Assessment of Waste Recycling Performance: A Study of School Garbage Banks in Thailand

Samonporn Suttibak and Vilas Nitivattananon

Abstract— *Solid waste management presents a serious challenge to most urban areas in developing countries including Thailand. An effective way to reduce this tremendous problem is to integrate waste recycling into the existing and future waste management schemes so as to conserve natural resources, save energy in production and transport of goods and materials, and reduce the risk of pollution and the demand for landfill. Understanding recycling performance is a key to achieving sustainable waste management. A study has been carried out aiming at exploring the status of existing recycling programs in Thailand, selecting recycling performance indicators, and assessing the performance. A total of 100 school garbage banks (SGBs) located in several urban areas of Thailand were observed and investigated. The results reveal that the SGBs are mostly initiated by schools and local governments and facing the inconsistency of the price of recyclable materials. The efficiency, effectiveness, and service ratio indicators were used to assess the performance, which was found to be good in terms of participation rate, recycling rate, and B/C ratio, while the diversion rate is fair if compared with national goal. Recommendations for improving performance of the recycling systems are also discussed in this paper.*

***Keywords*— Local governments, Performance indicators, School garbage bank (SGB), Waste recycling.**

1. INTRODUCTION

Solid waste management (SWM) is a major deplorable environmental problem faced by local government authorities (LGAs) in developing countries including Thailand. These countries have been confronted with rapid growing waste generation rates. The amount of solid waste generated in urban areas of Asia has been estimated to increase to 1.8 million tons per day by 2005 [1]. This massive amount of solid waste generated is beyond the capacity of most LGAs to provide even the minimum basic services. As a result, they are facing rapid depletion of landfill space and the problem in obtaining new disposal sites as most of the existing disposal sites are becoming open dump and nearly exhausted [2]. These problems are highly critical of concern to local authorities that are the centers of SWM systems and play an important role for changing the tradition to more sustainable approached of SWM.

In this regard, recycling has to be recognized and accepted as a sustainable municipal SWM. This sustainable approach attracts local governments because of its potential to reducing disposal costs, waste transport costs and prolonging the life span of the sanitary landfill site in recent years [3], [4]. Furthermore, the increase of the waste recycling level has become an indispensable environmental-policy goal for the number of countries, which have many previous models of recycling focused on recycling behavior, socio-demographic variables, and waste generation rate [5].

There are many successful recycling programs implemented in developed countries, which are now available to local governments. Some successful programs highlight curbside collection, material recovery facilities (MRFs), and composting, and others address drop-off and buy-back programs. Several involved private-sector sponsorship and others are run by private enterprises [6]. These successful recycling programs have factors influencing their performance that also depend on their capacity to manage recycling programs. Some of these programs could not be met by the needs of local governments in developing countries and surpass capacity of LGAs to implement.

In Thailand, one of recycling programs has been implemented widely in the communities that is the “School Garbage Bank” (SGB), begun in several cities in 1999. This recycling program has long played an important role in recovering recyclable materials and raising awareness of youth and community members. In recent years, however, their role has become increasingly important by the convenience and the implementation cost that is inexpensive. This tremendous role has contributed to SGB as an element of municipal SWM systems in Thailand. It is a positive sign of recycling promotion in Thailand, the percentage level of recycling has been targeted to utilize organic and recyclable wastes of 15% by 2006 [7]. The challenge now is to put it into effective practice in many different recycling programs in Thailand. Many of these SGBs are in the decision process on how best to modify this program to achieve greater overall efficiencies and high performance.

In order to cope with the increasing waste generation rates and variety of waste composition, this study is based on the case study of SGBs and aimed at improving the existing practices. The main subjects covered in this

S. Suttibak (corresponding author) is a Ph.D. candidate with the Urban Environmental Management Field of Study, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand. Phone: +66-2-524-5639; Fax: +66-2-524-6380; E-mail: st102847@ait.ac.th.

V. Nitivattananon is Assistant Professor with Urban Environmental Management Field of Study, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand. Email vilasn@ait.ac.th.

paper are (i) investigation of the current status of waste recycling practices related to SGB programs in Thailand, (ii) selection of recycling performance indicators, (iii) assessment of SGB performance, and (iv) recommendations for improving performance of SGB recycling systems.

