Conclusions and Recommendations

Conclusions and Recommendations

The team presents here conclusions and recommendations in regard to non-HW management, HW management and the common matters. It should be noted, however, that even though the team grouped conclusions and recommendations into three, some of those for non-HW management can be still applicable to HW management, and vice versa. Particularly, the use of cement factories that is recommended for HW management is valid not only for non-HW management but also municipal waste management.

1 Non-HW Management

1.1 Current Situation

As a result of the factory survey covering 215 factories, it was found that non-HW generation is 2.36 million ton/year in total, 1.5 tons per employee, or 0.274 ton per capita in the study area. The characteristics of the current non-HW management understood from the result of the factory survey is that the rate of reused/recycled non-HW to the total is as high as 78% (1.85 million tons) and the rate of off-site treatment/disposal is only 5.3% (0.125 million tons). The high reuse/recycling rate is obvious when compared with the rate in Japan, 42% in 1998. The reasons for this will be two: firstly the definition of industrial waste in Thailand is limited to "waste from factories" whereas in Japan industrial waste includes not only waste from factories but also sludge from public wastewater treatment works, construction debris, earth from a construction site and waste from agriculture, and secondly personnel cost in Thailand is relatively lower than the cost for materials.

Waste reduction by intermediate treatment is hardly be seen (the reduction rate in Japan is 74% in 1998) presumably because of low final disposal fee. The fee charged by BMA is 323-354 bahts/ton including transportation, and 200 bahts/ton only for disposal in Samut Prakarn. In short, factories do not need to reduce waste volume.

There are only three disposal sites with DIW's approval as of April 2002: one in Saraburi owned and operated by Better World Green, another in Chonburi by Eastern Seaboard Environmental Complex, and the other under construction in Sakeao by Professional Waste Technology (1999). All of these are outside of the study area. There are, however, landfills for municipal waste approved by the provinces or municipalities in every province, and they receive non-HW together with municipal waste. These landfills satisfies minimum requirement for non-HW final disposal, although some have problems such as insufficient soil cover.

1.2 Master Plan

The fundamental policies of the team for the formulation of the M/P are as below.

1. The minimization of waste generation at source should be promoted.
2. Generated waste should be reused or recycled as much as possible. The current reuse/recycling system should be improved and the reuse/recycling rate as high as 80% should be maintained even in the future when labor cost will increase.

3. Only after making efforts for waste minimization or waste reuse/recycling, waste finally discharged should be properly treated and disposed of without giving environmental negative impacts. In particular, on-site final disposal should be strictly controlled and shift to off-site final disposal, since on-site disposal tends to lack care for the environment.

With such policies, the team planned the waste flow in the target year 2010 as follows.

	2001		2010	
	Amount (ton/year)	Proportion (%)	Amount (ton/year)	Proportion (%)
Generation	2,364,782	—	2,601,993	—
Reuse/Recycling	1,853,964	78.4	2,067,445	79.5
On-site Final Disposal	335,526	14.1	173,833	6.7
Off-site Treatment/Final Disposal	124,718	5.3	352,091	13.5
On-site Reduction	8,493	0.4	8,624	0.3
On-site Storage	42,081	1.8	0	0

1.3 Recommendations

a. Improvement of Reuse/Recycling System and Maintenance of High Reuse/Recycling Rate

The most important issues of non-HW management are to improve the present reuse/recycling system and to maintain the high reuse/recycling rate. To achieve these, the team recommends DIW to take the following measures in cooperation with relevant governmental bodies such as MOSTE.

1. To investigate the real situation of the reuse/recycling system, understand such problems as the treatment and disposal of rejects from reuse/recycling processes, formulate an improvement plan, and to put the plan into effect.
2. To develop a system to control waste reuse/recycling enterprises including waste buyers (Por Kha Khong Kao), and for this purpose, to strongly promote the registration of waste separation and/or landfill facilities as Code 105 factory and waste reuse/recycling facilities as Code 106 factory.
3. After having the said facilities registered, to regulate their reuse/recycling activities and to develop technical and/or financial support systems for the promotion of appropriate reuse/recycling practices.

b. Construction of Treatment and/or Final Disposal Facilities

The amount of non-HW finally discharged for off-site treatment and/or final disposal after the effort of generation prevention and reuse/recycling is 125,000 tons in 2001. This is only 3.3% of the treatment/final disposal amount of municipal waste, which is 3.8 million ton/year. According to the future projection by the team, it increases 2.8 times in 2010, coming to no more than 352,000 tons.

The team calculated the tipping fee to be charged at a sanitary landfill which can receive the non-HW of 350,000 tons a year for six years. If the cost for land purchase is excluded, the tipping fee of 250 bahts/ton can give the FIRR of 14.3%, which

implies landfill construction is feasible taking account of the interest rate and inflation in Thailand. IEAT is forwarding the construction of an incineration plant for HW in Bangpoo Industrial Estate as of June 2002 and plans to charge 3,300 bahts/ton including 2,800 bahts/ton for incineration treatment and 500 bahts/ton for transportation. The team also has had information of some incineration plants whose treatment fee is also more than 2,000 bahts/ton. Therefore, intermediate treatment technology, especially waste incineration, is not financially viable at present.

Meanwhile, the importance to properly treat and dispose of waste without affecting the environment cannot be emphasized enough. Accordingly, the team recommends DIW to take the following measures in regard to the construction of treatment/disposal facilities.

1. To promote sanitary disposal as far as there are landfills available, since it is clear that intermediate treatment not for reuse/recycling but for volume reduction is hardly required in the present circumstances.
2. To encourage the private sector to construct landfills for non-HW, but at the same time, to continue disposing of waste as far as it is strictly controlled not to contain HW at municipal waste landfills for the time being taking account of the fact that there are only three disposal sites authorized by MOI in the whole country.
3. To strictly control and eliminate illegal treatment/disposal routes including illegal dump sites and non-registered treatment/final disposal facilities.

2 HW Management

2.1 Current Situation

As a result of the factory survey covering 215 factories, it was found that HW generation is 560,000 ton/year in total, 0.35 ton per employee, or 0.065 ton per capita in the study area. The characteristics of the current HW management understood from the result of the factory survey is that the rate of reused/recycled HW to the total is merely 18.2% (101,000 tons) and the rate of on-site treatment/final disposal is as high as 54.3% (303,000 tons). The high on-site treatment/final disposal rate is probably attributed to the facts that there are only a limited number of off-site treatment/final disposal facilities available in and around the study area, competitive pricing does not work, and consequently the fee for off-site treatment/final disposal is high.

To cope with such situation, DIW is increasing the number of authorized waste recycling/treatment/final disposal facilities. Nevertheless, as of August 2002 such facilities for HW are only three (one for Code 101 (intermediate treatment) and two for Code 106 (recycling)) in the study area, and 14 in the whole country including 11 for recycling, 2 for intermediate treatment and 3 for final disposal (some facilities provide more than two services). The 11 recycling facilities include 4 cement plants, 3 solvent recycling factories and 4 other facilities and waste recycled by them is still limited in terms of quantity and variety. Two intermediate treatment facilities include a wastewater treatment facility and a sludge stabilization facility: there is no thermal treatment facility.

Three final disposal facilities are not in the study area but in Rachaburi, Rayong and Sakaeo. The number is so small to serve for the demand in the whole country and it is desired to develop the facilities as close to the major HW generation areas as possible.

In conclusion, there is pressing demand for the treatment/final disposal facilities for HW, but their capacity is small and available only for limited types of waste. However, the development of the facilities for HW in a short-term seems to be significantly difficult as the strong opposition of the local people against construction is anticipated.

2.2 Action Plan

In formulating the Action Plan (A/P), the team adopted a principle of waste management hierarchy as follows aiming at the development of the proper HW management system: (i) to minimize HW generation as much as possible, (ii) to reuse/recycle HW generated as much as possible and (iii) to properly treat/dispose of HW, which could not reused/recycled.

With this principle, the team set targets for the waste flow in 2005 as shown below.

	2001		2005	
	Amount (ton/year)	Proportion (%)	Amount (ton/year)	Proportion (%)
Generation	557,456	—	580,909	—
Reuse/Recycling	101,337	18.2	163,141	28.2
On-site	22,455	4.0	22,838	4.0
Off-site	78,882	14.2	140,303	24.2
On-site Final Disposal	120,063	21.6	48,844	8.3
Off-site Treatment/Final Disposal	208,279	37.3	239,541	41.2
On-site Reduction	123,935	22.2	129,523	22.3
On-site Storage	3,842	0.7	0	0

The team considers that the increase in the annual off-site treatment/final disposal capacity by 30,000 ton of the A/P is certainly possible by the capacity expansion at the Samae Dum Center and the completion of the incineration plant at Bangpoo.

The increase in annual off-site reuse/recycling amount by 61,000 ton will be possible by the measures recommended below.

2.3 Recommendations

a. Promotion of the Use of cement factories

The most critical question that the current HW management system is confronted with is how to enhance the capacity of proper off-site reuse, recycling, treatment and/or final disposal which is severely inadequate at present. Especially, export-oriented industries under pressure from the high requirement of ISO14000 are eager for the urgent development of such facilities.

Under such situation, the use of cement factories as waste reuse/recycling facilities has the following advantages.

1. It promotes waste reuse/recycling by utilizing waste as raw material or fuel, and at the same time it makes up the deficit in final disposal capacity since residue is little.
2. It will not encounter public opposition as fiercely as the construction of new facilities because the existing cement factories are utilized.

HW that the cement factories in Thailand will receive will be waste oil and organic HW (sludge, etc.) among others from the result of the factory survey. Waste flows of these kinds of HW in 2005 was examined, and the amount of the two subject to the recycling at the cement factories was estimated at 56,000 tons/year. The possibility of the cement factories to receive this amount was examined as below.

1. In Japan the cement factories that produce 82 million tons of cement in a year receive 25.58 million tons of waste that is equal to 31% of the production.
2. Waste oil and organic HW share 1.3% and 6.8%, respectively, of waste received at the cement factories.
3. The total production capacity of four kilns of Kaeng Koi factory of Siam Cement, which has been approved by DIW as waste treatment plant, is 5.7 million tons/year. If the proportion given by the experience in Japan stated above is applied, the kilns can receive 22,971 tons/year (5,700,000 x 0.31 x 0.013) of waste oil and 120,156 tons/year (5,700,000 x 0.31 x 0.068) of organic HW. The total is 143,000 tons/year, well exceeding 56,000 tons/year.
4. The team executed a financial analysis by roughly estimating revenue and expenditure at a cement plant. The team assumed that revenue includes the savings from the substitution of virgin raw material and fuel with waste and the treatment fee charged on waste generators, while expenditure includes investment in plant modification for waste utilization, operation and maintenance cost of the modified section of the plant, and purchase of valuable waste such as waste oil. If the average treatment fee is set at 2,000 baths/ton and 3.4 tons out of 5.6 tons of waste is subject to the fee, FIRR is calculated at 21.1%. Therefore it is concluded that investment in plant modification is economically viable.

In this way, with the target to increase the annual off-site reuse/recycling amount by 62,000 tons, it is presumed that the reuse/recycling of 56,000 tons/year at the cement factories is technically and financially viable. Understanding the severe situation of current HW management, the team strongly recommends DIW to promote the use of cement factories.

b. Promotion of Waste Analysis/Blending/Adjusting Industry

Cement factories do not apply waste to production lines without a guarantee of quality and quantity that are satisfactory enough to substitute the raw material and fuel currently used. Waste from one factory may not meet the requirement of the cement industry, but if the qualitative and quantitative characters of waste generated at different factories is well understood and blended together to adjust quality and quantity, waste can be acceptable at cement factories. Waste blending and adjusting facilities and technology is essential to establish a recycling system driven by the cement industry. The team recommends DIW to foster and lead the waste analyze,

blending and adjusting industry in the following way to appropriately utilize cement factories as a treatment/reuse/recycling facility.

1. In order to stimulate the demand of the waste generators for the waste blending industry, DIW should strengthen the requirement to factories for proper IWM. As a result, the needs for the waste generators to supply waste that is currently difficult to recycle and has to be disposed of on-site or off-site will increase.
2. DIW should provide to the cement factories with information about the demand of the waste generators for waste recycling at the cement factories. Information will include information on what kinds of waste can be recycled at cement factories, and how such waste is currently treated and disposed of in Thailand. Also, DIW should promote and support the cement factories to prepare waste reception standards.
3. In order to promote the waste blending industry, DIW should publicize waste blending technologies used in Japan and other countries.
4. DIW should introduce a licensing system that does not only control the waste collection/transportation system, but also officially authorize the ability of the blenders so that their clients will trust them.

Assuming that all the HWs that are planned to be accepted for recycling in the cement factories in 2005 are pre-treated by HW blenders, the team made a preliminary financial appraisal of the HW blending project. Under the preconditions such as the blenders receive waste oil by charging only collection and transportation cost on the generators, and they receive solid waste by charging collection and transportation cost and treatment fee at 5,000 bahts/ton on the generators, the project was concluded financially feasible for the private sector (cf. the answers of HW disposal fee in the factory survey ranged from 700 to 16,700 bahts/ton, and weighed average was 6,940 bahts/ton).

c. Promotion of HW Reuse/Recycling not by Cement factories

There are many waste reuse/recycling methods other than waste application at cement factories, and DIW should also promote them. DIW needs to consider the following in promoting waste reuse/recycling business.

1. Top priority should be given to the improvement of existing facilities and reuse/recycling processes so that HW can be reused, recycled and/or treated.
2. The quality and quantity of waste that is acceptable should be clarified.
3. The necessity to install pollution prevention equipment must be examined and the fulfillment of the discharge standards should be ensured.
4. The profitability of the business is confirmed.

With such understandings, the team examined a method to recycle HW containing heavy metals which cement factories do not receive at non-ferrous smelting furnaces together with electric arc furnace dust. Assuming that the generators of electric arc furnace dust only bear the cost of collection and transportation and other HW treatment fee is set at 1,500 bath/ton in average in addition to collection and transportation cost, FIRR is calculated at 16.8%, which means this recycling method is financially feasible considering the interest rate and inflation in Thailand. The

analysis, however, was made on several assumptions and the team recommends DIW to further carry out the following.

1. Investigation of actual conditions of non-ferrous smelting factories which can serve as waste recycling/treatment facilities (in the whole country, if possible).
2. Selection of the smelting factories with higher possibility as waste recycling/treatment facilities.
3. Investigation of waste that can be accepted at the selected smelting factories (investigation of the source of zinc, i.e. electric furnaces, if zinc smelting factories are selected in Step 2).
4. Formulation of project implementation plan and evaluation of financial viability.

