

**Indicators for Urban Environmental Management Capacity:
Urban Air Quality Management in Bangkok (Thailand) – Transport Sector**

Dr. Mushtaq Ahmed Memon
Research Associate, Urban Environmental Management,
Institute for Global Environmental Strategies (IGES), Kitakyushu Office, Japan
Tel: 81-93-513-3711, Fax: 81-93-513-3712, E-mail: mushtaq@iges.or.jp

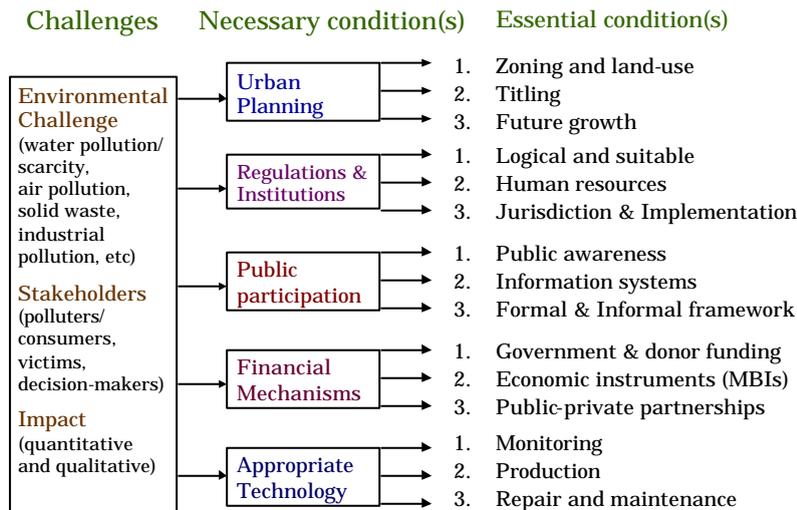
1. Objective

The objective of this brief paper is to assess urban environmental management capacity in terms of indicators, which we may codify as low, moderate, and high. These indicators can facilitate local governments to assess their capacity for urban environmental management and to assess tangible urban environmental improvements over time.

2. Urban environmental capacity

This capacity may be classified under two categories: assessment capacity and response capacity. The first one may include the ability to assess the environmental conditions, for example air quality in this case study, its major sources, and its impact. This requires monitoring and analytical capacity. The second one may include the selection and implementation of appropriate response, which may be based on one or more of the available means viz.: urban planning, regulations, institutions, technology, financial mechanisms, and social capacity and public participation. Fig 1 shows the framework for assessment and response capacity.

Fig 1 Critical Path Analysis



Source: Memon (2003)

3. Urban air quality management in Bangkok

Bangkok was named the capital of Thailand in 1782, when it was only a tiny village named Siam. Its population at the turn of last century (1900) was just 600,000 and it was covering an area of 18 sq. km. only. Its current population within city limits is about 6 million; however, the population within metropolitan area is about 10 million, and over 15 million residents live in Bangkok and the five surrounding provinces. Most of these residents travel to the city for work, business, health, shopping, and entertainment purposes. Hence, all these activities have a direct relationship with the air quality management in Bangkok. Therefore, in this study, the first section elaborates on the air quality in Bangkok and some of the successes in improving the air quality, mainly by managing lead and sulphur content in the gasoline. The second section discusses the important aspects of the urban environmental management capacity, which includes the monitoring or assessment capacity, and the response capacity.

3.1 Urban air quality

Urban air pollution in Bangkok is mainly from transport, industrial, energy, and construction sectors, but this study is only focused on air pollution management from transport and related energy uses. Although

additional 300,000 vehicles use the city roads every year, but roadside carbon monoxide (CO), sulphur dioxide (SO₂), and oxides of nitrogen (NO_x) concentrations have been decreasing since 1993 (Haq et al. 2002). In year 2000, no violations of SO₂ and NO₂ were observed in the general areas as well as along roadside in the city (Table 1 and 2). Air concentrations of lead (Pb) have also reduced significantly. However, particulate matter is a major air pollution problem, especially along streets with congested traffic.

