3.2

The Implications of Urbanization for Atmospheric Emissions at Multiple Levels

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INTRODUCTION

Urbanization has been fundamental to the economic and social transformation of Southeast Asia (Marcotullio 2003). It has greatly expanded the opportunities for people to pursue education for their children, develop their entrepreneurial skills and find better paying work. It has contributed to gains in quality of life for many both within the city and increasingly closely linked rural areas through migration and remittances. By virtue of denser patterns of settlement it has made plausible much more efficient mass transit, climate control in places of work and residence, and ways of delivering many other public and private services than would be possible to an equivalent-sized, but widely scattered population.

Rapid economic growth has nevertheless been accompanied by tremendous absolute growth in energy use, in particular, of fossil fuels for cars and to produce electricity (Marcotullio and Lee 2003). Most cities have struggled to cope with the emissions from expanding vehicle use in densely settled and commercial centers. Biomass burning associated with conversion of forest lands to agricultural uses and from seasonal land management practices has compounded the difficulties of managing air quality in urbanizing regions (Awang et al. 2003; Bergin et al. 2005). Poor combustion of biofuels in stoves for cooking and heating is also an important source of emissions in some regions (Ludwig et al. 2003). Together fossil fuel, biofuel and biomass burning are driving changes in atmospheric emissions, with significance to human well-being and ecosystems at local, regional and global levels. Urbanization is

central to many critical multi-level environmental challenges (Marcotullio and McGranahan 2007).

Urbanization is, moreover, far from over (Sheng, this volume). The prospects of substantial further industrial-urban development in most countries in the region (Rock and Angel 2005) underlines that the *way* urbanization and urban transformations unfold will be very significant for atmospheric emissions (Lebel 2005; Mitra and Sharma 2002; Ooi 2007). On the one hand, poor urban and energy planning could result in further deterioration in local air quality with all its myriad impacts on human health, as well as exacerbating regional air pollution problems and expanding contributions to greenhouse gas emissions and aerosols at the global level. On the other hand, urbanization contains within it many opportunities to decoupling harmful emissions growth from social development (Global Carbon Project 2003). The lifestyles of people in urban areas, for instance, are crucial to patterns of energy demand for mobility, comfort and the production of consumer goods (Lebel 2004b; Lebel 2005); services which can often be provided more efficiently in highly urbanized contexts (Sanchez-Rodriguez et al. 2005); and activities in urban areas are central to the design and operation of transport and energy systems (Dhakal 2004; Dhakal and Schipper 2005; Marcotullio and Lee 2003).

In this chapter we explore some of the main implications of urbanization for emissions, air quality and health.

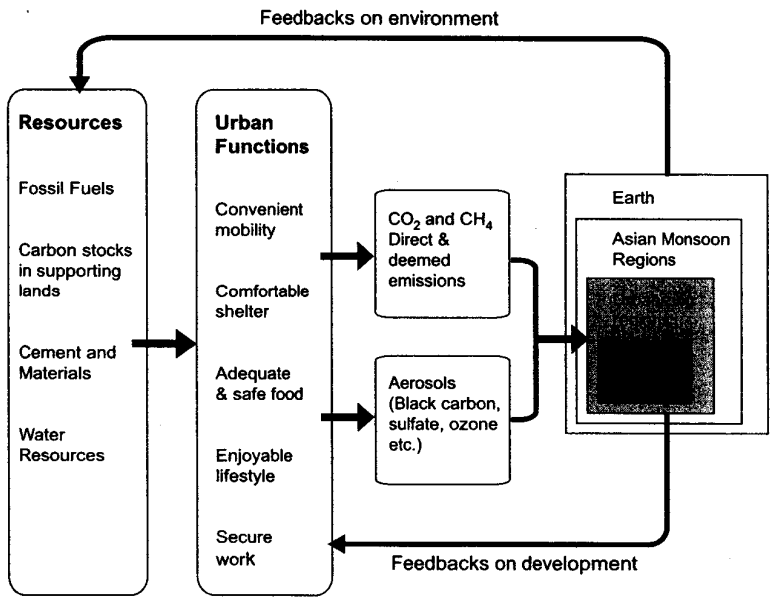
URBANIZATION AS DRIVER

Urban areas are the nexus of multiple production and consumption systems (Lebel 2005). Cities drive important emissions within their boundaries as well as beyond, for instance, in making and providing goods and services consumed within a city. Urban form, function and roles can have major implications for energy and emission intensities (Lebel et al. 2007a).