3 Common Matters

3.1 Elimination of Illegal or Inappropriate Treatment/Final Disposal Routes

Although statistic data or previous systematic studies are not available, there are a number of illegal or inappropriate industrial waste treatment/final disposal routes. The following is some of findings of the present study.

1. There is a large scale illegal waste dump near to Bangpoo Industrial Estate, that is the largest industrial estate in Samut Prakarn province, although the province has a municipal waste disposal site which was approved by the province and the municipality and receive non-HW at abound 200 bahts/ton. Similar situations can be found in other provinces or other industrial estates.
2. The factory survey tells that 21.6% of HW is disposed of on-site. Although the team did not investigate the real practices of on-site final disposal, environmental pollution such as groundwater contamination is anticipated since appropriate HW final disposal requires substantial facilities. The team has observed HW simply dumped into a simple hollow in earth without liners.
3. Sulfate electrolyte in waste batteries is illegally discarded somewhere in the course of collection for recycling. Moreover, illegal smelters produce 40% of primary lead by primitive technology without environmental countermeasures such as simple burning in drums.

According to the result of the Public Opinion Survey (POS), illegal dump is pointed out as the most concerned industrial waste problem and the majority (84%) answered that illegal dumps are seriously influencing the environment. From the result of POS, the team concludes that it is necessary to strengthen illegal dump control and to restore public confidence in order for the Thai government to execute the IWM plan.

The presence of the illegal or inappropriate treatment/final disposal routes not only hamper the emergence of appropriate treatment/final disposal routes but also can destroy the existing appropriate ones. In fact, as for waste battery recycling, the activities of illegal smelters have raised the price of waste batteries, which hamper the business of environmentally sound smelters.

At present in Japan, housing development is progressing in urban land plots from which old factories were moved out to the suburb. However, the biggest obstacle that it encounters is soil pollution caused by HW discharged to the factory premises in the past. Most IIW found was disposed of before the 1970s when enough number of proper off-site treatment/final disposal facilities did not exist. It is significantly costly to deal with soil pollution and the financial problem often hinders the development plan. DIW should therefore urgently regulate on-site final disposal of HW.

Japan also leaned from its experience that the clean up of illegal dumps cost further more than initial proper waste treatment. The most effective way to stop illegal dumps is to strictly lay the responsibility for IWM on waste generators. DIW should stringently require factories to manage their waste in a proper manner, and let them understand that disposing of waste at a landfill as far as Sakaeo, 300 km away, is still financially advantageous than dumping waste now and cleaning up in future.

Therefore, the elimination of illegal or inappropriate industrial waste treatment/final disposal routes is a prerequisite to establish a proper IWM system and requires urgent actions. Since the supervision, control and exposure of illegal or inappropriate treatment/final disposal routes are the responsibility of several governmental bodies, DIW needs to cooperate them for the elimination. In order to prevent illegal dumps from taking place, DIW should take the following measures by working together with other governmental organizations.

1. To more strictly impose responsibility for illegal dumps (including the implementation of land cleanup and payment for the cost) on waste generator.
2. To clearly define the jurisdiction of relevant governmental organizations in regard to illegal dumps, so that they can cooperate effectively.
3. To make penal regulations against illegal dumps more severe and raise fines. To develop a law enforcement system to immediately expose offenders.
4. To urgently put the HW manifest system, this is proposed by PCD, into force and to thoroughly implement it. In future, to introduce a digital manifest system and to also cover non-HW.
5. To introduce a licensing system of waste collectors/transporters and waste buyers so that all the actors involved in the industrial waste management business can be under the administrative control.
6. To show the real condition of illegal dumps to the public and to conduct public relations activities to call for cooperation in the prevention of illegal dumps, so that the governmental bodies, waste generators and the citizens work together.
7. To strengthen the illegal dumps prevention system (patrols, joint works with the Police, cooperation with local population, etc.).
8. To ensure the capacity of industrial waste treatment and final disposal facilities which are technically appropriate and financially reasonable.

3.2 Thorough Waste Management at Source

Industrial waste management should start with the waste reduction at source. The team recommends DIW to take the following measures in order to enforce thorough waste management at factories based on waste reduction.

1. To direct factories to have a clear mechanism to place responsibility of waste management and a technical control system.
2. To establish training programs and a certificate system and legally enforce the appointment of the technical manager of IWM at every factory.
3. To strictly impose punishment upon inappropriate on-site waste treatment or final disposal through inspection or other occasions.
4. To further strengthen governmental technical and financial supports to promote waste minimization and reuse/recycling.
5. To stop the mixed discharge of non-HW and HW, and enforce separate discharge.

The basic idea of waste reduction at source will follow the four steps as below.

Step 1: Correct understanding of the real condition of waste generation

Step 2: Minimization of waste generation within factories

Step 3: Waste reuse/recycling within factories

Step 4: Waste minimization, waste reuse/recycling, and consequently waste reduction within a group of factories such as an industrial estate

MOI has been promoting Steps 1, 2 and 3 in cooperation with international aid agencies, but the execution of Step 4 is still limited. The team recommends DIW to learn from the example of Kokubo Industrial Park introduced in the Main Report and to promote waste minimization, reuse/recycling and waste reduction in an industry buildup area.

3.3 Use of WUDC

DIW and the team established Waste Utilization Data Center (WUDC) in the pilot project of the present study. WUDC is, however, not fully utilized. The adequate use of WUDC needs to solve such questions as below.

- How to disseminate WUDC
- How to materialize waste exchange

As of the July 2002, WUDC has a registration of 414 factories as a database user. This number is only 1% of the factories registered in the study area in total. WUDC should have further more users to be really useful. DIW will require to diffuse the existence of WUDC and to urge factories to be registered in cooperation with other relevant organizations. The establishment of new industrial codes, 105 for waste separation and final disposal facilities and 106 for waste reuse and recycling facilities, is a good opportunity to involve new users. Furthermore, it is recommended not to limit the database users with full access to factories alone but to involve sectors other than industry considering such facts as waste from food processing can be fed to livestock, and casting sand waste can be used as alternative raw material of construction materials. When such user expansion is difficult for DIW, it will be another way to make WUDC linked with the Material Exchange Center of TEI and other new databases to be emerged in future.

The experience of Pilot Project 2 tells that waste exchange between factories is not as simple as it would be expected. The enhancement of data volume through user expansion as stated above is one solution, and the other will be to make a breakthrough in the current conventional waste reuse/recycling system. As the factory survey revealed, the study area already has an extended waste reuse/recycling system and waste that factories want to supply through WUDC is waste difficult to be reused/recycled in the current system. It is needed to transform such waste into material that can be used by factories with new knowledge and technology in an economically viable way.

Most waste exchange programs in Japan have been organized by the government sector and some to them have a technical committee, which gives advice on the method of waste reuse/recycling. Such committees led by the government, however, tend not to pay enough attention to the economics, and take part in waste exchange only at the commencement without commitment. The team considers that the governmental side may make the basic advice and comments, but specific technical support required for individual cases should be made by the private enterprises which run their business with their expertise.

In Pilot Project 3, the DIW and the team tried to increase the number of WUDC users using one of the provincial industrial offices, and it was successful.

From such understanding, the team recommends DIW to take the following measures, with involving the provincial industrial offices, for the promotion of WUDC.

1. To strongly promote the registration of waste selection and landfill facilities as Code 105 and waste reuse and recycling facilities as Code 106.
2. To strongly promote the database user registration of those factories with Codes 105 and 106.
3. To hold seminars and/or workshops for the factories with Codes 105 and 106 to let them know waste exchange examples that could be realized in Thailand, including waste reuse/recycling at cement factories.

3.4 Unification of Industrial Waste Administration and Introduction of Manifest System

Waste management administration needs to involve many governmental organizations such as Ministry of Industry, Ministry of Public Sanitation, Ministry of Science, Technology and Environment, and local administration offices. However, there is no legislation or policy that demarcates and assigns responsibilities related to waste management to each organization in a consolidated manner. In future, the team proposes that MOI, MOPS, MOSTE and other administration organizations should work together to enact what is to be called Waste Management Act which covers not only industrial waste but also municipal waste, hospital waste and others.

Under the unified framework set by the act, registration with authorities and the acquisition of a license should be obligatory for all the industrial waste business enterprises including waste collection and transportation companies, waste buyers, waste reuse/recycling companies, intermediate treatment companies and final disposal companies to run their business. The license should be issued for each type of services provided and for each type of waste dealt with (or at least for non-HW or HW).

The process to build such an administration system with necessary legislation, however, requires substantial time and careful coordination among related organizations. Therefore the team recommends DIW to establish its unique license system described below as a tentative measure. Since the Factory Act can not be applied to collection and transport business, it is nothing but an expedient. DIW should urgently develop legislation and establish its authority over waste collection and transport companies.

1. Any company which is to collect and/or transport waste from a factory must be registered at DIW and acquire a license.
2. The transport permit is no longer necessary for a factory to discharge its waste outside. Instead, the factory must entrust waste collection and transport work to those registered companies. The factory should make a waste discharge record every time, and the record should be kept at the factory and ready to submit at the request of DIW.
3. The licensed collection/transport company should make a reception record when it receives waste from the factory and keeps the record ready to submit at the request of DIW.

The system above is proposed to be developed in the short term for the whole industrial waste management system either no-HW management or HW management.

Moreover, in order to trace the movement of HW and to make sure that HW undergoes proper disposal, the development of a manifest system is necessary in the middle and long term. On the legislation of HW manifest system of PCD/MOSTE, DIW should bear the responsibility to oversee factories that generate HW, cooperate with PCD for the management of the manifest system, and control HW management by applying the licensing system and the manifest system.

3.5 Database Update

DIW has Information Technology Center that keeps a database of factory registration and other data concerning factories. The team found, however, the management and data update of the database is not adequate. The establishment of the database is not enough and the database needs to continuously develop. The team recommends DIW to take the following measures for the proper maintenance and expansion of the database.

- To make a reporting rule thoroughly understood and executed so that data and information necessary for the database update can gather from bureaus within DIW, DIW regional offices, IEAT, and other relevant offices.
- To develop procedures to share the data in the databases such as waste classification by code numbers.
- To appoint the necessary number of personnel who control and update the databases.

The data communication between regional offices and the IT center has critical problems. The DIW factory database has data of 120,000 factories over the country. Inspection to those factories, comparison of the real condition to the registered data, data update, and registration of newly established factories are carried out by 600

DIW inspectors at 74 regional offices. Data to be entered to the database and data in the database to be renewed are sent from the inspectors to DIW headquarters in a paper form and the reports are simply piled up in the IT center. This should be urgently improved.

The improvement of data transmission between the provincial industrial offices and the IT Center was attempted in Pilot Project 3 (PP3) at the Nonthaburi office from May to June 2002. From the experience of PP3, the team recommends DIW to carry out the following.

1. It is necessary to unify the structure of the databases of the IT center and all the provincial industrial offices. Therefore, DIW should investigate the database structure of the provincial industrial offices, clarify the difference between that of the IT center and that of the provincial industrial offices, and develop a new universal database structure that can be most easily applied to all the databases.
2. DIW should apply the universal database structure to the IT center and all the provincial industrial offices. It should then followed by intensive trainings for the staff that operate the database and the preparation of manuals.
3. DIW may need to adjust the interface program that was developed in PP3 to the universal database structure, and install the program to the provincial industrial offices one by one. The data transfer can be then proceeded.

3.6 Accurate Understanding of IWM

The team surveyed 215 factories by interviews to understand the real situation of IWM from generation to final disposal. Replies from 206 factories out of 215 were valid and used for analysis. However, 206 factories are merely 0.62% of the total number of registered factories, i.e. 33092. It should be therefore well recognized that the picture of IWM revealed in the present study is based on the survey of only 0.62% of factories.

The improvement of IWM should start with the accurate understanding of real IWM. The team recommend DIW to take the following measures in order to raise the reliability of what the team figured out.

1. To regularly carry out the factory surveys as the team did in the present study (every five years in Japan).
2. To issue the ministerial notification which obligates factories to disclose the information of their waste management at the request of the authority in order to facilitate the factory surveys.
3. To check and analyze the newly obtained data and the existing data of 206 factories, and to renew the estimated amount of present and future waste generation and waste flows that the team elaborated.

Using the waste generation rate per employee that was obtained through the present study and the number of employees available from the DIW's database, the team estimated the amount of waste in the whole country as below.

	Number of Factories	Number of Employees	Non-HW Generation Amount	HW Generation Amount (tons/year)

			(tons/year)	
Whole Country	121,231	2,978,165	5,409,832	854,603
Study Area	33,092(27.3%)	1,584,782(53.3%)	2,364,782(43.7%)	557,456(65.2%)

Note: The figures in the parenthesis are the proportion to the whole country.

Similar estimation is possible by 33 industrial sectors and/or by 26 waste categories. The execution of the regular factory survey as in the present study will give a more reliable waste generation rate per employee, which in turn gives more reliable indicators necessary for the formulation of IWM plans.

3.7 Formulation of IWM Plans for Industrial Sectors

Following the S/W, the team did not investigate the IWM of particular industrial sectors. The plans developed in the present study are, therefore, not specific but comprehensive. It is, however, necessary to formulate IWM improvement plans by industrial sectors in order to put the M/P or A/P into effect. The formulation of IWM improvement plans for specific industrial sectors requires the detailed investigation of waste generated from that sector and experts with abundant knowledge about appropriate waste management (generation reduction, reuse/recycling, intermediate treatment and final disposal) gained from experiences.

The team studied IWM of the paint industry and proposed the improvement plan in Chapter 12 of the main report in order to demonstrate the formulation of an IWM improvement plan for a specific industry. Learning the method applied by the team, the DIW should work out the IWM improvement plans for particular industrial sectors with higher priority.

Chapter 1

Introduction

1 Introduction

1.1 Background

Due to the excessive concentration of socio-economic activities into the Bangkok metropolitan area and its neighboring provinces, waste issues have become a growing concern.

Solid waste has two categories: municipal waste (MW) and industrial waste (IW). Bangkok Metropolitan Administration (BMA) and provincial governments deal with the former to a certain extent, although not fully satisfactorily because of the difficulties of finding a future waste disposal site. The management system for the latter, which is under the control of Department of Industrial Works (DIW) of Ministry of Industry (MOI), is, however, still immature in spite of its efforts.