2. METHODOLOGY

The present study is based on data collection and analysis from interviews, postal questionnaire surveys and on-site observations. This paper discusses only part of a more comprehensive SGB study in Thailand, and describes the relevant methodologies used to assess its performance. It mainly analyses the current SGB patterns and focuses on selection of recycling performance indicators and assessment of SGBs implementation. In addition, the key informants have been interviewed to assess the SGB situation in urban areas of Thailand. Around 180 postal questionnaire-based surveys were mailed between January and March 2007 with a response rate of 55% (100 SGBs) was achieved.

In selecting recycling performance indicators, a set of indicators is taken from various literature sources and followed by selection criteria. The indicators for recycling system should be reflected by the function and the performance of the system, relevant, showing something about the system that decision makers need to know, understandable, meaningful, reliable, and need to be collected and reported at the right time to influence many management decisions [8]. On the part of an assessment of recycling performance to obtain the result of SGB performance, selected performance indicator and existing situation of SGB implementation is assessed. The recycling performance is assessed and compared with benchmarking indicators or other available options [9].

3. OVERVIEW OF THE SGBs AND STUDY AREAS

Existing Situation of SGBs

The first essential step toward promoting SGB is to understand the current status of this program. Wongpanit recycling company has introduced the SGB since 1999. Watpunpee school is the pioneer of SGBs where is located in Phitsanulok municipality, Phitsanulok province. This SGB has been replicated throughout country. References [10], [11] report that there were 500 schools in 30 provinces of Thailand has implemented SGBs since 2001 that recycled a total of 2,500 tons of recyclables a year.

The SGB has been conceived as initiative to encourage recycling activities at the school and community level, which are currently undertaken by students and supervised by teachers. This SGB is often implemented in conjunction with the local government, which may supply building, equipment, and staff. The SGB is very typical of the buyback center, where the generators are financially compensated for recyclable materials. The SGBs' members take the recyclable materials and receive an earning in exchange, depending on the weight and the type of the recyclable materials. The amount earned at a time is recorded into the passbook, which is analogous to a commercial bank. This can function as a banking transaction, for example cash withdrawal and loaning. The SGBs activities focus on encouraging people and youth participation, as well as creating understanding among them on waste separation and the SGB operation. It is one of waste management strategies implemented by school and community. Physical layout of a SGB varies by the volume and number of recyclable materials processed, site characteristics, and level of supervision.

The general objectives are to raise awareness of youth and their parents in value of recyclable waste, to train youth on their responsibilities in environmental conservation and to encourage them to spend free time constructively, to generate income for youth and reduce family's expenditures, and to reduce amount of waste that go to dispose. Most SGBs were supported by NGOs and external agencies (e.g. GTZ, CIDA) and subsidized by the school. The recycling through implementing SGB is a good practice because of the environmental impacts from sorting and recycling recyclable material are less than the environmental impacts to provide virgin material and dispose residual solid waste safely.

Potential for Recycling

Presently, only aluminum cans, plastics, and papers, have potential high-value materials in the SGB program. The recyclable materials were sold to recycling dealers, either at the junk shop. It was observed that aluminum cans have high-value materials and can be the greatest revenue generator of SGB program. It is estimated that it takes 95 percent less energy to produce aluminum can from an existing can than from ore [12]. However, the price of aluminum varies depending on location of centralized processing plants.

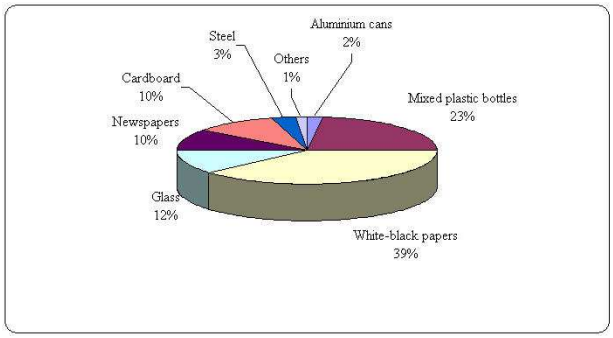

Fig. 1. Percentage of Materials Collected From 100 SGBs

The composition of recyclable materials collected from the 100 SGBs is shown in Fig. 1 based on percentage by weight. The largest component consisted of white-black papers with 38.90%, followed by mixed plastic bottles, glass, cardboard, and newspaper at 22.79%, 11.68%, 10.18%, and 9.94%, respectively. The remaining 6.51% comprised steel, aluminum cans, and others. A study by World Bank and Pollution Control Department (PCD) found that metal and paper have tremendous recycling potential and approximately two

thirds of these recyclables are currently discarded [11]. In addition, materials recovered from solid waste in Bangkok are glass bottles, paper, and plastic products [4]. The ease of taking these major recyclable materials to SGB is the reason why this portion different from others.