Table 1 Ambient air quality in the general areas of Bangkok in 2000

Concentrations					
Pollutants	Range	95 percentile	Average	Standard	Frequency of Exceeding Standard
TSP (24-hr), mg/m ³	0.02 - 0.33	0.19	0.09	0.33	0/351 (0%)
PM-10 (24-hr), µg/m ³	18.6 – 169.4	102.7	56.1	120	37/1, 725 (2.1%)
CO (1-hr), ppm	0.0 – 12.50	2.6	0.96	30	0/70,186 (0%)
CO (8-hr), ppm	0.0 – 8.20	2.31	0.97	9	0/71,609 (0%)
O ₃ (1-hr), ppb	0.0 - 203	54	15.6	100	161/54,415 (0.3%)
NO ₂ (1-hr), ppb	0.0 - 136	22.8	22.8	170	0/67,094 (0%)
SO ₂ (1-hr), ppb	0.0 - 161	20	6.7	300	0/72,750 (0%)
Pb (1-month), µg/m ³	0.02 - 0.33	0.21	0.09	1.5	0/93 (0%)

Source: PCD Thailand

Table 2 Ambient air quality at the roadside sites in Bangkok in 2000

Concentrations					
Pollutants	Range	95 percentile	Average	Standard	Frequency of Exceeding Standard
TSP (24-hr), mg/m ³	0.05 – 0.48	0.35	0.19	0.33	25/424 (5.9%)
PM-10 (24-hr), µg/m ³	27.0 – 244.4	146.6	82.6	120	206/1,613 (12.8%)
CO (1-hr), ppm	0.0 – 18.5	5.6	2.20	30	0/41,879 (0%)
CO (8-hr), ppm	0.0 – 13.13	5.17	2.19	9	34/42,452 (0.1%)
O ₃ (1-hr), ppb	0 - 136	31.0	7.6	100	5/23,615 (0.02%)
NO ₂ (1-hr), ppb	0 - 169	81.0	35.4	170	0/22,962 (0%)
SO ₂ (1-hr), ppb	0 - 12	24.0	9.2	300	0/22,988 (0%)
Pb (1-month), µg/m ³	0.03- 0.24	0.16	0.09	1.5	0/62 (0%)

Source: PCD Thailand

Success in air quality improvements is visible in reduced lead (Pb) and sulphur dioxide (SO₂) concentrations. These pollutants were phased out gradually (Table 3 and 4) due to effective regulations.

Table 3 Phase-out of leaded gasoline in Thailand

Year	Phase-out of leaded gasoline
Before 1984	0.84 grams of Pb/litre
1984	0.45 grams of Pb/litre
1990	0.40 grams of Pb/litre
1991	Introducing unleaded premium gasoline
1992	0.15 grams of Pb/litre in leaded gasoline
1993	Introducing unleaded regular gasoline
1994	Complete phase-out of regular leaded gasoline
January 1, 1996	Complete phase-out of premium

Source: PCD Thailand

Table 4 Reduction of maximum allowable sulphur content in diesel

Date	Sulphur content
Before September 1993	1 per cent by weight
September 1993	0.5 per cent by weight
January 1, 1996	0.25 per cent by weight
January 1, 1999	0.05 per cent by weight

Source: PCD Thailand

3.2 Indicators for capacity

3.2.1 Assessment capacity

This capacity includes monitoring, identification of the sources, and the impact of air pollution for selecting cost effective and appropriate responses. National government agency (pollution control department PCD, under Ministry of Science, Technology, and Environment) and local government (Bangkok Metropolitan Administration BMA) are responsible for monitoring of ambient air quality in the city. Out of PCD's 53 monitoring stations, 17 fully automated stations are working in the city for general as well as roadside ambient levels. BMA also has one modern station for noise as well ambient air quality monitoring. The other aspect is the availability of human resources and their capacity. Although we do not have exact figures, but the quantity and quality of the human resources have tremendously increased in this sector.

The identification of sources for the air pollution is a responsibility different agencies including both of these agencies. Local police also help these agencies for on spot inspections and there are inspection stations in the city, which check vehicles for their pollution levels. BMA has one mobile station for on sport checking, where traffic police can fine the vehicles with high pollution levels. The pollutants from various types of vehicles are shown in Table 5.

Table 5 1997 Emission loads of air pollutants from vehicles in BMR

Vehicle Types	CO (tonnes)	HC (tonnes)	NO _x (tonnes)	PM (tonnes)	SO ₂ (tonnes)
Gasoline	134,311 (38.5%)	35,886 (15.4%)	34,133 (12.9%)	701 (3.4%)	4,250 (43.4%)
Light Duty Diesel	34,821 (9.9%)	15,739 (6.8%)	65,836 (24.9%)	6,366 (30.9%)	1,679 (17.2%)
Heavy Duty Diesel	68,331 (19.5%)	17,671 (7.6%)	163,703 (61.8%)	10,663 (51.7%)	3,068 (31.4%)
Motorcycle	112,308 (32.1%)	163,677 (70.2%)	976 (0.4%)	2,871 (14%)	786 (8%)
Total	349,771 (100%)	232,973 (100%)	264,648 (100%)	20,602 (100%)	9,784 (100%)

Source: PCD Thailand

The other important source of is the congestion on the roads, as with higher congestion the same type of vehicle emits more pollution. So far, there is no comprehensive study available to show the holistic situation in Bangkok; however, there are some good studies for some specific roads in the city.