IW is further divided into two: non-hazardous waste (non-HW) and hazardous waste (HW). Enough attention has not been paid to non-HW and how and how much it is actually generated, discharged, collected, transported, treated and disposed of is not well known. Without such information, DIW does not have an effective control measure over waste sources, i.e. industries.

On the other hand, a number of studies on HW have been carried out. "Preparation of register on hazardous waste generation and GIS application for the province Samutprakarn" is coming to its final stage with an assistance of the German government, and the master plan of HW management is being prepared by DIW. The progress of actual waste management projects is, however, very little because of a lack of concrete action plans and strong oppositions of local residents against the projects.

Given these conditions, the Government of Thailand requested to the Government of Japan a study on a master plan (M/P) of industrial waste management (IWM) in the Bangkok Metropolitan Area and its vicinity to be made. In response, the Japan International Cooperation Agency (JICA), Japan's technical assistance implementing agency, discussed the details of the study with the Thai side and the both parties signed a Scope of Work (S/W) to implement the study.

After the competitive tender, JICA appointed a joint venture of Kokusai Kogyo Co., Ltd. and Ex Corporation as the consultant of the study.

1.2 Scope of the Study

1.2.1 Objectives of the Study

The objectives of the study were as below as defined in the S/W.

1) To formulate a master plan (M/P) for the proper management of non-hazardous waste (non-HW) in the Bangkok Metropolitan Area and its vicinity with the target year 2010 as well as an action plan for immediate improvement, taking integrated environmental protection and waste minimization/recycling into consideration.

2) To set up proper standard and regulations for non-hazardous waste management (non-HWM).

3) To formulate an action plan (A/P) on hazardous waste management (HWM) concentrating in the area of waste reuse/recycling, industrial cluster and zero emission concepts.

1.2.2 Study Wastes

The study covered industrial waste (IW) that generates at factories regulated by the Factory Act, B.E. 2535 (1992). The industrial waste has two categories: HW and non-HW. The former one is stipulated in the MOI Notification No.6, B.E. 2540 (1997) and the latter in the MOI Notification No.1, B.E. 2541 (1998).

1.2.3 Study Area

The study covered the Bangkok Metropolitan Area (or simply referred as Bangkok in the report which corresponds to the area administered by the Bangkok Metropolitan Authority (BMA)), Samut Prakarn, Nonthaburi, Pathum Thani and Samut Sakhon Provinces (See Figure 1-1).

1.3 Policies of the Study

The team set up four core policies for working on industrial waste management plans (IWMP, either M/P or A/P) in this study.

The IWMP must be:

1. **practical;**
2. **sustainable;**
3. **accepted by the society;**
4. **formulated by the Thai initiative.**

1. Practicability

Any plans will be in vain unless they are implemented. The present situation of IWM in the study area is seriously paralyzed and further economic growth largely depends on the establishment of a proper IWMP. The team attempts to formulate a practical IWM M/P and A/P not replicating the systems running in other countries but reflecting the real conditions in Thailand. It understands that the pilot projects (P/Ps) are the effective tool to make the A/P practical.

2. Sustainability

Whenever goods are produced, waste generates. All the actions required in IWM – minimizing waste generation at source, reusing and recycling waste generated, and finally disposing of waste with due attention – must be continued over decades. The team attempts to formulate a IWM M/P and A/P which aim at the establishment of sustainable IWM not passing environmental burden on to the next generation.

3. Social acceptance

Productive activities, which are always accompanied by waste, are not only for profit making but also for providing wealth and convenience for the society. Therefore problems of IWM should not be left with only industries but must be tackled by the society. In order to involve the society, plans for IWM requires social acceptance.

4. Thai initiative

The Thai side should take the initiative in carrying out the study, so that it can smoothly bring the output of the study, i.e. M/P and A/P, into effect and apply the experience in other occasions. Thai initiative is particularly expected in executing the P/Ps since they should provide lessons useful for future actions to be taken by the Thai side.

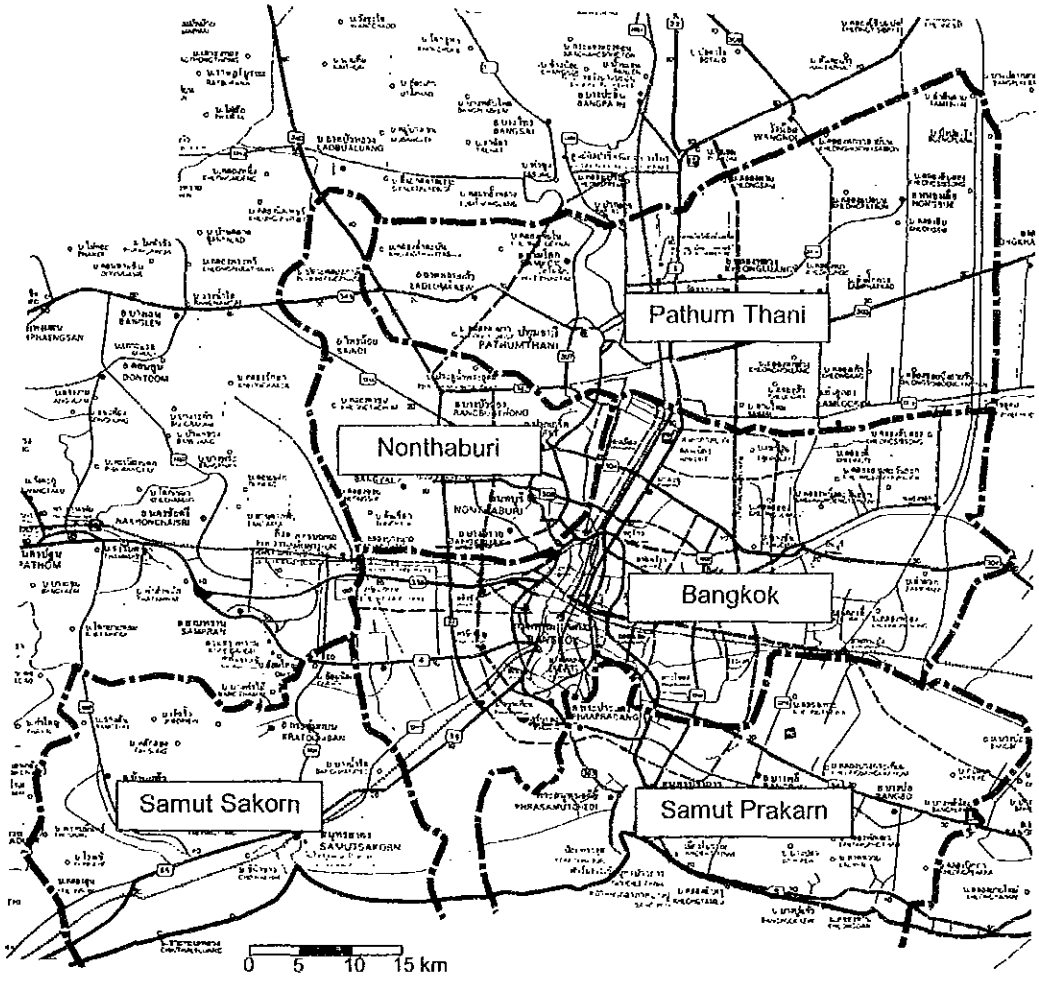
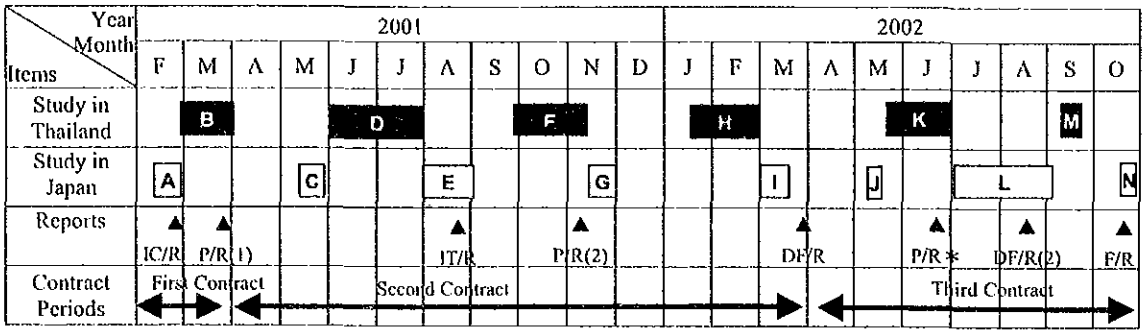


Figure 1-1: Study Area

1.4 Work Schedule

The work schedule is illustrated below.



Note: IC/R: Inception Report, P/R: Progress Report, IT/R: Interim Report, DF/R: Draft Final Report: F/R: Final Report.
P/R* refers to the progress report of waste blenders in Japan.

Below is the outline of the work procedure. It is shown also in Figure 1-2.

A. Preparatory work

- A1 Collection and Analysis of Information
- A2 Preliminary Examination of P/Ps
- A3 Examination of Sampling Method for Factory Survey
- A4 Preparation of IC/R

B. First Study Work in Thailand

- B1 Presentation of IC/R
- B2 Evaluation of Current IWM
- B3 Conceptual Planning for P/Ps
- B4 Planning for Factory Survey
- B5 Planning for Database Development
- B6 Planning for Public Opinion Survey
- B7 Submission of P/R (1)

C. First Study Work in Japan

- C1 Review of First Study Work in Thailand

D. Second Study Work in Thailand

- D1 Confirmation of Study Plan
- D2 First Seminar
- D3 Field Survey on IWM by Industries
- D4 Study on MW Management
- D5 Study on Evaluation Criteria for Locating IW Treatment/Disposal Facilities
- D6 Public Opinion Survey
- D7 Planning for P/Ps
- D8 Database Development (1)
- D9 Planning for Workshops

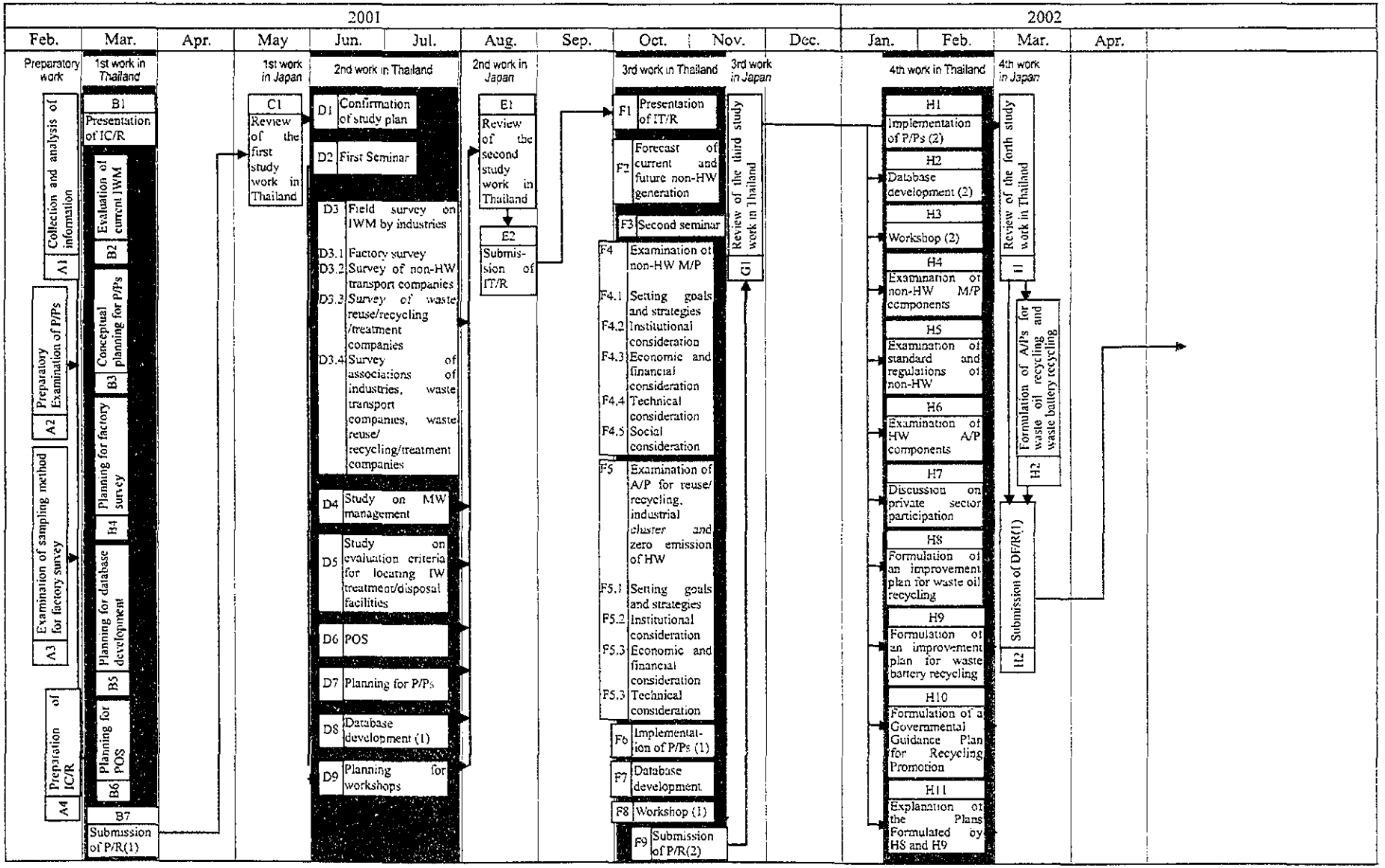


Figure 1-2: Work Schedule (1)