Rapid economic growth and industrial transformation

Industrial sources of pollution are linked to urban environments throughout Asia as many of them have developed around the expansion of labor-intensive manufacturing and agro-industries. In earlier periods of nationalist development, the policy of import-substitution industrialization has led to the concentration of industries in capital cities. Concentration of urban growth in capital cities has resulted in primary cities which dominate the economies, and often also the demographics, of the country in which they sit. Bangkok and Metro-Manila generate about one half to a third of their countries' GDP, handle most of the imports and have the giant share of the countries' industrial

Figure 3.2.1. Role of urbanization in altering atmospheric emissions relevant to environment at different scales (*Source*: Fu et al. 2006)



establishments. Ho Chi Minh City is becoming both an industry and trade center. Increasingly, national and international trade and other banking, financial transactions as well as services have been channelled via these cities.

Urban expansion has been explosive, creating extensive corridors linking previously separate cities or towns. In Indonesia, Jabotabek (the greater Jakarta region) covers a vast area of increasingly densely connected human settlements. In Malaysia, the entire corridor extending from the former capital city of Kuala Lumpur to the port city of Port Klang is now an urban conurbation. The Metro-Manila region is another example of such mega-urban regions.

The spatial arrangement of industrial, service and residential areas, however, often continues to evolve in response to increasing congestion, value of land, and worsening air pollution (Bai 2002). Capital cities and other rising urban centers are now less attractive for primary industries due to rising land rents. Manila, Jakarta and Bangkok have seen the expansion of their metropolitan spaces from capital cities to become an urban sprawl with a core city that is now basically a commercial and service center, with industrial corridors radiating outwards into the periphery that has become a part of the larger urban space.

Economic liberalization also greatly influenced the present spatial structures of cities. The globalization of production, mainly through the operation of transnational corporations (TNCs), deepened the integration of countries to the world economy. Frequently, industry is encouraged to relocate and new investments are guided into special zones in the peri-urban periphery. Industrial dispersion, whether induced by government policy or by sheer market forces, has taken full advantage of surplus rural labor and reinforced high rates of rural to urban migration.

In the case of smaller industries, different regulatory, incentive and other policies have often been needed. Frijins (2001), for example, assessed how a policy of relocation for small industries in Ho Chi Minh City was not working and argued for the need to switch to promoting cleaner production.

Fast-growing economies of East Asia, with varying degrees of success and sectoral specificities, have each shown some capacity to undertake technological improvements that reduce pollution impacts of industrialization (Angel and Rock 2000; Rock and Angel 2007). The Thai firm, Siam City Cement, for example, has improved its environmental performance over time, benefiting later from a joint venture with multinational firms (Rock and Angel 2005). Malaysia and Singapore successfully introduced regulatory agencies with monitoring and enforcement capacities on emissions, but other countries, like Thailand and Indonesia, have struggled (Rock 2002). These examples show that urban-based industrial growth can be directed by government policies towards cleaner futures.

Personal motorized transport dependency and sprawl

Undoubtedly, one of the most interesting aspects of Asian cities in the global context of urbanization has been the high density of activities, which, at least historically, made non-motorized and public transport plausible (Dhakal 2004). The last decade or two has seen a growing number of counter-examples as income thresholds for the purchase of personal motorcycles and cars have been surpassed and at the same time urban form has shifted in ways that make the convenience of personal mobility highly valued (Dhakal and Schipper 2005). Changes in employment and the large number of jobs in manufacturing obviously impact on travel demand as well. The outcome has been very rapid growth in vehicle ownership in most cities across Southeast Asia (Lee 2007).