Table 1. The Main Characteristics of the 100 Selected SGBs

Information of 100 Schools	Primary School (N=50)	Secondary School (N=48)	College, University (N=2)	Total (N=100)
System Supervision				
LGAs	22	14	-	36
Private school	7	5	-	12
Educational service area	21	29	-	50
Commission on higher education	-	-	2	2
Investment Costs				
Private office	4	4	-	8
NGOs, external donors	10	6	-	16
LGAs, central government	17	15	1	33
School	19	23	1	43
Operation Costs				
Private office	2	2	-	4
NGOs, external donors	6	3	-	9
LGAs, central government	10	7	-	17
School	5	8	1	14
Revenue from sale of materials	24	25	1	50
Reward from the SGB competition	3	3	-	6

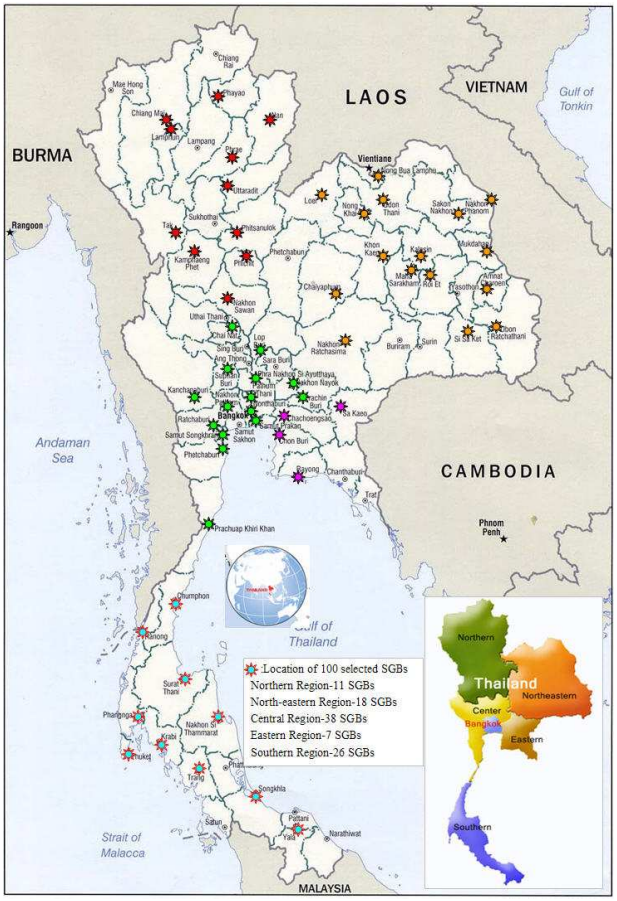

Fig. 2. Location of 100 Selected School Garbage Banks

Study Areas

How is study areas selected? This question was tackled through a recruitment of study areas from newspapers, mass media, experts' advice, and official documents and followed by utilizing selection criteria. The selection of SGBs is based on: (i) existence of SGBs located in different five regions of Thailand, (ii) various development partners such as NGOs, private sectors, or LGAs involved in such recycling program, (iii) whether were categorized into different school levels and system supervision, and (iv) the accessibility of reliable information.

As shown in Table 1, of the one hundred selected SGBs, 50 respondents were primary school, 48 were secondary school, and 2 were college. In terms of school supervision, 50 respondents were educational service area, 36 were LGAs, and 12 were private sector. One-third of investment costs are sourced from LGAs and central government, while the operation costs are obtained from revenues through the sales of materials. Their locations are given in Fig. 2. These are scattered throughout Thailand, there are 11 in Northern, 18 in North-eastern, 38 in Central, 6 in Eastern, and 26 in Southern areas.