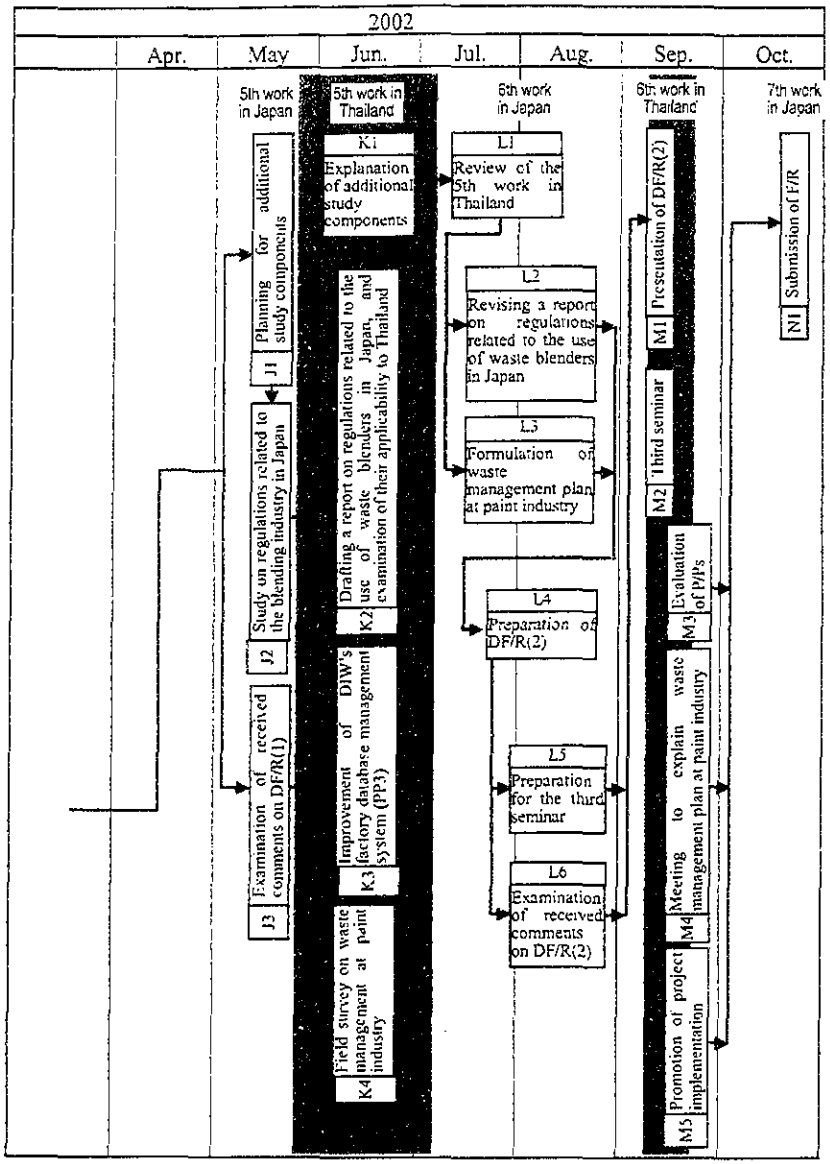


Figure 1-3: Work Schedule (2)

E. Second Study Work in Japan

- E1 Review of Second Study Work in Thailand
- E2 Submission of IT/R

F. Third Study Work in Thailand

- F1 Presentation of IT/R
- F2 Forecast of Current and Future non-HW Generation
- F3 Second Seminar
- F4 Examination of non-HW M/P
- F5 Examination of A/P for Reuse/Recycling, Industrial Cluster and Zero Emission of HW
- F6 Implementation of P/Ps (1)
- F7 Database Development (2)
- F8 Workshop (1)
- F9 Submission of P/R(2)

G. Third Study Work in Japan

- G1 Review of Third Study Work in Thailand

H. Forth Study Work in Thailand

- H1 Implementation of P/Ps (2)
- H2 Database Development (3)
- H3 Workshop (2)
- H4 Examination of Alternatives of non-HW M/P
- H5 Examination of Standard and Regulations of non-HW
- H6 Examination of Alternatives of HW A/P
- H7 Discussion on Private Sector Participation
- H8 Formulation of an Improvement Plan for Waste Oil Recycling
- H9 Formulation of an Improvement Plan for Waste Battery Recycling
- H10 Formulation of a Governmental Guidance Plan for Recycling
- H11 Explanation of the Plans Formulated by H8 and H9 to the Relevant Industries and the Governmental Bodies

I. Forth Study Work in Japan

- I1 Review of Forth Study Work in Thailand
- I2 Examination of A/Ps for Waste Oil Recycling and Waste Battery Recycling.
- I3 Submission of DF/R(1)

J. Fifth Study Work in Japan

- J1 Planning for Additional Study Components
- J2 Study on Regulations Related to the Waste Blenders in Japan
- J3 Examination of Received Comments on DF/R(1)

K. Fifth Study Work in Thailand

- K1 Explanation of Additional Study Components

K2 Drafting a Report on Regulations Related to the Use of Waste Blenders in Japan, and Examination of Their applicability to Thailand

K3 Improvement of DIW's Factory Database Management System (Pilot Project 3)

K4 Field Survey on Waste Management at Paint Industry

L. Sixth Study Work in Japan

L1 Review of the 5th Study Work in Thailand

L2 Revising the Report on Regulations Related to the Use of Waste Blenders in Japan

L3 Formulation of Waste Management Plan at Paint Industry

L4 Preparation of DF/R(2)

L5 Preparation for the Third Seminar

L6 Examination of Received Comments on DF/R(2)

M. Sixth Study Work in Thailand

M1 Presentation of DF/R(2)

M2 Third Seminar

M3 Evaluation of P/Ps

M4 Meeting to Explain Waste Management Plan at Paint Industry

M5 Promotion of Project Implementation (as originally planned)

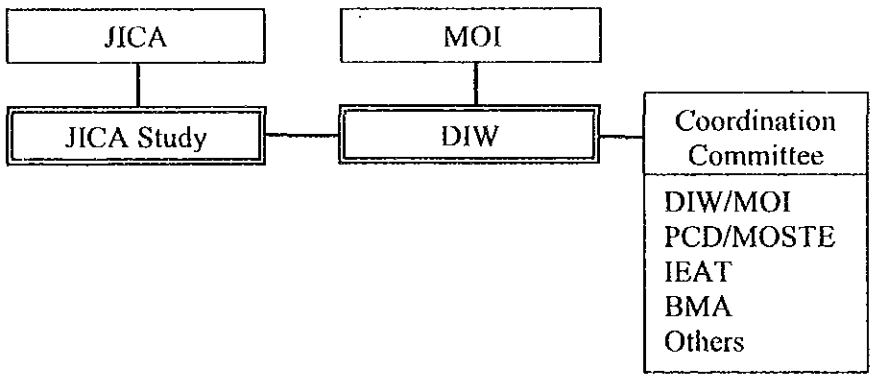
N. Sixth Study Work in Japan

N1 Submission of F/R

1.5 Study Organization and Persons Involved

It was agreed in the S/W that DIW acts as a counterpart agency to the Japanese study team and also as a coordinating body in relation with other relevant organizations for the smooth implementation of the study.

The organizational structure of the study was as shown below.



a. Study Team Members

The JICA study team consisted of the following members.

Table 1-1: Team Members

Field in Charge	Name	Nationality
Team leader / Industrial waste management planning	Susumu Shimura	Japanese
Institution building	Anek Hirunraks / Sakchai Suriyajantratong	Thai
Industrial waste management	Tamotsu Suzuki	Japanese
Waste recycling and minimization	Shoji Nakamura	Japanese
Public sector participation	Takeshi Kojima	Japanese
Industrial waste treatment facility planning / site evaluation	Ichiro Kono	Japanese
Economic and financial analysis	Satoshi Sugimoto	Japanese
Data management	Kunito Ishibashi	Paraguayan
Social and environmental consideration	Keiko Kani	Japanese
Pilot project (tannery industry)	Tomizo Ogawa	Japanese
Pilot project	Noriko Otsuki	Japanese
Governmental guidance for recycling promotion	Zensuke Inoue	Japanese
Waste oil recycling	Eiichi Yasuoka	Japanese
Waste battery recycling	Kenji Kunogi	Japanese
Hazardous waste survey	Takeshi Higo	Japanese
Paint industry waste survey	Toshihei Masuda	Japanese
Waste blender/Administrative coordinator 2	Kaoru Tsuda	Japanese
Administrative coordinator 1	Precha Chuntakorn	Thai

b. Counterpart Members

The following DIW officers worked with the JICA team as counterpart.

Ms. Kanya Sinsakul/ Mr. Virah Mavichak	Director General
Mr. Veerachat Bunnag/ Mr. Kosol Jairungsee	Director, Bureau of Industrial Environment Technology
Dr. Jullapong Thaveesri	Head, Waste Management Division, Bureau of Industrial Environment Technology
Mr. Supap Sansook	Scientist 8, Bureau of Industrial Environmental Technology
Mr. Sudsakorn Pudtho	Contract and International Cooperation Advisor
Ms. Kanokpan Supatanasinkasem	Scientist 7, Bureau of Industrial Environmental Technology
Mr. Naratip Lauhatirananda	Scientist 7, Bureau of Industrial Environmental Technology
Ms. Nuchanat Suphansri	Scientist 6, Bureau of Industrial Environmental Technology
Mr. Kajornpong Sirivisoot	Engineer 3, Bureau of Industrial Environmental Technology

1.6 Reports

Nine kinds of reports were submitted to the Government of Thailand as shown in the table below.

Table 1-2: Number of Report Copies Submitted

	Copies to be Submitted to GOT	
Inception Report (IC/R)	English main report	20
	English summary	20
	Thai summary	20
Progress Report (1) (P/R(1))	English main report	20
	English summary	20
	Thai summary	20
Interim Report (IT/R)	English main report	20
	English summary	20
	Thai summary	20
Progress Report (2) (P/R(2))	English main report	20
	English summary	20
	Thai summary	20
Draft Final Report (DF/R) (1)	English main report	30
	English summary	30
	Thai summary	30
Progress Report on Waste Blenders	English	20
	Thai	20
Draft Final Report (DF/R) (2)	English main report	30
	English summary	30
	Thai summary	30
Final Report on Waste Blenders	English	25
	Thai	15
Final Report (F/R)	English main report	50
	English summary	50
	Thai summary	50
	Data Book	20

1.7 Technology Transfer

Technology transfer was attempted as shown below.

Table 1-3: Technology Transfer Opportunities

Occasions	Target Group	Contents
Any time throughout the study	C/P members	Study planning, study methods, P/Ps, POS, Database development, evaluation of study results, identification of key issues, examination of countermeasures, etc.
Weekly meetings	C/P members	Implementation of the study, methods and approaches used/to be used in the study, project evaluation, etc.
Discussion on Reports (IC/R, P/R(1), IT/R,	C/P and Coordination Committee	Findings of the study at each stage, issues to be solved to proceed the study, directions of the following stages of the study, etc.

P/R(2), and DF/R(1)(2)	Members	
Seminars	Factories, governmental bodies and others	Outline of industrial waste management in Japan, study findings on industrial waste management in the study area, explanation of waste exchange, etc.
Workshops	Factories and others	Waste exchange: its concept, operation of waste exchange program, discussion
Explanation meeting to waste oil and waste battery recycling industries	Waste oil recyclers and waste battery recyclers, C/P	The improvement plan for waste oil and waste battery recycling industries was explained and discussed.
Explanation meeting to paint industry	Paint factories, TPMA (Thai Paint Manufacturers Association), C/P	The improvement plan for waste management of paint industry was explained and discussed.
C/P Training	Selected C/P member	IWM in Japan at the administration level and a factory level, IW recycling, Eco-town development, Contaminated soil remediation

Chapter 2

Profile of the Study Area

2 Profile of the Study Area

2.1 Natural Conditions

2.1.1 Location and Territory

The study area consists of Bangkok and surrounding four provinces in the Central region of Thailand. It covers the area of 5,593 square kilometers or 3,495,835 rai. The boundary and area are shown in Table 2-1 and Figure 2-1.

Table 2-1: Area of the Five Provinces in the Study Area

No.	Provinces	Area	
		Square kilometer	Rai
1	Bangkok	1,568.7	980,461
2	Nonthaburi	622.3	388,939
3	Pathum Thani	1,525.9	953,660
4	Samut Prakarn	1,004.1	627,558
5	Samut Sakhon	872.3	545,217
Total		5,593.3	3,495,835

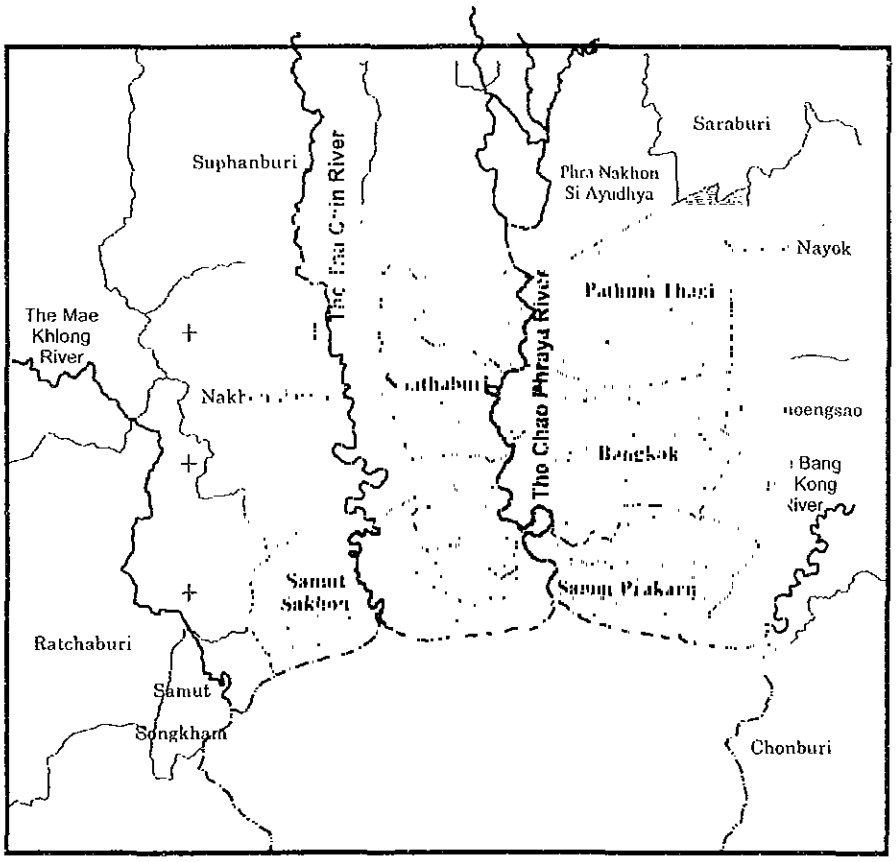


Figure 2-1: Five Provinces in the Study Area

2.1.2 Topography

The topography of the five provinces in the study area is as follows.

a. Bangkok

Bangkok is on a low flat land with no mountains or forests. The Chao Praya River flows in the west part of the city dividing it into two parts. There are many natural and manmade canals. Almost all of the area is a residential or industrial area. Agriculture and rice farms can be seen only in the sub-urban area.

b. Nonthaburi

Nonthaburi is also on a low flat land with 1.80 meters above the mean sea level. The Chao Praya River divides the area of Nonthaburi into the east bank and the west bank. There are also natural canals and dug canals that are connected each other. The areas in some districts that are connected with Bangkok are now changing into residential or industrial areas from an agricultural area.

c. Pathum Thani

Pathum Thani is established on a plain of the Chao Praya River. The river with 30 km length flows through and separates the province into two parts: the eastern and western parts. Pathum Thani is occasionally flooded in a rainy season with the average level of 50 cm.

d. Samut Prakarn

The Chao Praya River also flows through Samut Prakarn to the south. There are several important cannels such as Khlong Somrong, Khlong Sappasamit, etc. The province is generally divided into 3 areas: (1) plain along both sides of the river which is suitable for rice crop and gardening; (2) coastal zone in the south of the province which is good for palm harvesting; and (3) plain area in the north and east where industry is active.

e. Samut Sakhon

Samut Sakhon is about 1–2 m above the average sea level. The Tha Chin River flows from Nakhon Prathom, passes Amphoe Katom Ban and goes into the Gulf of Thailand at Amphoe Muang Samut Sakhon. The province has a good irrigation system with man-made cannel connected with The Tha Chin River. Watergates protect agricultural area from seawater. Total mangrove forest in the province is about 16,000 rai (2,500 ha) running 41 km along the coastline. However, this area has been gradually deforested due to shrimp and brackish fish farming.