Motorcycles are a special feature of the personal fleet in Southeast Asia with often relatively high levels of ownership and use. Many are two-stroke machines which emit 2–10 times as much particulate matter (PM), volatile organic carbon (VOC) and carbon monoxide (CO) per kilometre than four-stroke machines (Leong et al. 2001; McDonald et al. 2005).

The rapid rise in private motor vehicle use, in particular, represents a huge challenge to efforts at improving urban air quality (Barter 2000; Walsh 1999). City authorities face difficulty of matching road construction to growth in the number of vehicles in cities (Ooi and Kwok 1997) on the one hand, and on the other, dealing with consequences of new road infrastructure on urban sprawl or ribbon development along major highways, on the other.

There is a substantial variation in the use of public transport and private motor vehicles across cities in the region, with some of the wealthier cities, like Singapore, having largely escaped the "car-trap" (Lee 2007). Other middle-income cities like Bangkok and Kuala Lumpur remain dominated by cars and motorcycles (Barter 2000). Government polices towards urbanization, investment in road infrastructure and public transport make a difference to level of automobile dependency (Kenworthy and Townsend 2007).

Demographic transitions

The social changes associated with urbanization are also important for underlying demographic processes, often resulting in fertility declines associated with the higher education of women, trends towards later marriage, and smaller family sizes. When combined with the more immediate impacts associated with migration, the shifts in size, age and sex structure of local populations can be substantial, both reinforcing and dampening other developmental changes over decadal time scales. Simplistic and sharp separation of rural and urban—as landscapes or households—is often no longer possible as land use and livelihoods interpenetrate and span boundaries daily (Cohen 2004; Lebel et al. 2007b; Rigg and Nattapoolwat 2001).

Consider the following example. The population of the Chiang Mai–Lamphun urbanizing region in northern Thailand has progressed overall at a steady rate just below 1 percent per annum for several decades despite a very sharp fertility decline. By the mid-1980s, fertility had reached below replacement levels in the northern region of Thailand. This has profound implications for demographic change and the prospects of a significant collapse of many rural communities, with a sharp rise in median ages, family structures and dependencies, combined with rural-to-urban migration and death from AIDS (Jones and Pardthaisong 2000). These profound overarching demographic changes help shape and bound transformations of housing stocks, patterns of land inheritance, car ownership and consumption-based lifestyles.

Consumption of services

Urbanization helps shape key values and behaviors (Table 3.2.1). Urbanization is expected to, and often does, result in better access to these valued services.

Table 3.2.1. Four valued urban services with important implications for emissions: Challenges and opportunities for decoupling social development from emissions growth

Valued urban services	Critical emissions	Challenges	Opportunities
Mobility	Fuel-related including CO_2, SO_2, NO_x, VOC and PM	Wealth-linked rise in personal motorized vehicle ownership. Lags and poor initial spatial layout of transport systems relative to work and residences.	High use and density makes mass transit systems economically feasible.
Comfort	Embodied in electricity generation and manufacture, especially of cement and steel.	Increased use of air-conditioning and heating for climate control at work and home.	Waste energy recycling. Efficiencies from higher densities. Well-being and health.
Diet	Methane from livestock. Carbon from clearing of forests for agriculture	Increased consumption of meat and dairy products.	Protein-substitutes Efficient production and processing methods with waste recycling and energy capture.
Work	Energy consumed and other pollutants emitted in manufacturing. Indirect and deemed emissions in service sector work	Vicious cycle of over work to pay- off credit card debts from over-consumption. Poor regulation or perverse subsidies leading to high pollution intensities of firms.	Low energy and materials goods and services. Wise use of information technologies- Meaningful work.

Source: Lebel et al. 2007a.

The central issue in urbanization is whether as a process it actually contributes to reductions in energy and material use (Lebel 2004b; McGranahan and Satterthwaite 2003; Savage 2006). There are many reasons to expect that a household getting wealthier but remaining in a rural setting will use more

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resources than one which has moved or been transformed into an urban one because of greater access to public transport, shorter commuting distances to regularly used services, and smaller, more compact, settlements and thus social relations (Solecki and Leichenko 2006). On the other hand, the shift to an urban context also transforms lifestyles and patterns of consumption and production of waste, both involving emissions. Invariably, wealth and disposable incomes also change, and not always upwards either. There is surprisingly little direct data about such transitions in developing country contexts—this clearly should be a focus of future research.