The third aspect of assessment study is the impact analysis. This is more specialized field and generally, civil society and consultants help to establish a "dose-response function" to analyse the impact of different pollution levels on health, economy, and other socio-economic variables. For local air pollution impact, health is the most important issue to be analysed. Radian International, under the World Bank funding, carried out one of the major studies PCD in 1998. This study suggests that particulate matter (PM₁₀) is the major health threat and a 10 µg/m³ reduction in the annual average of PM₁₀ concentrations would result in an estimated reduction of:

- 700-2,000 premature deaths;
- 3,000-9,300 new cases of chronic respiratory diseases;
- 560-1,570 respiratory and cardiovascular hospital admissions;
- 2,900,000-9,100,000 days with respiratory symptoms severe enough to restrict a person's normal activities; and
- 2,200,000-74,000,000 days with minor respiratory symptoms

Economic impact of air pollution in Bangkok is also heavily influenced by the health expenditures, as a resident spends on an average of 12.5 per cent of their total medical expenses on respiratory illness alone. Hence, a reduction of $20 \mu\text{g}/\text{m}^3$ in annual average of PM_{10} concentrations would yield savings of 65-175 Bhat. The other study shows that the economic losses due to traffic jams are estimated between US\$272 million and \$ 1 billion a year.

From the above discussions, we can say that assessment capacity of the city has improved over the years and in comparison with the similar type of cities in the developing countries, this capacity is high on moderate side; however, in comparison to the cities in the developed countries this capacity is low on moderate level.

3.2.2 Response capacity

This capacity is classified in six categories, viz.: urban planning, regulations, institutions, financial mechanisms, technology, and social capacity and public participation.

Urban planning: The first category of urban planning in this city mainly includes the road network and its distribution for various vehicles including bus lanes, mass transit system including Sky train and underground, and the availability of green areas, especially near road to reduce the regeneration of particulate matter. The road network is being heavily congested as on an average 500 additional cars enter in the network everyday. At present the average speed is 10 km/hour and this will be reduced to 8.2 km/hour in 10 years, if appropriate measures were not taken. Bus lane system in Bangkok was quite famous and effective; however, in recent years the bus lanes that flow in the same direction of traffic have not been enforced effectively. As 30% of Bangkok's trip making is made by bus, there is a strong case to enforce existing buss lanes.

In December 1999, Bangkok's first mass transit system, electricity powered Sky train, became operational with 23.5 km line with a cost of US\$1.4 billion to manage the traffic congestions. During the first month, about 200,000 trips were made each day and it is estimated that the line will eventually carry 650,000 passengers per day. The total length of Sky train will be 200 km. This project is being entirely financed from private sector, supported by \$100 million from the International Finance Corporation (IFC), providing a new model for private sector participation in urban mass transit system. Moreover, the first phase of Bangkok's very own underground train system is scheduled to open on August 12th 2004, a considerable delay from the proposed opening in 2003. Fares, speeds, and regularity of the trains are somewhat on a par with the sky-train. Passengers can expect to pay somewhere between 18 and 38 baht for a ticket, and trains will run every 4-6 minutes.

The green areas in the city are also being rapidly increasing as BMA has a target of approximately 2.5 sq. m/person. The capacity for urban planning in Bangkok is improving; however, it is not high in comparison with other cities like Shanghai. Therefore, we may term it is in the middle of moderate level.

Regulations: The central government agencies usually set the emission standards and the local government like BMA usually enforce these standards. Table 6 and 7 show standards for in-use and new vehicles respectively.