2.1.3 Climate

The climate of the central plain of Thailand is categorized as Tropical Savannah (AW). Weather in this region can be divided into three seasons.

- Winter is from about November to February. The northeast wind blows with cold and dry air from the People's Republic of China to this region.
- Rainy season starts in May and ends in November as a result of the southwest wind from the equator, the India Ocean and Australia.
- Summer lasts from February to April.

The meteorological data of the five provinces by the Meteorological Department (B.E. 2541) indicates that an average rainfall was about 1,351.2 mm with an average of 117.8 rainy days. The average rainfall in three provinces including Bangkok, Nonthaburi and Samut Prakarn is relatively similar, being about 1,487.3 mm. The lowest rainfall of 1,078.6 mm is found in the Samut Sakhon province. The details are shown in Table 2-2. The average temperature in the region is 28.2 °C with 76% average relative humidity.

Table 2-2: Climate in B.E. 2541 (1998) of the Five Provinces

Province	Average Temp. (°C)	Average Relative Humidity (%)	Average rainfall (mm)	No. of rainy days (days)
1. Bangkok	28.0	76	1,487.3	127.0
2. Nonthaburi	28.0	76	1,487.3	127.0
3. Pathum Thani	28.0	73	1,215.7	109.8
4. Samut Prakarn	28.0	76	1,487.3	127.0
5. Samut Sakhon	28.9	76	1,078.6	98.0
Average	28.2	76	1,351.2	117.8

Source: The Meteorological Department, 1998.

2.2 Social Conditions

2.2.1 Administration

According to the National Public Administration Act B.E. 2534 (1991), the nation public administration of Thailand has 3 types as follows (Figure 2-2).

- Central Administration
- Provincial Administration
- Local Administration

These are further explained in the following sections.

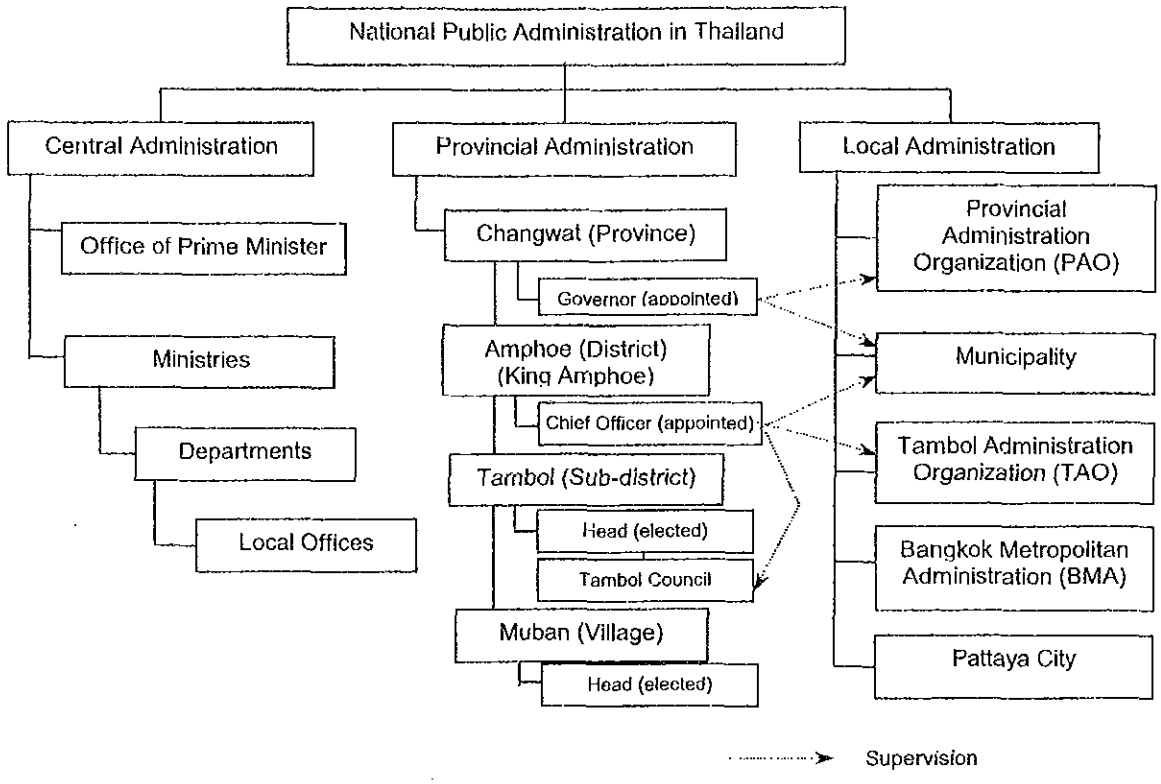


Figure 2-2: Structure of National Public Administration in Thailand

a. Central Administration

The central administration is under the concept of centralization by the government aiming at the application of national policies over the country and smooth implementation for policy accomplishment.

The central administration consists of the Office of Prime Minister and 13 Ministries. The Ministries have departments which act nearly independently and often have local offices.

b. Provincial Administration

The provincial administration, under the basic concept of decentralization, is responsible for taking policies from the central administration to perform and to be representative of the central government agencies. It has a hierarchical structure as in Figure 2-2.

b.1 Province (*Changwat*)

A governor is appointed to each province by the central government. The governor is responsible for duties to accomplish the policies and orders from the government,

ministries and departments in the suitable ways to the local people within the jurisdiction of the province and districts.

b.2 District (*Amphoe*)

Each province is divided into districts (Amphoe). The amphoe is a main government office at district level under provincial administration. The amphoe is headed by an Amphoe Chief Officer (Nai Amphoe) who is appointed by the central government and supervises the district officials.

b.3 Minor District (*King Amphoe*)

The king amphoe is also a government office at district level under provincial administration headed by a king amphoe chief officer. The objectives to establish the king amphoe office is to render services thoroughly to the people in remote areas which is not ready to establish the amphoe office because of, for example, too small population or too small area.

The provincial governor is authorized to set up king amphoes by proposing to the interior minister for cabinet's approval.

b.4 Sub-District (*Tambol*)

The tambol is a unit of provincial administration under the supervision of an amphoe or a king amphoe. As provided by the Local Administrative Act B.E. 2457 (1914) a tambol composes of a cluster of more than 8 villages. It is established by the interior ministry's announcement. The elected leader of a sub-district is called Tambol Headman (*Kamnan*).

The administration body of tambol is the Tambol Council which headed by Tambol Headman as chairperson.

The council is under the supervision of an amphoe chief officer.

b.5 Village (*Muban*)

The muban is the smallest structure of the provincial administration. The muban's head (*Pu Yai Ban*) is elected by the villagers to be in charge of administrative duties in the village. According to the Local Administrative Act B.E. 2547 (1914), a muban is overseen by a muban headman with two assistants. A village may have a Muban Committee as an advisory body of a village. The committee is composed of elected members from all works of life within the village.

c. Local Administration

The local administration is based on the concept of decentralization according to the National Public Administration Act B.E. 2534 (1991) which stipulates that any area is ready for people participation in the local administration. There are 5 types of the local administration in Thailand today:

- Provincial Administration Organization (PAO)
- Municipality
- Tambol Administration Organization (TAO)
- Bangkok Metropolitan Administration (BMA)
- Pattaya City

The first 4 items are relevant to the study, and are explained below.

c.1 Provincial Administration Organization (PAO)

PAO is a local administration at the highest level over the municipality and TAO and is established in every province in Thailand (except Bangkok) whose area of responsibility is as same as that of provinces.

PAO consists of Provincial Administration Council as a legislative body and Chief of PAO sits in the administrative body who is elected by the council members. PAO council members are also elected in a 4-year term. The administration of PAO is under the supervision of the governor.

c.2 Municipality

Municipality is a local administration, established in the prosperous community, commenced in Thailand since 1933. The Municipality Act B.E. 2496 (1953) divides the municipalities into 3 types according to its size.

c.2.1 Tambol Municipality

The Tambol Municipality is the smallest municipality. The interior ministry defines its criteria as follows:

- Actual revenue, excluding state subsidy, amount more than Baht 12,000,000
- Population more than 7,000
- Population density of over 1,500 per 1 sq.km.

c.2.2 Town Municipality

The town municipality is established where the city hall is located or an area which is inhabited more than 10,000 and the population density of over 3,000 per 1 sq.km.

c.2.3 City Municipality

The city municipality is established in large community areas, more than 50,000 population and its density of over 3,000 per 1 sq.km.

c.2.4 Structure of Municipality

Regardless the type, the municipalities comprise the similar structure with two main parts.

- Municipality's Council, as a legislative body, functions for monitoring and examining the administrative body. Its members come from the election.
- Municipal Councilors, as an administrative body, are elected from the members of Municipality's Council.

The administration of municipality by the Municipal Councilors is under the supervision of the amphoe chief officer and the governor.

c.3 Tambol Administration Organization (TAO)

TAO is a local administration at a countryside level and its structure is similar to the municipality such as the legislative and administrative bodies consisting of:

- TAO's council, as a legislative body, comes from village's representatives under TAO's administration.
- TAO's committees are elected by and from TAO's council members with the nomination from the district chief officer to act for the administrative body.

c.4 BMA

BMA is one of two special local administration forms in Thailand, established by the Bangkok Administration Act B.E. 2518 (1975). It is administered by the governor and the council.

c.4.1 BMA's Council

BMA's Council performs the legislative duties and monitors BMA administration. Its members are directly elected from people.

c.4.2 BMA's Governor

BMA's Governor is directly elected by the people, performing the administrative duties.

c.4.3 Districts and District's Council

Bangkok is divided into districts. Each district comprises 2 bodies which are: district office as an administrative body and district council to advise and monitor the district office. The district heads are appointed by the BMA governor.

d. Structure of Public Administration in Bangkok and its Vicinity

d.1 Bangkok

Bangkok consists of 50 districts and 154 sub-districts as in Table 2-3 and Figure 2-3.

Table 2-3: Administrative Unit and Population of Bangkok at the End of 1999

District	Area (km^2)	Number of Population	Density (person/km^2)	Number of Sub-district
Phra Nakhon	5.536	82,921	14,979	12
Pom Prab Sattru Phai	1.931	76,602	39,670	5
Samphanthawong	1.416	37,593	26,549	3
Pathum Wan	8.369	104,066	12,435	4
Bang Rak	5.536	63,038	11,387	5
Yan Nawa	16.662	93,774	5,628	2
Sathorn	9.326	110,491	11,848	3
Bang Kho Laem	10.921	120,388	11,024	3
Dusit	10.665	157,331	14,752	5
Bang Sue	11.545	161,393	13,979	1
Phaya Thai	9.595	91,616	9,548	1
Ratchathewi	7.126	106,728	14,977	4
Huai Khwang	15.033	78,593	5,228	3
Phra Khanong	13.986	100,071	7,155	1
Khlong Toei	12.994	142,029	10,930	3

District	Area (km^2)	Number of Population	Density (person/km^2)	Number of Sub-district
Prawet	52.673	118,330	2,247	2
Bang Khen	42.123	168,060	3,990	1
Don Muang	36.948	143,737	3,890	1
Chatuchak	32.908	170,408	5,178	1
Bang Kapi	28.523	142,347	4,991	2
Lat Phrao	21.851	107,372	4,914	2
Bueng Kum	24.311	136,617	5,620	1
Nong Chok	236.261	88,095	373	8
Min Buri	63.645	98,303	1,545	2
Lat Krabang	123.859	112,967	912	6
Thon Buri	8.551	188,610	22,057	5
Khlong San	6.051	113,817	18,810	4
Bangkok Noi	11.944	162,502	13,605	5
Bang Phlat	11.36	123,035	10,831	4
Bangkok Yai	6.18	89,763	14,525	2
Phasi Charoen	17.834	142,174	7,972	7
Bang Khun Thian	120.687	105,616	875	2
Chom Thong	26.265	174,611	6,648	4
Taling Chan	29.479	99,695	3,382	6
Rat Burana	15.782	94,620	5,995	2
Nong Khaem	35.322	109,320	3,095	1
Suan Luang	23.678	111,047	4,690	1
Din Daeng	8.354	166,187	19,893	1
Lak Si	22.841	117,644	5,151	2
Sai Mai	44.470	141,713	3,187	3
Khan Na Yao	25.980	76,535	2,946	1
Sa Phan Sung	28.308	71,629	2,530	1
Wang Thong Lang	19.937	106,563	5,345	1
Khlong Sam Wa	110.686	88,957	804	5
Vatthana	12.565	80,930	6,441	3
Bang Na	18.789	100,201	5,333	1
Thawee Vatthana	50.219	52,099	1,037	2
Bang Khae	44.226	172,026	3,890	4
Thung Kru	30.741	87,609	2,850	2
Bang Bon	34.745	72,726	2,093	1
50 Districts	1,568.737	5,662,499	3,610	154

d.2 Nonthaburi

The provincial administration consists of 6 Amphoes, 52 Tambols and 421 Mubans, while the local administration consists of 1 PAO, 9 Municipalities and 37 TAOs (Table 2-4 and Figure 2-4).

