic for others, creating a worsening situation and a political demand for more roads to be built. Alone among government departments, the traffic police took the sensible policy course of trying to increase movement speeds on the existing roads, by a range of strategies to remove impediments, and deter poor driver behaviour and bribery.

Political analysis

Bangkok's land use and built environment configuration have arisen over a long period, from a combination of formal and particularly informal decision making. In these processes, all stakeholders in the city, and many located beyond it, have for decades taken uncoordinated decisions in pursuit of very different goals, in a *laissez faire* regulatory context (Ross 1997). Mutually beneficial interactions between political and business stakeholders have been particularly influential in the past, with public servants also playing a role in assisting private enterprise interests to prevail over the public interest. Stronger press and public scrutiny in the 1990s, and exercise of democratic rights, have brought ordinary people and public interest campaigners into the stakeholder picture, moderating the excesses of the past. The new Thai constitution, passed in September 1997, provides further opportunity for control of self-interested urban development.

The built environment has therefore grown in a vernacular fashion, as particular developers buy land and develop it in certain ways to meet perceived demand and profit opportunities, and members of the public buy the shop houses or estate houses so provided. There are few effective planning constraints on the location of industry and retailing, small or large. Over many decades planners have tried to maintain some restraint on the form of the built environment, but have been unable to do so owing to weak regulations,

lack of political will and interdepartmental coordination problems. The city has therefore grown up casually and chaotically. The very mixed built environment is part of the city's charm, but also the source of much inefficiency for its residents, and environmental degradation.

Relationships between people and their physical environments need to be considered both in societal terms, for example in terms of political processes which favour particular stakeholders' rights and abilities to modify the built environment in major ways, and in individual and household terms, through the behaviour patterns which summarise people's use of the urban form. The underlying theory is a modified human ecology theory (also fundamental to environment-behaviour studies, or environmental psychology), in which people perceive their environments in certain ways, and act towards those environments in accordance with their perceptions. They make changes to their environments to reach a better fit with what they want. Meanwhile, by constraining or supporting certain potentials for action, the physical environment modifies people's behaviour (Ross et al. 1997).

Scales

The analysis given above illustrates an interrelationship between social scales in the creation of people-environment relationships, from political decision making at national and city-wide scales (with international influences on these) to more localised household and community decision making. Each influences the way in which the built environment is amended over time, and the way in which it is used.

The different societal scales of decision making are capable of different degrees of geographic influence. For instance, national or city-level government can, if it wishes, make decisions which transform the whole city. Communities have more localised capabilities, and their exercise of these capabilities helps to create the texture of variation in the built and social environments.

Actions at the different scales interact. For instance, a government decision to build a system of expressways, while not improving the public bus system or the roads the buses run on, alters the population's transport options. Many households might then change their modes of transport according to the new incentive structure provided by the expressways, depending on whether they are more concerned with cost or travel time.

Sectors and sectoral issues

There are infinite options in how we choose to view urban sectoral issues. Common issues are traffic and transportation, air and water pollution, housing and poverty. It is important that we try out different ways of viewing these issues. Seeing them in systemic context through an integrative urban analysis may offer different solutions. It is particularly important to seek integrated solutions, which solve the issue of focus

harmoniously with other aspects of the system.

Our analysis of Bangkok turns away from the conventional view of the traffic problems as being caused by the nature of the road system, to focus on the behaviour patterns of commuters (Punpuing 1996) and the decision making which causes the land use pattern underlying the road system, and the neglect of public transport opportunities (Ross 1997). Our analysis of water pollution (Poungsomlee and Ross 1992) goes beyond the common measures of dissolved oxygen levels (DO) and biological oxygen demand (BOD) to look at the altered water-based ecological system of the floodplain, the political decision making behind the land use-built environment system, and particular behaviour patterns (such as those of factory managements) which contribute to the problems.

Curitiba's environmental management

One of the few cities taking an integrative ecological approach to its management is Curitiba in Brazil. For over two decades the city, under an enlightened series of governments which gave priority to public awareness and support for environmental initiatives, has sought to harmonise its built environment with the natural processes of its site, and with the needs and behaviour patterns of its citizens. The watercourses through the city form a linked series of lakes and parks which cater well for flooding. Grazing sheep in the parks act as biological lawnmowers and fertilisers of the grass. The recycling programme extends to separation of rubbish in public bins, which are carefully labelled. The highly innovative transport network provides high speed bus travel through business and commercial destinations which are spread along five arterial roads rather than gathered into a 'centre'. Spaces for leisure, and heritage protection, are other priorities. The Open University for the Environment, built in a former quarry to reclaim a disused and dangerous urban space, provides environmental education to all sectors of the adult population. The curriculum focuses on the city's ecology. Employed people attend in salaried time.

Conclusion

It is valuable to make integrative analyses of urban systems, and indeed doing so can raise new perspectives on what have conventionally been thought to be urban problems. Key issues to consider in designing an integrative analysis are the nature of people-environment interactions, and societal and personal scales; the relevance of social and geographical scale (household or government actions, for instance) in tracing the patterns of people-environment interactions; and the relationships between sectors (such as transport) and sectoral issues and the total system. This summary of considerations should not be viewed as a recipe – various study frameworks are available as a guide to issues and variables to consider (Boyden 1979, Ross et al. 1977).

While integrative studies of such complex systems as cities are difficult to conduct and fund, there are ways of creating a systemic picture which doesn't require intensive original research into all aspects of the city. The aim is to understand

how the city system works in terms of linkages among its parts, not necessarily to document everything in detail. As one of our early collaborators quipped, 'Most of our scientists would measure the pollution at every bend in the river, without ever questioning where it was coming from!' Our Bangkok research team has never exceeded ten people, with only four staying with the project throughout. Its cash budget, apart from our salaries and other in-kind contributions by our employers, was under \$200,000.

On the other hand, integrative studies cannot necessarily be achieved from secondary data alone. Leitmann's (1993) criticism of the nine years taken by Boyden's Hong Kong study, compared to his design for a well-funded rapid urban appraisal under the United Nations Environment Programme and the World Bank, is somewhat unfair since a secondary data study is only possible if predecessors have collected suitable primary data. The abundance of funding also helps to reduce the time required.

While resources assist the process, the main challenges in conducting integrative analyses of urban or any other system

are intellectual ones. An intellectual leaning towards systems analysis is necessary, as is teamwork to combine the inputs of different disciplines fruitfully.

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