Table 6 Emission Standards for in-use Vehicles

Pollutants	Type of Vehicles	Standards	Measuring Device	Test Procedure
Black Smoke	Diesel vehicle	50 per cent	Filter	Snap Acceleration Test
		45 per cent	Opacity	Snap Acceleration Test
		40 per cent	Filter	Full Load Test
		35 per cent	Opacity	Full Load Test
CO	Gasoline vehicle registered from November 1, 1993	1.5 per cent	NDIR	Idle Test
	Gasoline vehicle registered before November 1, 1993	4.5 per cent	NDIR	Idle Test
	Motorcycle, Three Wheelers	4.5 per cent	NDIR	Idle Test
	Gasoline vehicle registered from November 1, 1993	200 ppm	NDIR	Idle Test
HC	Gasoline vehicle registered before November 1, 1993	600 ppm	NDIR	Idle Test
	Motorcycle, Three Wheelers	10,000 ppm	NDIR	Idle Test
White Smoke	Motorcycle	30 per cent	Smoke meter; full-flow opacity system	Quick acceleration the engine to $\frac{3}{4}$ of maximum power rpm.
Noise	Diesel vehicle			Measuring at the max. power rpm
	Gasoline vehicle			Measuring at $\frac{3}{4}$ of max. horse power rpm.
	Motorcycle, Three Wheelers	100 dBA	Sound Level metre as standard of IEC	Measuring at $\frac{1}{2}$ of max. power rpm., if engine has max. rpm. Over 5,000 rpm Measuring at $\frac{3}{4}$ of max. power rpm., if engine has max. rpm. Less than 5,000 rpm

Source: PCD Thailand

Table 7 Emission Standards for new Vehicles

Type of Vehicles	Level	Reference Standards	Implementing Date
Light Duty Gasoline Vehicles	1	ECE R 15-04	-----
	2	ECE R83-B	30 March 1995
	3	ECE R83-01(B)	24 March 1996
	4	93/59/EEC	1 January 1997
	5	94/12/EC	1 January 1999
	6	96/69/EC	25 August 2001
	7	1999/102/EC (A)	Under Discussion
	8	1999/102/EC (B)	Under Discussion
Light Duty Diesel Vehicles	1	ECE R 83-C	29 January 1995
	2	ECE R 83-01(C)	23 February 1996
	3	93/59/EEC	1 January 1997
	4	94/12/EC	1 January 1999
			30 September 2001 for DI Diesel
	5	96/69/EC	25 August 2001
	6	1999/102/EC (A)	Under Discussion
	7	1999/102/EC (B)	Under Discussion
Heavy Duty Diesel Vehicles	1	ECE R 49-01	-----
	2	EURO I	12 May 1998
	3	EURO II	23 May 2000
Motorcycles	1	ECE R 40-00	10 August 1993
	2	ECE R 40-01	15 March 1995
	3	- CO \leq 13 g/km - HC \leq 5 g/km	1 July 1997
	4	- CO \leq 4.5 g/km - HC+NOx \leq 3 g/km - White Smoke \leq 15 per cent - Evaporative 2 g/test for sizes \Rightarrow 150 cc up	30 July 2001
	5	- CO \leq 3.5 g/km HC+NOx \leq 2 g/km - White Smoke \leq 15 per cent - Evaporative 2 g/test	1 July 2003 for sizes \leq 110 cc 1 July 2004 for all sizes

Source: PCD Thailand

Thailand has adopted some of the Asian regions' strictest standards for vehicle emissions. European Union standards were set as reference standards for light-duty gasoline vehicles, light duty diesel vehicles, and heavy-duty diesel vehicles. Implementation dates are 2 years after these standards have been enforced in Europe. Due to large number of motorcycles, Thailand has adopted second and third stage motorcycle emission standards of Taiwan, the world's stringent. Furthermore, vehicles registered under Motor Vehicle Act, such as passenger cars, taxis, and motorcycles, have been subject to emission inspection since 1995. For taxis, the Land Transport Department or the local Land Transport office carries out the inspection every six months. For motorcycles and cars, 5 and 7 years old and older respectively, were subject to emission inspection annually at the time of the renewal of their licence by the authorized private inspection centres or garages.

The regulatory capacity, for vehicle emissions, could be considered high on moderate level in comparison with the other similar cities. The ambient air quality standards have also been set in 1995, as shown in Table 8.

]

Table 8 Ambient air quality standards of Thailand (1995)

Pollutants	1- hr average		8 - hr average		24 - hr average		1- month average		1 - year average**		Methods
	mg/m ³	ppm	mg/m ³	ppm	mg/m ³	ppm	mg/m ³	ppm	mg/m ³	ppm	
CO	34.2	30	10.26	9	-	-	-	-	-	-	Non - Dispersive Infrared Detection
NO ₂	0.32	0.17	-	-	-	-	-	-	-	-	Chemiluminescence
SO ₂ ^a	0.78	0.30	-	-	0.30	0.12	-	-	0.10	0.04	UV - Fluorescence
TSP	-	-	-	-	0.33	-	-	-	0.10	-	Gravimetric - High Volume
PM ₁₀	-	-	-	-	0.12	-	-	-	0.05	-	Gravimetric - High Volume
O ₃	0.20	0.10	-	-	-	-	-	-	-	-	Chemiluminescence
Pb	-	-	-	-	-	-	1.5	-	-	-	Atomic Absorbtion Spectrometer