Table 2-4: Administrative Unit and Population of Nonthaburi at the end of 1999

Amphoe	Area (km^2)	Number of			Number of Population	Number of Dwelling	Number of Municipality
		Tambol	Muban	TAO			
Muang Nonthaburi	77.018	10	32	4	377,011	118,152	2
					296,667 1/		
					80,344 2/		
Bang Kruai	57.408	9	41	6	81,642	27,950	2
					59,330 1/		
					22,312 2/		
Bang Bua Thong	116.439	8	66	7	138,968	79,810	1
					33,327 1/		
					105,641 2/		
Sai Noi	186.023	7	60	7	41,682	16,426	1
					1,447 1/		
					40,235 2/		
Pak Kred	89.023	12	51	7	180,583	90,176	1
					146,919 1/		
					33,664 2/		
Bang Yai	96.398	6	65	6	59,143	26,518	2
					11,468 1/		
					47,675 2/		
6 Amphoe	622.309	52	315	37	879,029	359,032	9

Remark : 1/ Number of Population in Municipal Area
2/ Number of Population in Non-municipal Area
Source : Department of Local Administration, 2001

d.3 Pathum Thani

The provincial administration consists of 7 Amphoes, 60 Tambols and 494 Mubans, while the local administration consists of 1 PAO, 13 Municipalities and 52 TAOs (Table 2-5 and Figure 2-5).

Table 2-5: Administrative Unit and Population of Pathum Thani at the end of 1999

Amphoe	Area (km^2)	Number of			Number of Population	Number of Dwelling	Number of Municipality
		Tambol	Muban	TAO			
Muang Pathum Thani	120.151	14	81	13	130,923	55,269	2
					24,980 1/		
					105,943 2/		
Khlong Luang	299.152	7	89	5	112,593	55,041	2
					64,762 1/		
					47,831 2/		
Thanya Buri	112.124	6	22	1	122,554	60,906	3
					115,399 1/		
					7,155 2/		

Nong Sua	413.632	7	69	7	45,548 1,803 [1/] 43,745 [2/]	10,630	1
Lat Lum Kaeo	188.120	7	61	7	42,548 5,618 [1/] 36,930 [2/]	15,762	1
Lam Luk Ka	297.710	8	114	8	135,949 56,427 [1/] 79,522 [2/]	64,552	3
Sam Khok	94.967	11	58	11	43,879 8,351 [1/] 35,528 [2/]	14,468	1
7 Amphoe	1,525.856	60	494	52	633,994	276,628	13

Remark : [1/] Number of Population in Municipal Area
[2/] Number of Population in Non-municipal Area
Source : Department of Local Administration, 2001

d.4 Samut Prakarn

The provincial administration consists of 5 Amphoes, 1 King Amphoe, 50 Tambols and 406 Mubans, while the local administration consists of 1 PAO, 16 Municipalities and 32 TAOs (Table 2-6 and Figure 2-6).

Table 2-6: Administrative Unit and Population of Samut Prakarn at the end of 1999

Amphoe	Area (km^2)	Number of			Number of Population	Number of Dwelling	Number of Municipality
		Tambol	Muban	TAO			
Muang Samut Prakan	190.557	13	93	5	425,941 358,694 [1/] 67,247 [2/]	145,339	6
Bang Bo	245.007	8	74	8	84,379 26,939 [1/] 57,440 [2/]	21,918	3
Bang Phli	243.888	6	92	6	139,546 19,313 [1/] 120,233 [2/]	68,667	2
King Amphoe Bang Sao Thong	130.894	3	38	3	44,615	24,270	0
Phra Pradaeng	73.368	15	67	6	199,615 163,724 [1/] 35,891 [2/]	74,061	3
Phra Samut Jede	120.378	5	42	4	83,292 25,090 [1/] 58,202 [2/]	24,823	2
5 Amphoe	1,004.092	50	406	32	977,388	359,078	16
1 King Amphoe							

Remark : [1] Number of Population in Municipal Area
[2] Number of Population in Non-municipal Area
Source : Department of Local Administration, 2001

d.5 Samut Sakhon

The provincial administration consists of 3 Amphoes, 40 Tambols and 288 Mubans, while the local administration consists of 1 PAO, 7 Municipalities and 31 TAOs (Table 2-7 and Figure 2-7).

Table 2-7: Administrative Unit and Population of Samut Sakhon at the end of 1999

Amphoe	Area (km^2)	Number of			Number of Population	Number of Dwelling	Number of Municipality
		Tambol	Muban	TAO			
Muang Samut Sakhon	492.040	18	115	15	207,410	73,543	2
					63,693 [1]		
					143,717 [2]		
Krathumbaen	135.276	10	76	8	122,472	94,163	2
					51,726 [1]		
					70,746 [2]		
Ban Phaew	245.031	12	97	8	91,856	18,647	3
					43,469 [1]		
					48,387 [2]		
3 Amphoe	872.347	40	288	31	421,738	186,353	7

Remark : [1] Number of Population in Municipal Area
[2] Number of Population in Non-municipal Area
Source : Department of Local Administration, 2001

2.2.2 Population

Population statistics B.E. 2542 (1999) prepared by the Department of Local Administration indicates that Bangkok is the most crowed city where 5,662,499 people live. Population in Nonthaburi, Pathum Thani, Samut Prakarn, and Samut Sakhon is 879,029, 633,994, 977,388 and 421,738 respectively (Table 2-8). The proportion of population in these areas to the whole population is 9.3%, 1.4%, 1.0%, 1.6%, and 0.7% in the order as above, which sum up to 14.0%.

Table 2-8: Population in the Study Area

Area	Population	Proportion (%)
Bangkok	5,662,499	9.3
Nonthaburi	879,029	1.4
Pathum Thani	633,994	1.0
Samut Prakarn	977,388	1.6
Samut Sakhon	421,738	0.7
Area Total	8,574,648	14.0
Whole Country	60,606,947	100.0

Source: 1) Population statistics B.E. 2542 (1999) prepared by the Department of Local Administration
2) National Statistics Office, April 2000.

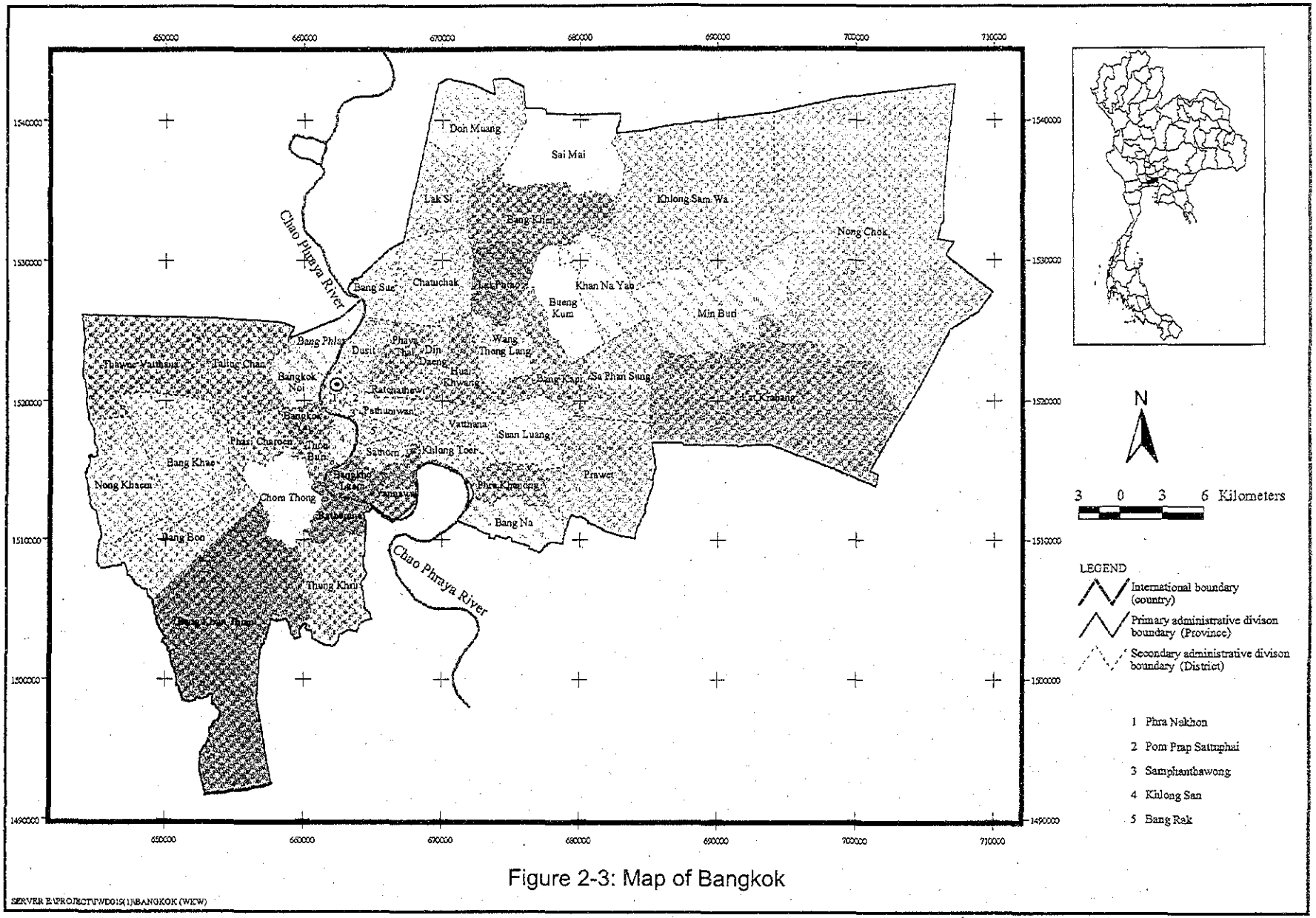


Figure 2-3: Map of Bangkok

SERVER E:\PROJECT\WD015(1)\BANGKOK (WEW)