4. PERFORMANCE INDICATORS AND ASSESSMENT RESULTS

Selecting Recycling Performance Indicators

Performance indicators are measures of project impacts, outcomes, outputs, and inputs that are monitored during project implementation to assess progress toward project objectives. They are also used later to evaluate a project's success. Indicators organize information in a way that clarifies the relationships between a project's impacts, outcomes, outputs, and inputs and help to identify problems along the way that can impede the achievement of project objectives [13]. Furthermore, the Organization for Economic Cooperation and Development (OECD) defines an indicator as *"a parameter, or a value derived from parameters, which provides information about a phenomenon. The indicator has significance that extends beyond the properties directly associated with the parameter value"* [14].

In addition, according to World Bank, performance indicators can be used for (i) strategic planning, (ii) performance accounting, (iii) forecasting and early warning during program implementation, (iv) measuring program results, (v) program marketing and public relations, (vi) benchmarking, and (vii) quality management [13].

Selecting appropriate and useful performance indicators requires careful consideration through iterative refining, collaboration, and consensus building [15]. Since there are time and resources constraints, only existing performance indicators could be reviewed rather than new indicators are developed. Each candidate indicator is discussed in more detail below together with possible calculating example.

Set-Out Rate

The set-out rate is the percentage of households, which set out their recyclables on collection days. This indicator determines the number of stops for trucks and affects the collection time, and thus is necessary for estimating the size of collection areas [16].

Participation Rate
The participation rate denotes the percent of households or business that regular set out recyclables. This indicator usually applies to participation in curbside collection, and has been applied as measure of the effectiveness of drop-off or buy-back centres [17]. The participation rate does not indicate the quantities of materials recycled or what materials were recycled, but does provide some useful measure of the extent of household or community member involvement in their recycling program [16]. Participation rate will be the same as the service ratio that was defined by Chang and Wei as the population serviced by recycling drop-off stations divided by total population in district [18].

Quantity Recovered or Recycling Rate
This denotes the quantity of recyclables collected per household per unit of time (e.g., 50 kg/ residence. month) [17]. Wang et. al. states that a very useful indicator of recycling performance is the quantity of recyclables collected, which can be expressed in terms of the average quantity of recyclable per participating household or the average quantity of recyclable per household [16]. In addition, Gies evaluated drop-off performance by using this indicator in four municipalities of Canada [19].

Diversion Rate or Recovery Rate
The success of a recycling program is measured by the diversion rate that represents the weight of total solid waste, which is not landfilled or not incinerated [17]. However, diversion rate sometime will be the same as the recycling rate that is the amount of material recovered from the generators served divided by total amount of available waste from the generators served [20], [21].

Net Cost per Ton
This indicator refers to net recycling program costs per ton recycled [21].

Ratio on Benefit to Cost
The benefit to cost ratio (B/C) has been applied as a measure of the efficiency of recycling program. This indicator represents the ratio of inputs needed per unit of output produced and examines percentage of revenue cover cost of recycling program [22]. In this paper, benefit is defined as the revenue from sale of recyclable materials over period of project and cost is defined as the investment cost and operation and maintenance cost (O&M).

Utilization rate
This defines the recyclables collected by drop-off stations divided by total capacity provided by drop-off stations in district [18].

Average walking distance
This defines the average walking distance of residents from their household to the recycling containers, that is the total service distance between node i and k of network link divided by total number of drop-off stations [18].

Value of Waste Recycled
This measures the value of recycled waste in a recycling program. The value of recycled waste is calculated by multiplying the volume of waste by the respective price, on an annual basis, in order to determine the value of recycled waste [23].

$$\text{Value of recycled waste} = \text{quantity}_{\text{type}} \times \text{price}_{\text{type}}$$

After reviewing the list of possible indicators was reviewed, appropriate indicators were selected to evaluate the performance of recycling programs that are applicable to existing recycling implementation in Thailand, which are differentiated from those implemented in developed countries. Throughout this paper, the process of selecting performance indicators was linked based on relevance to existing recycling implementation in Thailand. The set contained a total of 9 candidate indicators that were then assessed by using criteria for judging an indicator's appropriateness and utility. These criteria are related to [14]:

- policy relevance and utility for user-should be simple, easy to interpret and able to show trends over time, provide a basis for international comparisons, be either national in scope or applicable to regional environmental issues of national significance;
- analytical soundness-should be theoretically well founded in technical and scientific terms, be based on international standards and international consensus about its validity; and
- measurability-should be readily available or made available at a reasonable cost/benefit ratio, adequately documented and known quality, and updated at regular intervals in accordance with reliable procedures.