Notes:

**geometric mean; /a 1-hr SO₂ Standard 1.3 mg/m³ for Mae Moh area

Source: PCD Thailand

Institutions: As discussed above, PCD of central government and BMA (local government) are currently the major institutions, along with other agencies like Land Transport, which are responsible for air quality management. However, their role is sometimes overlapping resulting in redundancy of efforts or confusion at some levels. For example, monitoring stations under PCD and BMA, which should be ideally under one agency. The ideal situation for national government agency like PCD would be to set the regulations and BMA should carry out the ground activities like monitoring and enforcement. Like UK, where local governments monitor the situation and take the actions including set their own regulations like congestion fee in inner London, BMA should also be given the same role. Therefore, the human, technical, and financial capacity of these institutions should also be streamlined accordingly. Hence, the current overlapping shows that the institutional capacity is not that high, and we may put this at the middle of the moderate level.

Financial mechanisms: This can be divided into two sub-categories: government finances and private finances. Only 25 per cent of municipal revenues are locally collected and retained. As a result of newly adopted constitution, a Decentralization Commission has been established. The key centralized reforms as envisioned in the Constitution (passed in October 1997) include increasing the share of local government expenditures, assigning more revenue sources to local governments, and revising the system of intergovernmental transfers to provide grants in a more transparent and predictable way. The government expenditures for air quality management are moderate as PCD and other central government institutions play a major role and the central government is responsible for their finances.

Private sector finances mainly comes on two accounts, one is under market based instruments, which is also know as polluter pay principle, and the other is through private sector participation in the projects, which are directly related with air pollution management, including the Sky train. We do not have enough data on the finances being generated through market based instruments; however, private sector is quite active for investment and management of urban projects, which may improve the air quality. Therefore, the financial capacity is not yet commendably high; however, due to current decentralization and privatisation, we can put this in the middle of a moderate level.

Technology: This capacity can further be classified under 3 sub categories, viz.: technology for monitoring, technology for vehicles, and technology for repair and maintenance. First one, which is already discussed under monitoring, is quite good and effective. The monitoring stations as well as mobile stations are well equipped and the human resources are also well trained. For vehicles, vapour recovery system is essential since July 2001. Furthermore, switching to cleaner fuels and installation of catalytic converters including diesel catalytic converters for diesel vehicles, and replacement of 2 stroke motorcycles with cleaner 4 stroke ones. The repair and maintenance technology has also improved, as a result of technology transfer as a result of international car industry in Thailand. The government also relies on these private garages for annual inspections of cars and motorcycles. Furthermore, the introduction of Sky train and underground

train will make this city a technologically sound city. Therefore, in comparison with similar cities, the technology is at the higher side of moderate level.

Social capacity and public participation: Civil society and private sector are actively involved in air quality management. NGOs and academia are engaged in carrying out research, public awareness, and public pressure to plan and implement various short-term and long-term measures, in support from the local government. This includes Car free days and intensive use of mass transit system, and carrying out proper maintenance of their cars and motorcycles. BMA is carrying out a public relations campaign on air pollution and its effects, and on how to reduce air pollution. BMA uses boards, pamphlets and other materials, advertisements on TV and Newspapers, to increase the awareness and participation. An environmental report, supported by UNEP, has been launched in Thai as well as in English in a form of a book as well as video. However, it is difficult to evaluate this capacity with the limited available information. Nevertheless, based on the existing information, we can say that this capacity lies in the middle of a moderate level.

4. Conclusion

We conclude this brief paper with two points. Firstly, the indicators for urban environmental management may include assessment and response capacity. This will help the concerned agencies or individuals to identify the strengths and shortcomings of the system and may propose appropriate strategies for the capacity building. Secondly, the case study of Bangkok shows that the air quality management capacity has been improving due to various strategies. This includes the capacity building for monitoring by incorporating new technology and appropriate human resources. Similarly, various means, including launching of mass transit system, setting and enforcement of standards, private sector participation, better technology for vehicles and their inspections, and improved social capacity and public participation, have contributed towards response capacity. The tangible improvements in air quality in Bangkok are the evidence for a better capacity in urban air quality management. Nevertheless, there is still a lot of room for improvements in terms of capacity as well as in terms of tangible improvements in air quality, mainly for particulate matter like PM_{10} and $PM_{2.5}$.