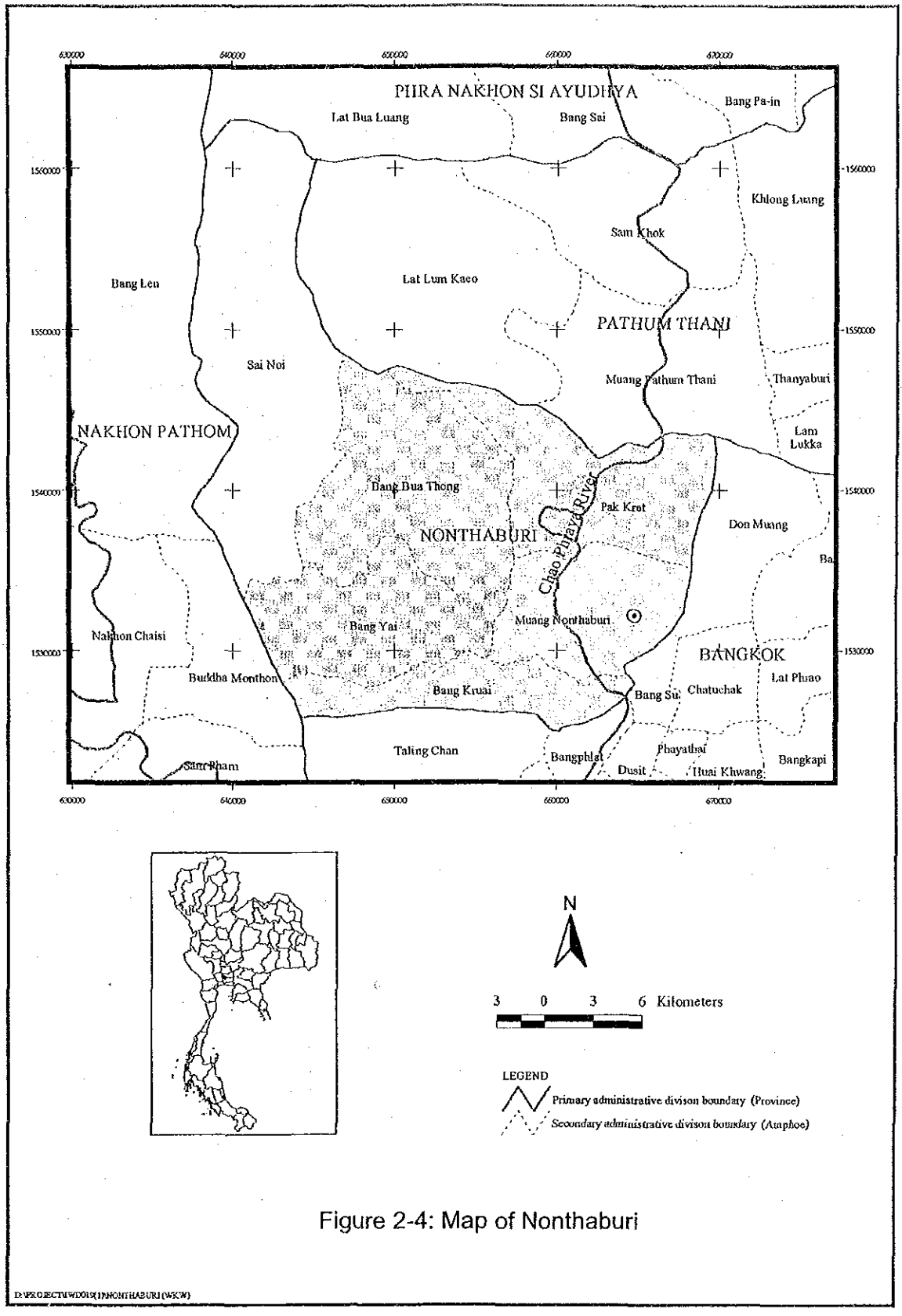


Figure 2-4: Map of Nonthaburi

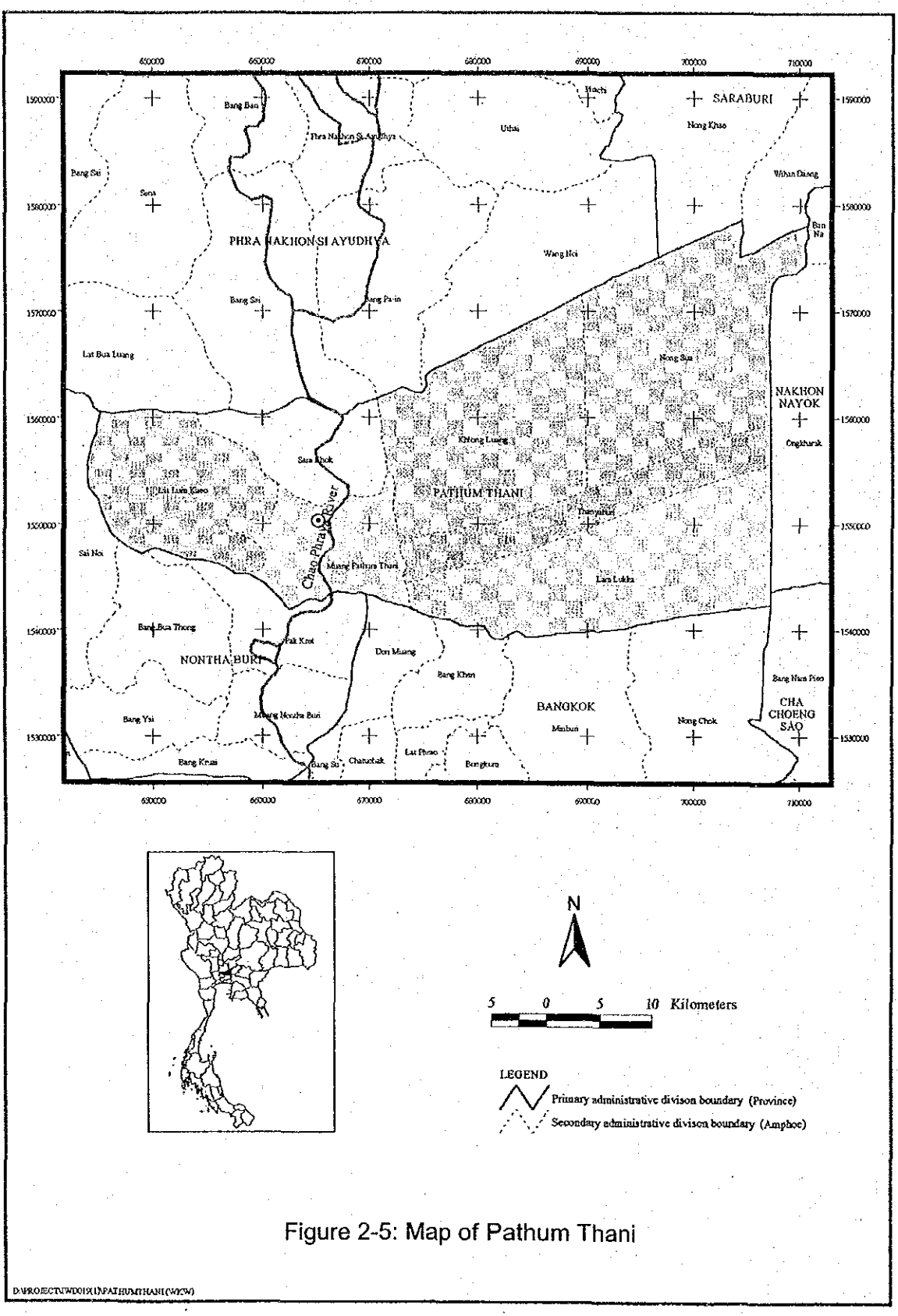


Figure 2-5: Map of Pathum Thani

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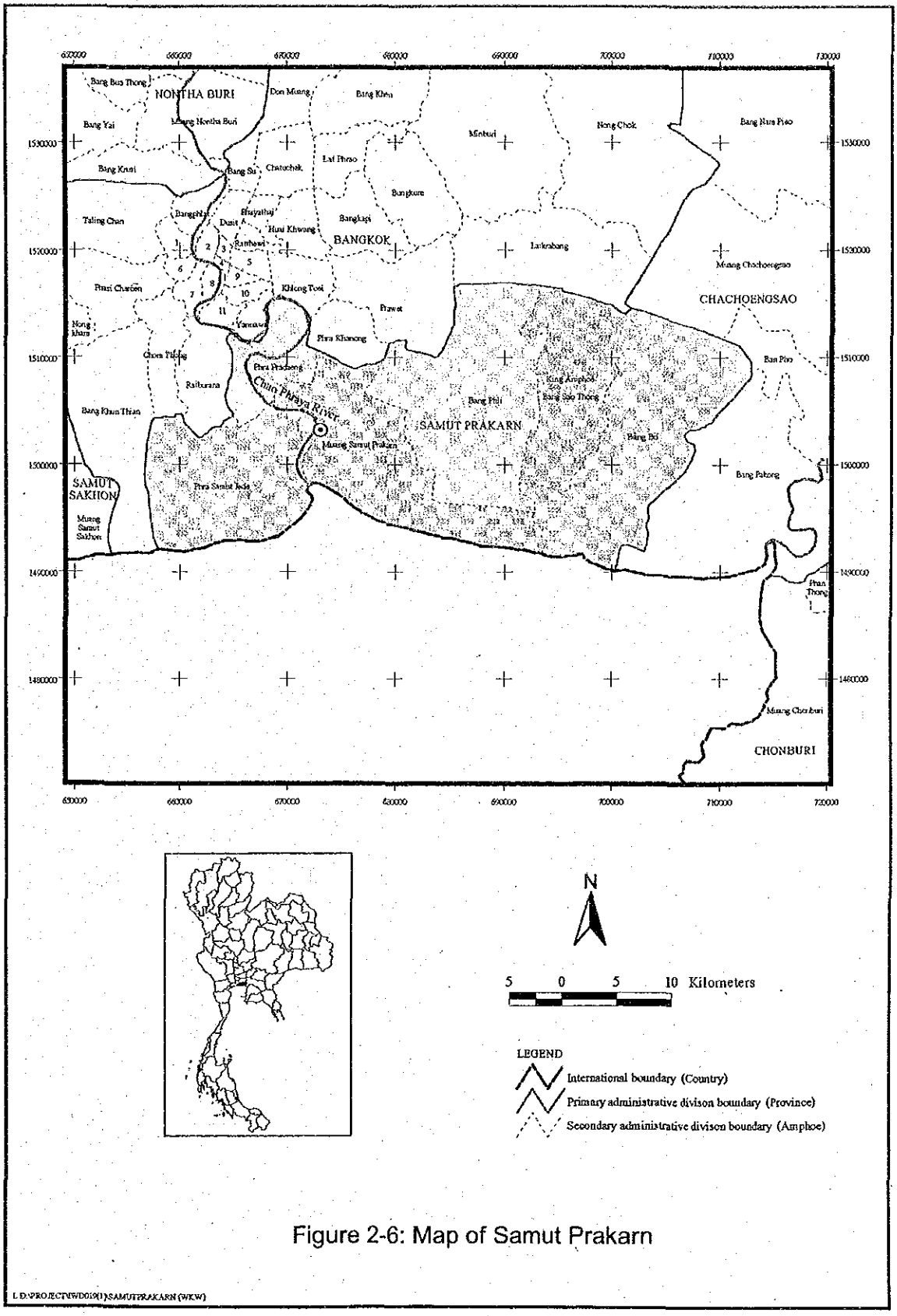

Figure 2-6: Map of Samut Prakarn

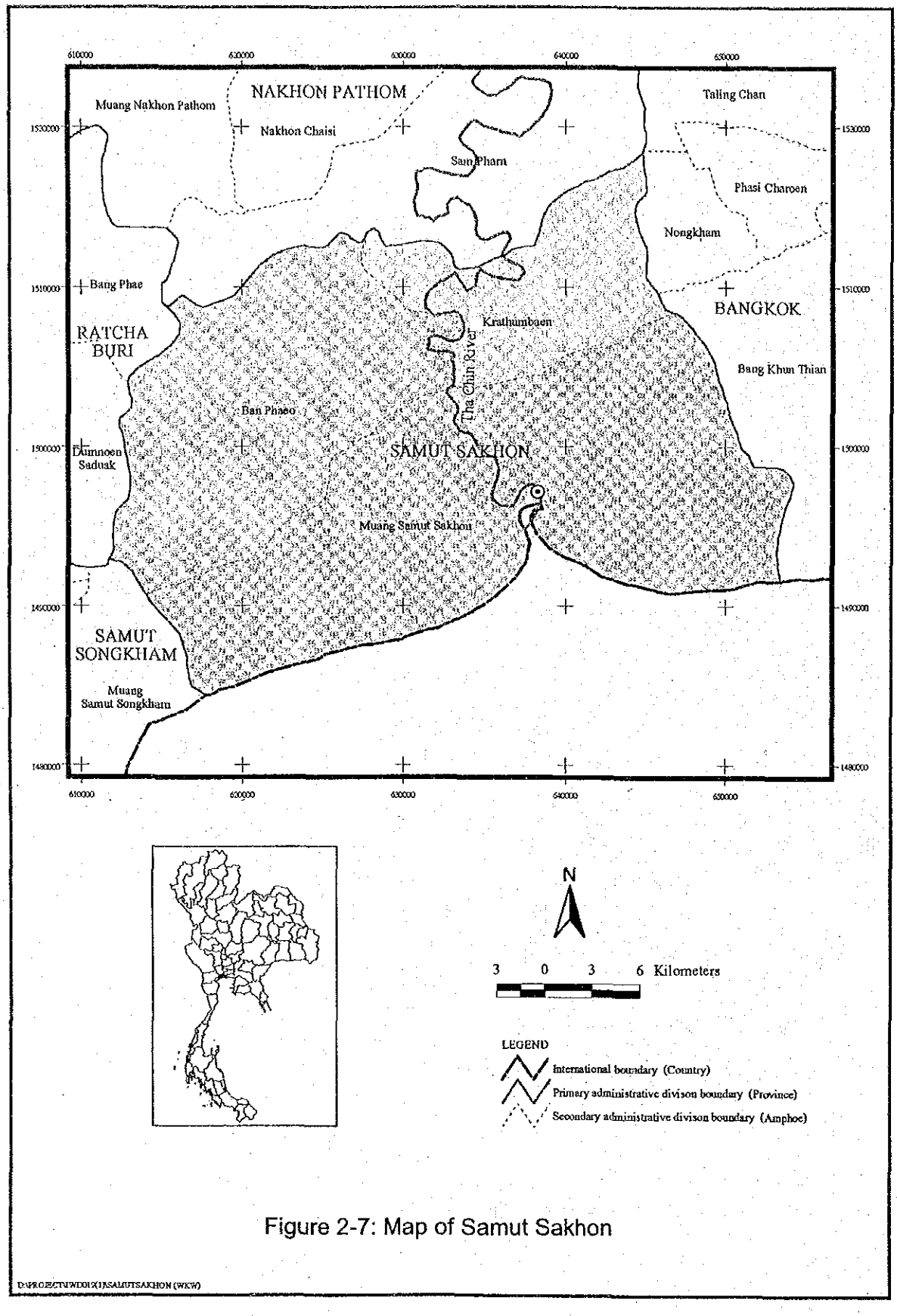

Figure 2-7: Map of Samut Sakhon

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2.2.3 Public Utilities

a. Electricity

Electricity supply in Bangkok is under the responsibility of Metropolitan Electricity Authority, which also supplies electricity to part of Nonthaburi and Samut Prakarn. Most of other area in the study area is supplied electricity by the Provincial Electricity Authority, with an exception of part of Nonthaburi, where the Electric Generation Authority of Thailand (EGAT) is the supplier.

Table 2-9: Electricity Supply in the Study Area

Province	Electricity Supplier	Areas of Responsibility
Bangkok	Metropolitan Electricity Authority (MEA)	Whole area
Nonthaburi	MEA Nonthaburi branch	N.A.
	EGAT	N.A.
Pathum Thani	PEA	Whole area
Samut Prakarn	PEA	4 Amphoes (Amphoe Muang, Amphoe Bnag Plee, Amphoe Bnag Bo, King Amphoe Bang Sao Thong)
	MEA	2 Amphoes (Amphoe Phra Pradaneng, Aphoe Phra Samut Jaedi)
Samut Sakhon	PEA	Whole area

Taking MEA as an example, the electricity bill is set as follows.

i. In case of the consumption not exceeding 150 kWh per month

First 5 kWh (1-5 kWh)	0 Baht
Next 10 kWh (6-15 kWh)	1.3576 Baht per kWh
Next 10 kWh (16-25 kWh)	1.5445 Baht per kWh
Next 10 kWh (26-35 kWh)	1.7968 Baht per kWh
Next 65 kWh (36-100 kWh)	2.1800 Baht per kWh
Next 50 kWh (101-150 kWh)	2.2734 Baht per kWh
Next 250 kWh (151-400 kWh)	2.7781 Baht per kWh
Over 400 kWh (up from 401 kWh)	2.9780 Baht per kWh
Service Charge	8.19 Baht per user
F_t Charge	0.03 Baht per kWh
Value Added Tax (7%)	Sum of the above x 0.07
Monthly bill	**Sum of the above**

ii. In case of the consumption exceeding 150 kWh per month

First 150 kWh (1-150 kWh)	1.8047 Baht per kWh
Next 250 kWh (151-400 kWh)	2.7781 Baht per kWh

Over 400 kWh (up from 401 kWh)	2.9780 Baht per kWh
Service Charge	40.90 Baht per user
F_t Charge	0.03 Baht per kWh
Value Added Tax (7%)	Sum of the above x 0.07
Monthly bill	**Sum of the above**

b. Water Supply

Water in Bangkok is provided by Metropolitan Waterworks Authority, which also provides water some part of Nonthaburi and Samut Prakarn. Its water sources are the Chao Praya River, the Tha Chin River and groundwater.

In the other provinces, the Provincial Waterworks Authority (PWA) is the water supplier, but supply is limited to large communities: small communities and villages outside the PWA service area mostly draw up groundwater by themselves.

Table 2-10: Water Supply in the Study Area

Province	Water Supplier	Capacity (million m^3)	Supply (million m^3)	Area Coverage
Bangkok	Metropolitan Waterworks Authority	1,518.22	880.3	60%
Nonthaburi	Provincial Waterworks Authority (PWA) Nonthaburi	119.167	74.498	50%
Pathum Thani	PWA Pathum Thani and Rangsit	21.07	N.A.	20%
Samut Prakarn	PWA Samut Prakarn	58.46	N.A.	26%
Samut Sakhon	• PWA • Samut Sakhon Municipal Waterworks • Kra Tum Ban Municipal Waterworks	N.A.	N.A.	11%

Taking MWA as an example, the water tariff for industrial use is as follows.

Water Used (cubic meters)	Water Rate (bath per cubic meter) (Minimum 45 baht)
0-10	9.50
11-20	10.70
21-30	10.95
31-40	13.21
41-50	13.54
51-60	13.86
61-80	14.19
81-100	14.51
181-120	14.84
121-160	15.16
161-200	15.49
201 up	15.81

Notes: bulk sale: 13 baht/cu.m

c. Wastewater Management

There are a number of wastewater treatment plants constructed and operated in the study area including Bangkok, Nonthaburi and Pathum Thani. The plants in the

Bangkok mostly employ the activated sludge system. In Samut Prakarn, a plant is under construction in tambol Khlong Dan, being expected to complete by 2004. There is no wastewater management project in Samut Sakhon.