From an initial set of 9 candidate indicators identified, the following 4 indicators (Table 2) have been selected as core indicators for presenting in this paper that respond to the completed questionnaires. The selected indicators could be available in all SGBs since inter-school comparisons have a common purpose with such performance assessment.

Table 2. List of Selected Recycling Performance Indicators

Indicators category	Definitions	Units
Service ratio ▪ Participation rate	(Number of recycling program member/ total students and teachers) x 100	Percentage
Output ▪ Recycling rate or quantity of recyclables per recycler	(Total waste recycled/total recycler)	Kg/recycler.unit of time
Effectiveness ▪ Diversion rate or recovery rate	(Total waste recycled/total waste generated) x 100	Percentage
Efficiency ▪ Ratio on benefit to cost (B/C ratio)	(Revenue from sale of recyclable materials/ Investment cost+O&M cost)	-

Performance Results

Most required data is provided by the recycling coordinators that given through the postal questionnaire survey. Obtaining recycling performance results, four selected performance indicators and existing situation of 100 SGBs were assessed. The SGB performance assessment results were presented in Table 3.

By considering assessment result, it is seen that participation rate is good because the participants were

enhanced by education and economic incentive. If compared to other separation projects that have been implemented in Thailand, it was revealed that the participation rate was quite low, at less than 14% [24], [25]. In addition, if compared with drop-off recycling program such as those implemented in Taiwan [18], SGB performance reaches a satisfied level.

In terms of recycling rate, it was found that about 32.00 kg/recycler/year were recycled. This result was satisfied if compared with the performance of drop-off centers that have been implemented in four Canadian municipalities namely: the city of Calgary, township of Amabel, town of Gananoque, and city of Laval. These cities recovered recyclable materials through their drop-off programs representing 12, 60, 40, and 10 kg/recycler/year, respectively [19]. In addition, the average diversion rate of 8.25 % was lower than a national goal of 15 percent recycling of wastes in 2006 [7]. However, this diversion rate was close to the diversion rate of Thailand since only 11 percent of discarded wastes are recycled. If compared with other level it was found that the value is much lower than other cities such as Seoul, Hong Kong, Singapore, and Manila [11].

A simple benefit-cost analysis was performed to show the economic feasibility of SGB implementation. This B/C ratio was assessed by identifying benefit from sale of recyclable materials and cost from start up and operating cost. Start up costs is a one-time cost to initiate the SGB program. These include capital cost (e.g. providing recyclable material storage cost, measuring instrument and pass book), while operating costs are transportation cost and incentive cost for committee. The result showed that the B/C ration was greater than 1.00, which implies that SGB is economically feasible and also plays an important role for the improvement solid waste management within school and their communities.

Table 3. The Performance Results of 100 SGBs

Indicators	Mean	SD	Available Benchmark	References
Participation rate	60%	35%	<10% , (Yala, Thailand)	[24], 2005
			14% , (Hatyai, Thailand)	[25], 2006
			4% to 66, (Taiwan)	[18], 1999
Recycling rate	32	38	10-60 kg/recycler/year, (Canada)	Gies , 1995
Diversion rate	8%	9%	11% , (Thailand)	World Bank , 2003
			15% , (Bangkok)	
			36% , (Hong Kong)	
			45% , (Seoul)	
			39% , (Singapore)	
			13% , (Manila)	
			<10% , (Beijing)	
B/C Ratio	3	3	1[a]	Glenn, 1988

[a] B/C ratio is based on revenue from sales of recyclable material, disposal cost saving, capital costs, operation and maintenance costs.