Income is likely to be strongly associated with direct and deemed emissions. Our interest here is to what extent differences at particular income levels associated with lifestyle are present and whether policies around carbon management could foster less carbon-intensive lifestyles. Again not numbers, but transport modes, vehicle choices and use and housing size and design are likely to be good indicators.

Multi-level consequences

Consequences of urbanization for atmospheric emissions are multi-level (see Figure 3.2.1). Some short-lived components are of importance primarily for local air quality and health, whereas others are significant for regional or global environment.

Local air quality and health

The air pollution problems in mega-cities of Asia are infamous (Marshall 2005). High concentrations of PM, ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, volatile organic compounds and hydrocarbons each have important local and sometimes also regional and global effects (Molina and Molina 2004). Biomass and biofuel combustion produce CO, volatile organic compounds, black and organic carbon (Ludwig et al. 2003; Streets et al. 2003).

The combination of meteorological conditions and high emissions of ozone precursors from traffic frequently produce photochemical smog in Jakarta with ozone episodes in downwind areas of the city centre (Suhadi et al. 2005). Similar findings have been modeled for Bangkok in which ozone production occurs as a result of various combinations of anthropogenic and biogenic emissions in Bangkok and surrounds (Oanh and Zhang 2004; Zhang et al. 2005). They suggest 50–60 percent reductions in emissions within Bangkok Metropolitan Area are needed to meet Thailand's ambient air quality standards for ozone. Scenarios modelled included replacing two-stroke motorcycles by four-stroke engines, and converting bus fleet to compressed natural gas (Oanh and Zhang 2004).

Ambient aerosols around Chiang Mai were measured at four locations during the day over 10-hour periods in the dry season December 2003–January 2004 (Tippayawong et al. 2006). Total PM values averaged 149 μg m^{-3} and occasionally peaked above 330 μg m^{-3}, Thailand's national standard for 24-hours (ibid.). Road and soil dust are important sources (Tippayawong and Lee 2006). In some years, smoke haze from biomass burning also affects air quality for short periods during the dry season. One of the challenges for Chiang Mai municipality has been to deal with the multi-scale characteristics of the city's air pollution problems (Garden et al. 2004).

Many epidemiological studies around the world have underlined associations between exposure to even moderate ambient concentrations of particulate matter under 10 μg (PM_{10}) or ozone and health in urban areas (Brunekreef and Holgate 2002). Both short-term and long-term exposure to particulate matter has been associated with mortality (Samet and Krewski 2007). The high density of activities means that relatively modest individual emissions can, in their aggregate, more easily exceed thresholds of local ecosystems to assimilate pollution or levels risky for human health and comfort. Rapid growth of industry, energy and motor vehicle use, often in the absence of adequate monitoring and enforceable regulations, means that urban air pollution has often become a major public health problem in the developed and developing countries of Southeast Asia.

There are some suggestions that warm and humid tropical climate can exacerbate both interaction among pollutants and its health impacts (Oanh and Zhang 2004; Suhadi et al. 2005; Vichit-vadakan et al. 2001). Impacts of high concentrations of PM_{10} are of particular concern for children and those in high-risk occupations such as traffic policemen (e.g. Preutthipan et al. 2004; Tamura et al. 2003). Urban heat islands are another important local phenomenon which may interact and compound health impacts associated with regional and global environmental changes (Stone 2005).