Constraints of SGB Implementation and Recommended Strategies

One of the initial objectives of the study was not only to quantify the recycling rate of recyclable materials and participation rates at SGBs, but also to use more qualitative methods to determine what possible factors were expected to have success in recycling implementation. These factors can be contributed to the development of strategies to enhance SGB performance in order to reduce the amount of wastes to be disposed. Using some of the results of this study as a starting point, decision maker will continue to explore this issue in the future. The performance of SGBs is high in terms of participation rate, recycling rate, and B/C ratio, while the diversion rate is moderate if compared with national goal. This result implies that the participation rate does not associate with the quantity of recyclable materials that put out by recyclers. In fact, it was found in some cases that recycling programs with high participation rates yielded few amount of recyclables [16]. The convenience to be taken and separated out in the recyclable materials from students or residents leads to both higher participation and recycling rate. In terms of cost effectiveness, labor is usually one of the most costly aspects of recycling program. However, SGB is an exception.

Findings and observations of al1 100 SGBs, the success is tentatively dependent upon good attitude of administrator to initiate the establishment of SGB, transportation cost, method to increase value added recyclable materials, students provided incentive by giving bicycle, electrical appliances, or interest for SGB's member to gain saving, or students can take a loan. In addition, the encouragement of NGOs and external donors are also potential factors in SGBs success. These factors were considered into corresponding SGBs performance results, where high performance were achieved.

In contrast, there have been some implementation constraints, which can be found from SGBs competing with many itinerant recycling buyers. Sometimes students and their parents decide selling recyclable materials to such buyers, since they are not willing to store accumulated recyclable materials for a long time in their house. The fluctuation of recyclable materials prices cause SGBs member gain less profit that expected. This problem might affect the sustainability of the recycling program. The burden of transportation cost is also a major constraint to impede SGBs performance. In addition, training and site visit of students committee and teachers were neglected which cause them missed knowledge and technique to implement SGB efficiently. Another major constraint is the limited time of teacher supervisors and students committee. Therefore, SGB implementation has not been done completely. Most schools implemented such garbage bank last for only 6-8 months per year.

As SGB implementation constraints have been occurred, some strategies to enhance SGB performance are taken into consideration. First, provision of areas for storing the accumulated amount of recyclable materials should be done in order to negotiate the price of materials with recycling dealers. Second, LGAs should contact recycling company who provides high price of recyclable materials to buy those materials in the school. Third, university or large schools should be the center to contract with recycling dealer. Recyclable materials price would be guaranteed with the exact amount of recyclable wastes and the nearby schools can take recyclable materials to that SGB's center where economies of scale can be significant. Lastly, in order to reduce the heavy load of students committee, they should be categorized into several groups and several grades and provide them

some incentive to run it smoothly despite changing conditions and personnel turnover.

5. CONCLUSIONS AND RECOMMENDATIONS

The results obtained show that the 500 schools in 30 provinces of Thailand have implemented SGBs since 2001 which recycled a total of more than 2,500 tons of recyclables a year. The composition of recyclable materials mianly consists of white-black papers followed by mixed plastic bottles, glass, cardborad, and newspaper respectively. The remaining small portions are steel, aluminum cans, and others. One-third of investment costs are sourced from LGAs and central government, while the operation costs are obtained from revenue through sale of materials. Four peformance indiactors were selected which cover efficiency, effectiveness, and service ratio indicators based in relation to policy relevance, analytical soundness, and measurability. The performance results from the assessment were found to be good in terms of participation rate, recycling rate, and B/C ratio, while the diversion rate is fair if compared with the national goal.

The strategies for improving SGB implementation that should be considered include: provision of areas for storing the accumulated amount of recyclable materials; university or large schools to be the center of the SGB implementation to contract with recycling dealer; and student committees to be categorized into several groups and grades and with provision of some incentive.

REFERENCES

[1] Terazono, A.; Moriguchi, Y.; Yamamoto, Y. S.; and Sakai, S.-i. 2005. Waste management and recycling in Asia. *International Review for Environmental Strategies* 5(2): 477-498.

[2] Suttibak, S. and Nitivattananon, V. 2005. Enhancing solid waste management capacity of local government authorities: review of current status in Thailand. In *Proceeding of International Conference on Integrated Solid Waste Management in Southeast Asia Cities*. Siem Reap, Cambodia, 5-7 July. Thailand: Southeast Asia Urban Environmental Management Applications (SEA-UEMA) Project, Asian Institute of Technology.