Several studies have, making diverse assumptions, tried to estimate the costs of air pollution's impacts on public health, primarily to underline its overall significance as an issue. Quah and Boon (2003), for example, estimated the costs associated with mortality and morbidity caused by particulate air pollution (PM_{10}) on the population of Singapore at US$3662 million or 4.3 percent of Singapore's GDP in 1999. Another study in Jakarta, which has much worse ambient air quality, estimated much lower cost of around $US220 million for the same year (Resosudarmo and Napitupulu 2004) underlying the importance of assumptions in valuation studies. Health was incorporated into a composite index to explore changes in national income and health for Bangkok with economic development (Clarke and Islam 2005). There is

compelling evidence that efforts to reduce air pollution yield large economic benefits, but it has sometimes been much harder to attribute improvements in air quality directly to particular air quality policies (Samet and Krewski 2007).

Relationships between cities and their surrounds are two-way and may involve interactions important to conditions in urban areas. Long range transport is a significant source of fine sulfate particles, especially from north-northeasterly trajectories, to the city of Hanoi (Hien et al. 2004). Local burning contributes mostly to coarser black carbon. Emissions arising in urbanizing regions may have implications for ecosystems, including agriculture, in the surrounds as well as larger scale atmosphere-climate system. Important emissions include acids, ozone, particulate matter, mercury and persistent organics (Bergin et al. 2005).

Regional transport and atmosphere

Typical pollutants important at regional scale are acids, ozone, particulate matter and persistent organics (Bergin et al. 2005). These are transported hundreds to a few thousand kilometers. A series of major studies have been carried out on emissions and atmospheric transport and chemistry in Asia. Southeast Asia has not been the primary focus of some of this research, but the findings are highly relevant to understanding source and receptor issues and pollution policies at different levels.

Concerns about long-range transport and deposition of dust and sulfur drove early research in north and east Asia (Carmichael et al. 2001; Lebel 2002). In South Asia much of the initial interest came from studies revealing large contributions of biomass burning to aerosols (Lelieveld et al. 2000; Streets et al. 2003). In Southeast Asia recurrent major fire-haze episodes associated with dry phases of ENSO have also been a focus of substantial research (Murdiyarso and Lebel 2007; Murdiyarso et al. 2004). In each case, research has had to tread a fine line between the political sensitivities associated with blaming others for transboundary pollution problems and the imperatives for greater regional and global cooperation on reducing atmospheric pollution (Bergin et al. 2005). As Ramanathan and colleagues (2002) neatly summarized the INDOEX findings at the height of controversy over media coverage on the "Asian Brown Cloud": "the Brown Haze is a worldwide phenomenon and should not be assumed to be just an Indian or an Asian problem".

Using inputs for SO_2 emissions from the RAINS-Asia program, Carmichael et al. (2001) carried out a comparison of several models helping to cross-validate key patterns in source–receptor relationships. Subsequent observations using satellites and aircraft have improved and expanded our understanding of

atmospheric transport and chemistry to a much wider range of species (Carmichael et al. 2003; Woo et al. 2003). Cross-validation between emission inventories, models and atmospheric measurements helped reveal likely underestimates in domestic sector emissions by a factor of three to five (Carmichael et al. 2003).

Impacts are generally easiest to detect around large urban conglomerations or the region's megacities (Guttikunda et al. 2003; Molina and Molina 2004). The possibilities of recognizing impacts of megacities from characteristic ratios in their emissions were confirmed by observations in plumes (Carmichael et al. 2003). For example, lower sulfur dioxide and nitrogen oxide emissions in Tokyo or Seoul reflect the larger role of transport and smaller emissions from coal compared to, for example, other cities like Beijing (Carmichael et al. 2003). In short, different urbanizing regions can have their own bouquet of emissions.

Urbanization in the Pearl River Delta in China has been associated with a reduction in local precipitation, particular in winter (Kaufmann et al. 2007). The effect may not be just the result of increases in aerosol concentrations, or the "heat island" effect, but also a consequence of changes in hydrology (Kaufmann et al. 2007). Increased aerosols, globally, produce dimming (reduced sunlight) largely over urban areas (Alpert et al. 2005).

On a larger scale, most Southeast Asian countries are characterized by relatively high contributions of biomass burning relative to biofuel and fossil fuel emissions (Woo et al. 2003). Singapore, for instance, has almost no bio-emissions. Patterns in atmospheric CO/CO_2 ratios reflect regional economic development, whereas BC/OC distinguish fossil fuel and biomass burning (Woo et al. 2003).

Asia is a major source of aerosols from biomass burning. (Streets et al. 2003). The ACE-ASIA experiment was conducted to better understand the complex regional aerosols originating in Asia (Seinfeld et al. 2004). Aerosols typically include salts, organic carbon, black carbon, mineral dust and water from dust, fossil fuel and biomass burning. Effects on climate are difficult to assess accurately as there are cooling impacts by blocking radiative flux reaching the earth's surface as well as heating impacts from absorbing substances like black carbon. Dust also interacts with other gases, pollutants and particles and may influence cloud formation (Seinfeld et al. 2004). Interactions may also impact iron and nutrient delivery to the ocean's surface.

The abundance of aerosols and trace gases in a remote location on the Tibetan plateau of southwest China were affected more by emissions from biomass burning in Southeast Asia and South China than urban and industrial emissions from Central and South China (Chan et al. 2006). The measurements were made in April–May 2004 corresponding to periods with the seasonally

high incidence of fires across Southeast Asia. Air masses from south/southwest monsoon that start in Bay of Bengal travel across Myanmar, and sometimes northern parts of Thailand and Lao PDR before reaching southwest China (Chan et al. 2006).

Earth system feedbacks

Trends in greenhouse gas emissions for only a few cities and urbanizing regions in Southeast Asia have been compiled, but a lot more is known about patterns of energy consumption in transport and buildings that can be used to begin to understand the magnitude of earth system feedbacks and the most important processes for urban carbon cycles (Global Carbon Project 2003; Pataki et al. 2006).

Between 1980 and 200 for example emissions from the transport sector in Manila tripled and rose from 42 percent to 51 percent of total emissions (Lasco et al. 2005). While vehicle ownership and associated emissions in Chiang Mai have also grown strongly, the trends in the patterns in per capita carbon emissions for Manila and Chiang Mai are, overall, substantially different over these two decades, with rising electricity emissions being much more important for Chiang Mai (Lebel et al. 2004) and transport for Manila (Lebel et al. 2007a).

The share of renewable energy in power generation mixes makes a difference to a city's greenhouse gas budget. Jakarta draws energy from a national grid, which in 1980 was 20 percent renewables. By 2000 this had fallen to 15 percent of the total even though the contribution in absolute terms had increased fivefold (Sari and Salim 2005). In contrast, the contribution of hydro and geothermal sources to the Manila's power generation mix has remained more stable at around 30 percent over the same two decades (Lasco et al. 2005).

Examination of land use in Jakarta, Manila, Chiang Mai and Ho Chi Minh City underline that the contribution of green spaces and parks to carbon sequestration is very limited relative to the magnitude of fossil-fuel emissions from within those cities (Lebel et al. 2007a). For Metro Manila, for example, it was estimated at 29.4 Gg/yr or only about 0.2 percent of annual emissions (Lasco et al. 2005).

Apart from CO_2 there other emissions from urban areas that are important to the global environment. Bernsten and colleagues (2005) carried out experiments using chemical tracer and global circulation models to explore impacts of short-lived gases NO_x and CO, important ozone precursors, on global climate. They found that perturbations from the Southeast Asia region had much larger effects than those from Europe for NO_x but not CO. They

suggest that inclusion of NO_x in global assessments and Kyoto-like agreements should therefore assume different weighting factors for emissions in different regions of the world.

Changes in aerosol budgets associated with urban emissions, for example, could influence the Asian monsoon climate system. The monsoon climate provides a profound context against which agricultural areas, patterns of trade, emergence of human settlements and cultural practices and institutions have evolved over centuries. Urban sources of air pollution (including aerosols, ozone and ozone precursors) contribute to climate forcing. Aerosol composition and acid precipitation changes seasonally and in South Asia there is a switchover from black carbon to dust particles during the summer monsoon (A. P. Mitra, personal communication). The changes in aerosol composition are dependent on many factors. We expect that urbanization processes are an underlying cause of some of these changes with both positive and negative impacts on emissions relative to non-urban land use and human settlement patterns.