[3] Kaseva, M. E. And Gupta, S. K. 1996. Recycling-an environmentally friendly and income generating activity towards sustainable solid waste management : case study-Dar es Salaam City, Tanzania. *Resources Conservation and Recycling* 17: 299-309.

[4] Muttamara, S.; Visvanathan, C.; and Alwis, K. U. 1994. Solid waste recycling and reuse in Bangkok. *Waste Management & Research* 12: 151-163.

[5] Tucker, P.; Murney, G.; and Lamont, J. 1998. Predicting recycling scheme performance: a process simulation approach. *Journal of Environmental Management* 53: 31-48.

[6] U.S. EPA .1999. Recycling work: state and local solutions to solid waste management problems. EPA530-K-99-003. USA: United States Environmental Protection Agency (U.S.EPA).

[7] MONRE (1997). Thailand policy and perspective plan for enhancement and conservation of national environmental quality 1999-2006. Bangkok: Office of Environmental Policy and Planning (OEPP), Ministry of Natural Resources and Environment (MONRE).

[8] Eik, A.; Steinmo, S.; Solem, H.; Brattebo, H.; and Saugen, B. (2002). Eco-efficiency in recycling systems. Norway: Norwegian University of Science and Technology (NTNU), Industrial Ecology Programme (IndEcol).

[9] Ugwu, O. O. And Haupt, T. C. 2007. Key performance indicators and assessment methods for infrastructure sustainability-a South Africa construction industry perspective. *Building and Environment* 42: 665-680.

[10] DEQP 2003. Recycling Bank. *Nawatthakum Pamphlet* (Thai) 4(14): 21-25.

[11] World Bank (2003). Thailand environment monitor 2003. Bangkok, Thailand: Pollution Control Department, Ministry of Natural Resources and Environment (MONRE), The World Bank, Japan Bank for International Cooperation (JBIC), and United States-Asia Environmental Partnership (US-AEP).

[12] U.S. EPA (1989). Decision-makers guide to solid waste management. Washington, D.C.: Office of solid waste management programs, United States Environmental Protection Agency.

[13] World Bank (1996). Performance Monitoring Indicators: A handbook for task managers. Washington D.C.: Operation Policy Department, World Bank.

[14] OECD (2003). OECD Environmental indicators: development, measurement and use: Organization for Economic Co-Operation and Development.

[15] USAID (1996). Performance monitoring and evaluation: Selecting performance indicators. *USAID Center for Development Information and Evaluation*. Retrieved September 12, 2007 from the World Wide Web: http://pdf.dec.org/pdf_docs/pnaby214.pdf.

[16] Wang, F. S.; Richardson, A. J.; and Roddick, F. A. 1997. Relationships between set-out rate, participation rate and set-out quantity in recycling programs. *Resources, Conservation and Recycling* 20: 1-17.

[17] McMillen, A. and Skumatz, L. A. (2000). Separation, collection, and monitoring systems. In H. F. Lund (Ed.), Recycling handbook (2nd ed.). New York: The McGraw-Hill.

[18] Chang, N.-B. and Wei, Y. L. 1999. Strategic planning of recycling drop-off stations and collection network by multiobjective programming. *Environmental Management* 24(2): 247-263.

[19] Gies, G. 1995. Dropoff recycling as a low cost alternative. *Bio Cycle* 3 (March): 30-33.

[20] Thomas, C. 2001. Public understanding and its effect on recycling performance in Hampshire and Milton Keynes. *Resources and Conservation & Recycling* 32: 259-274.

[21] Folz, D. H. 2004. Service quality and benchmarking the performance of municipal services. *Public Administration Review* 64: (2).
[22] Glenn, J. 1988. Recycling economics: benefit-cost analysis. *BioCycle* 29(9): 44-47.
[23] Arendse, L. and Godfrey, L. (2006). Waste management indicators for national state of environmental reporting. Retrieved January 15, 2007 from the World Wide Web: http://www.csir.co.za/ciwm/Godfrey_Wastecon02.pdf
[24] Mongkolnchaiarunya, J. 2005. Promoting a community-based solid waste management initiative in local government: Yala municipality, Thailand. *Habitat International* 29: 27-40.
[25] Charuvichaipong, C. and Sajor, E. 2006. Promoting waste separation for recycling and local governance in Thailand. *Habitat International* 30: 579-594.