URBAN, REGIONAL AND GLOBAL INITIATIVES

There are several potential strategies available to cities and urbanizing regions for incorporating management of emissions into their future development (Lebel et al. 2007a). Public engagement often appears critical to the success of various initiatives—without it is hard to build support for the necessary policy changes (Craig et al. 2007). But the urban environmental challenge is fundamentally multi-scale requiring consideration of processes at local, regional and global levels (Marcotullio and McGranahan 2007).

Local

For example, cities may reduce auto-dependency through trying to shape the form of new urban areas with mass transit systems and by providing secure corridors for non-motorized transport with good linkages to such systems. Municipalities may also look at ways to improve energy efficiency through recycling and capturing energy from solid waste incinerators, increasing contributions of renewable energy in power supply, and using information technologies to reduce inefficiencies in transport logistics. Compact and modular forms can help cities function. Urban surfaces, because of their impacts on energy balance and boundary layers, may be amenable to planning to reduce heat island effects and improve local climate (e.g. Coutts et al. 2007). Urban redevelopment and renewal programs should focus on providing cheap, clean and safe mobility, shelter, work and food to the poorest. These programs

should be funded by those whose lifestyles contribute most to driving rises in harmful local and global emissions.

Most commonly, however, the initial focus of strategies is on technologies that are only in part linked to urbanization as a process. Large cities in Southeast Asia have in part benefited from innovations in pollution abatement technologies and energy efficiency experienced in the earlier industrializing regions of East Asia (Iwami 2005)—innovations that were spurred by civil protests. As a result most cities in Southeast Asia did not experience the high sulfur dioxide concentrations that Japan did (ibid.). At the same time lower-income cities in Southeast Asia in countries that are growing rapidly face huge challenges with no guarantee that income growth will automatically yield environmental improvements (Ooi 2007).

Most governments have been progressively improving the quality of fuel used in the transport sector and have been moderately successful at doing so. In Bangkok, for example, the 1991 campaign to use unleaded petrol and 1996 ban on leaded fuel has seen lead levels fall to below ambient air quality standards from earlier highs (Cheevaporn et al. 2004). Efforts to reduce vehicle emissions by retrofit technologies or emission standards on new vehicles are also recommended and pursued (e.g. Krupnick et al. 2003), but often struggle with problems of vehicle maintenance, inspection systems and, thus, enforcing long-term compliance. Even so, Singapore, Malaysia and Taiwan, have been successful in reducing ambient levels of total suspended particulates (TSP) and PM_{10} in urban areas (Rock and Angel 2007).

There are also important opportunities in new technologies for observing and sharing information. The Pollution Control Department of Bangkok, for example, has experimented with modified hand-held personal digital assistants linked to solid state gas sensors to carry out air pollution monitoring over large areas and report in real time at much lower cost than conventional methods. Results already reported on the Internet using base station data could be greatly expanded in coverage and detail (Pummakarnchana et al. 2005).

New knowledge may not, however, be taken up by policy or practice because its relevance is not understood (Lebel et al. 2007a). The capacity of national and municipal agencies to assimilate and understand technical information about air quality and management options is often limited. Administrative fragmentation can separate expertise that should be integrated, for example, with respect to land use, transport and energy planning.

Dialogue and communication are important and often insufficient (Craig et al. 2007). In Jakarta the non-governmental organization Pelangi and the Swiss Foundation for Technical Cooperation have played a valuable facilitation

role in bringing air quality and transport issues onto public policy agendas (Sari and Salim 2005). This eventually led to the successful introduction, for example, of dedicated bus lanes. Singapore has used a mixture of incentives and regulatory instruments to control traffic congestion and emissions from cars (Chin 2000). Many of the measures which need to be taken to improve air quality and health involve comparison of alternative road transport policies, which because of their complexity, may benefit more from systematic assessment methods (e.g. Kjellstrom et al. 2003).

One of the outstanding challenges to improving air quality is the tendency to deal with one pollutant at a time. It is increasingly argued that a "one atmosphere" approach may be more effective rather than the current step-by-step focus on individual pollutants (Craig et al. 2007; Samet and Krewski 2007). To this end, a strategy of controlling ozone and particulate matter may work as they are associated with many sources (Samet and Krewski 2007).

Regional

Regional air pollution creates governance challenges as most regulatory frameworks of countries in the region are focused on controlling ambient air pollution through air quality standards but emissions may arise elsewhere (Bergin et al. 2005). The most comprehensive and probably successful regional cooperation on transboundary air pollution has been in Europe following the 1979 Long-Range Transport Air Pollution (LRTAP) Convention (Lidskog and Sundqvist 2002). The Association of Southeast Asian Nations (ASEAN) first signed a cooperation Plan in 1995 (ASEAN 1995) and then in 2002 an Agreement on Transboundary Haze Pollution, but as Florano (2003) puts it it is a "blind and toothless paper tiger". The agreement makes no significant provisions for monitoring, compliance, inspection, standards or liability. The ASEAN Secretariat, may still find ways of getting compliance, through norm pressure, technical cooperation or other incentives (Florano 2003; Murdiyarso et al. 2004). The agreement, while non-enforceable, still sets up expectations for cooperation and action (Tan 2005). Whether this limited cooperation on pollution from land fires will make it easier in the future to deal with transboundary air quality issues related to industrial and urban emissions remains to be seen.

Building air quality management capacities in developing countries is an important precursor to cooperation on regional and global initiatives (Bergin et al. 2005). Regional cooperation among researchers and bureaucrats from cities in Southeast Asia to address urban air pollution issues has perhaps progressed further than measures directed at transboundary pollution issues (Bergin et al. 2005). An example is the Clear Air Initiative for Asian Cities

initially established in 2001 by the Asian Development Bank, World Bank and US-Asia Environmental Partnership.

Collaboration between municipal or metropolitan authorities and provincial or national governments is also crucial (Elsom 2004; Lasco et al. 2005).

Global

The challenge to maintain urban air quality with continuing economic growth while also minimizing emissions disruptive to regional air-sheds and the global climate-atmosphere system will increase and so will demand for effective action (Betsil 2001). Finding pathways of transformation for regions and urban areas that are less carbon-intensive (Dilling et al. 2003) would therefore be highly desirable, especially, if they can still deliver the social development gains and aspirations of the developing world (Lebel et al. 2007a). Understanding of such pathways in developing regions may also provide insights to mature industrial economies about how to de-carbonize their patterns of consumption while maintaining a high quality of life. Value and culture changes are likely to be part of any such transitions and therefore also need to be confronted and understood (Lebel 2004a).

Growing awareness of the importance of urban activities and environments has led to investments in monitoring, making inventories, building models and carrying out impact studies and assessments (Lebel et al. 2007a). Municipalities, local area government authorities and schools are learning about air pollution, making measurements and making demands (Chiang Mai Municipality 2004; Garden et al. 2004). Cities are linking with each other, independently of national governments, to share ideas on how to reduce emissions (Betsil 2001; Betsil and Bulkeley 2004; Lindseth 2004).

Urbanization is of course only one component, and one lens, through which to look at the remarkable social development and environmental transformation of Southeast Asia. But it is potentially a very important perspective because of its central role in economic and social development on the one hand, and the potential for high leverage in emission reduction strategies, on the other (Lebel 2005; Lebel et al. 2007a).

CONCLUSIONS

The contribution of urbanization to changes in emission and air quality in Southeast Asia are significant. Key emission sources exist in urban areas, and others outside them are strongly driven by activities in urban areas. There are significant opportunities to reduce climate-forcing greenhouse gases, aerosols

with multiple impacts, and particulates with health risks, into the public policies that help shape evolving urban form, function and role in Southeast Asia. Urban centers offer favorable circumstances to engage the public and build constituencies for change.

Acknowledgements

This chapter is dedicated to Professor A. P. Mitra who passed away on September 3, 2007, aged 80. He will be sorely missed by all his colleagues.

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