Table 2-11: Wastewater Treatment Plant (WWTP) in the Study Area

Province	Community	Type of WWTP	Capacity (cu.m./day)
Bangkok	Sriphraya	Activated Sludge	30,000
	Yan Nawa	Activated Sludge	200,000
	Huay Kwang	Completely Mixed Activated Sludge with Anaerobic Digestion	2,400
	Bangna	Activated Sludge (Oxidation Ditch)	1,300
	Khlong Jan	Extended Aeration Activated Sludge	700
	Tong Song Hong 1	Aerated Lagoon	1,800
	Tong Song Hong 2	Activated Sludge	480
	Hua Mark 1	Oxidation Pond	500
	Ta Sai	Activated Sludge	1,200
	Khlong Toei 3	Completely Mixed Activated Sludge	1,200
	Piboon Wattana	Activated Sludge	400
	Bang Bua 2	Activated Sludge	1,200
	Bon Kai	Activated Sludge	350
	Pom Prab-Samphanthawong-Pathum Wan-Ratchathewi	Activated Sludge	350,000
Nonthaburi	Muang Nonthaburi Municipality	Extended Aeration Activated Sludge	38,500
Pathum Thani	Muang Pathum Thani Municipality	Activated Sludge (Oxidation Ditch)	11,500

2.3 Economic Conditions

2.3.1 National Economy

Thai economy has been keeping its high growth for a long term since 1960s. Rapid industrialization in 1980s changed the agriculture-oriented economy to industry and service oriented. A large inflow of direct capital investment and increase in export took the key roles in realizing this industrialization. Direct investment made up the capital shortage while the exports of diversified industrial products maintained a high growth of export value in Thailand. In the case of Thai economy, the trend of export and import has a high correlation with the growth of national economy because the total of export and import value covers more than 50% of the gross domestic product (GDP). However, while the increase in export accelerated the imports of raw materials as well as the production of relevant industries, its positive impacts on domestic economy were limited. After the economic crisis in 1997, export industries revived themselves rapidly while the growth of other domestic economic sectors remained at lower level.

Another important characteristic of Thai economy is the disparity in income among the regions, especially between the Bangkok metropolis including its vicinity and other regions. This disparity reflects the difference in industrial location between them. Large-scale industries including foreign firms dealing with export and import businesses are mostly located in the vicinity of Bangkok, while agriculture and small and medium size enterprises (SMEs) are the main industries in other regions. With the expansion of market economy to other regions, the linkage between domestic and international economy will be further strengthened in Thailand. It implies that poverty alleviation and reduction of income disparity will be a more important policy issue to be addressed in Thailand.

a. History and Present Status of Thai Economy

As shown in Figure 2-8, Thai economy recorded the average annual growth rate of 6.5% during 1970-1999 though the growth speed had slowed down in 1997 because of the unprecedented economic crisis. Thailand is considered to be one of the most successful countries in Asia in its economic development.

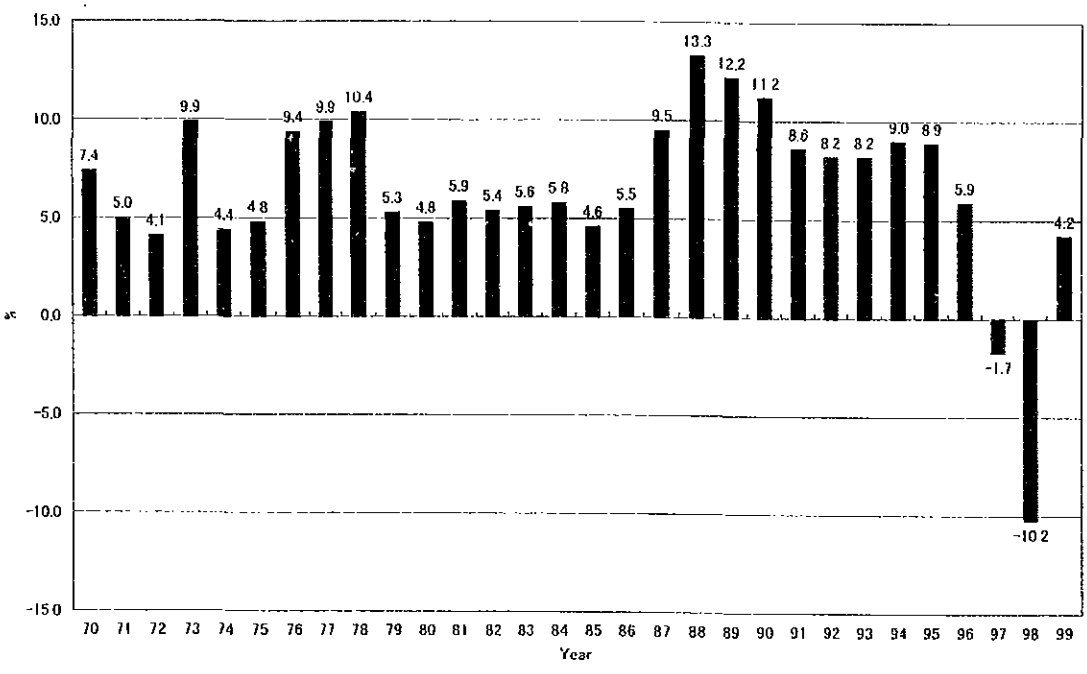


Figure 2-8: Trend of Actual Economic Growth Rate in Thailand (1970-1999)

Source: NESDB (National Economic and Social Development Board)

In the early 1970s, Thai economy decelerated its growth due to outbreak of the first oil crisis, decrease in the development assistance from the United States after the end of Vietnam War, and a decline of foreign capital investment in the context of socialization of Indochina countries. However, it jumped up again in the late 1970s to reach annual average economic growth of 6.8% in this decade. In the beginning of 1980s, the growth of Thai economy stayed at the annual average rate of 5.4% due to the second oil crisis and subsequent worldwide recessions. Between 1988 and 1990, however, it recorded the growth rate of over 10% for the consecutive three years mainly due to the increased inflow of direct investment influenced by the trend of a strong yen and a

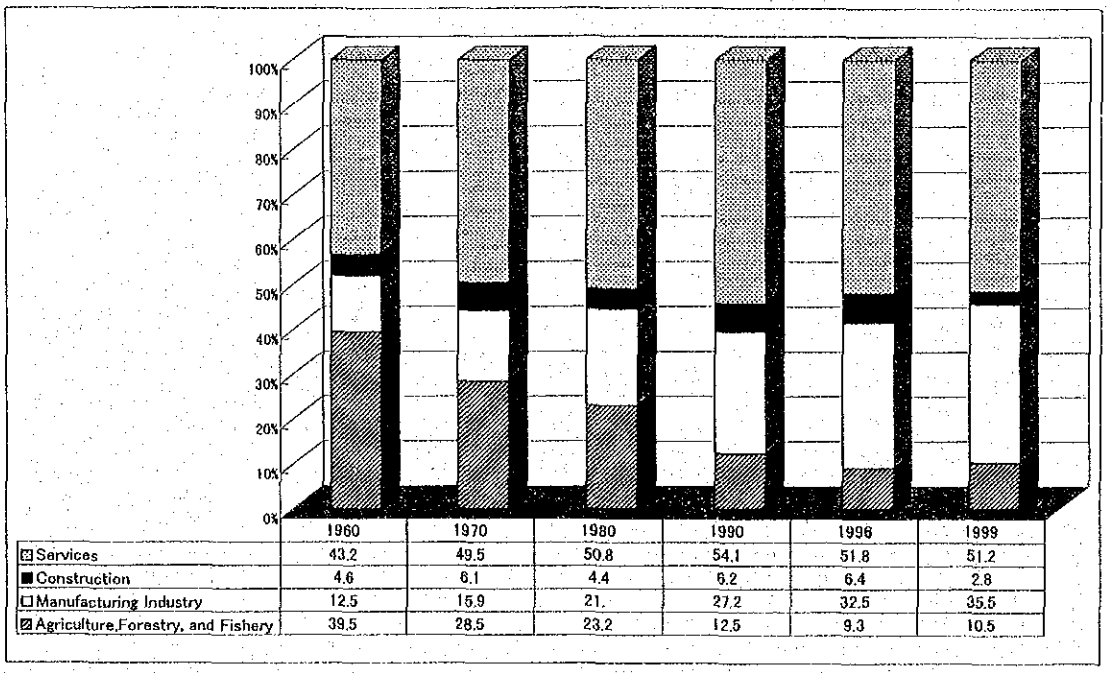
weak dollar, as well as to the increase in the exports of diversified products. The average annual growth of economy in 1980s ended up with 7.8%. Rapid growth of Thai economy continued up until the middle of 1990s with the annual average rate of 8.6% during 1990-1995. In the second half of 1990s, a disastrous economic crisis that has never been experienced hit Thai economy, ending with the negative economic growth for two years (1997 and 1998). Finally, the average annual growth of economy in 1990s remained at 0.2%.

Currently in 2000, the GDP in Thailand reached around 122 billion US dollars, which was the second largest after Indonesia among the ASEAN countries. Thailand is also taking the leading role in the development of Indochina economic zone in terms of its economic scale in comparison with other CLMV countries (Cambodia, Laos, Myanmar, and Vietnam).

b. Structure of Thai Economy

Thai economy drastically changed its structure with rapid industrialization in the late 1980s. Comparing the structure of Thai economy between 1980 and 1990, the ratio of agriculture to the GDP decreased from 23.2% to 9.3% while the ratio of manufacturing industry increased from 21.5% to 35.5%.

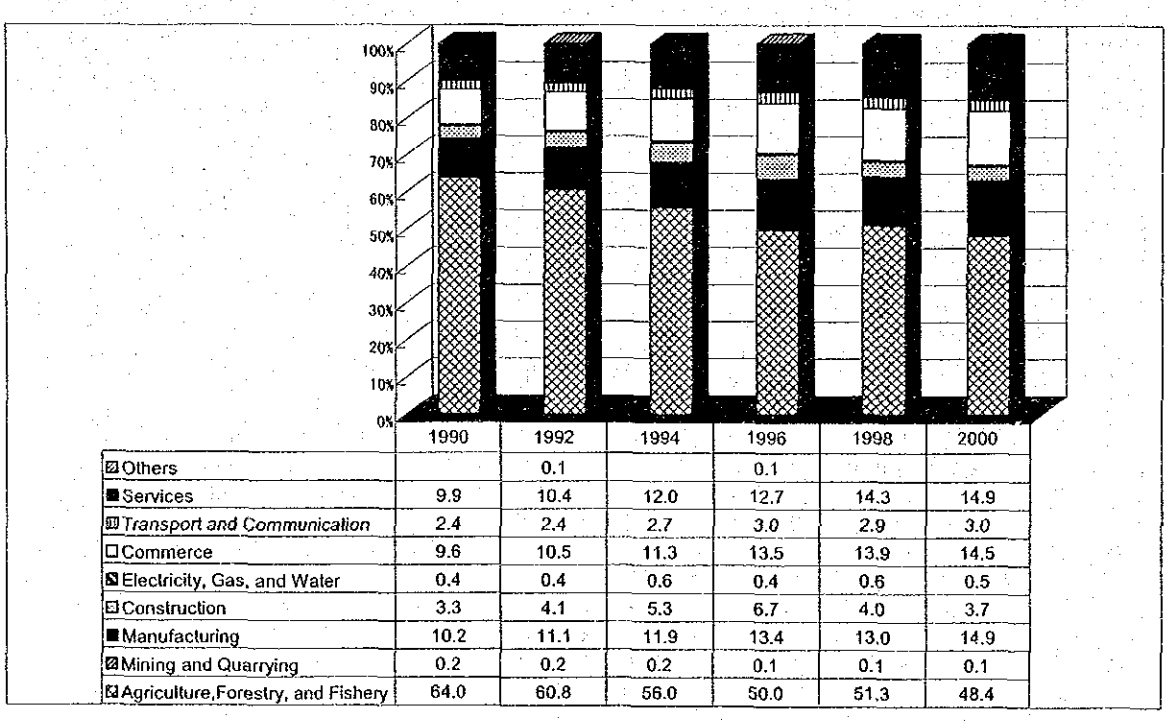
Regarding the ratio of employed persons by sector, the percentage of agriculture sector decreased from 64.0% to 48.4% between 1990 and 2000 while manufacturing, commerce, and services sectors increased their percentage of employed persons during the same period.



	1960	1970	1980	1990	1996	1999
Services	43.2	49.5	50.8	54.1	51.8	51.2
Construction	4.6	6.1	4.4	6.2	6.4	2.8
Manufacturing Industry	12.5	15.9	21.	27.2	32.5	35.5
Agriculture,Forestry, and Fishery	39.5	28.5	23.2	12.5	9.3	10.5

Figure 2-9: Changes in Structure of GDP in Thailand (1960-1999)

Source: NESDB



	1990	1992	1994	1996	1998	2000
Others		0.1		0.1		
Services	9.9	10.4	12.0	12.7	14.3	14.9
Transport and Communication	2.4	2.4	2.7	3.0	2.9	3.0
Commerce	9.6	10.5	11.3	13.5	13.9	14.5
Electricity, Gas, and Water	0.4	0.4	0.6	0.4	0.6	0.5
Construction	3.3	4.1	5.3	6.7	4.0	3.7
Manufacturing	10.2	11.1	11.9	13.4	13.0	14.9
Mining and Quarrying	0.2	0.2	0.2	0.1	0.1	0.1
Agriculture,Forestry, and Fishery	64.0	60.8	56.0	50.0	51.3	48.4

Figure 2-10: Changes in Percentage of Employed Persons by Sector (1990-2000)

Source: National Statistical Office, Office of the Prime Minister.

However, agricultural sector still takes the biggest role in the employment of potential labor force as shown in Figure 2-10 above.

c. Per Capita GDP and its Regional Disparities

Per capita GDP has also increased with the growth of national economy in Thailand. Figure 2-11 showed the trend of per capita GDP in Thailand. Per capita GDP of 2,173 bahts in 1960 had doubled to 4,077 bahts in 1970 and increased 3.5 times more to 14,180 bahts in 1980. Just before outbreak of the economic crisis in 1996, per capita GDP recorded 77,043 bahts or 3,100 dollars US. Since the outbreak of economic crisis, per capita GDP drastically decreased with the depreciation of Thai bahts against US dollars and other foreign currencies, ending up with 74,675 bahts or 1,976 dollars US in 1999.

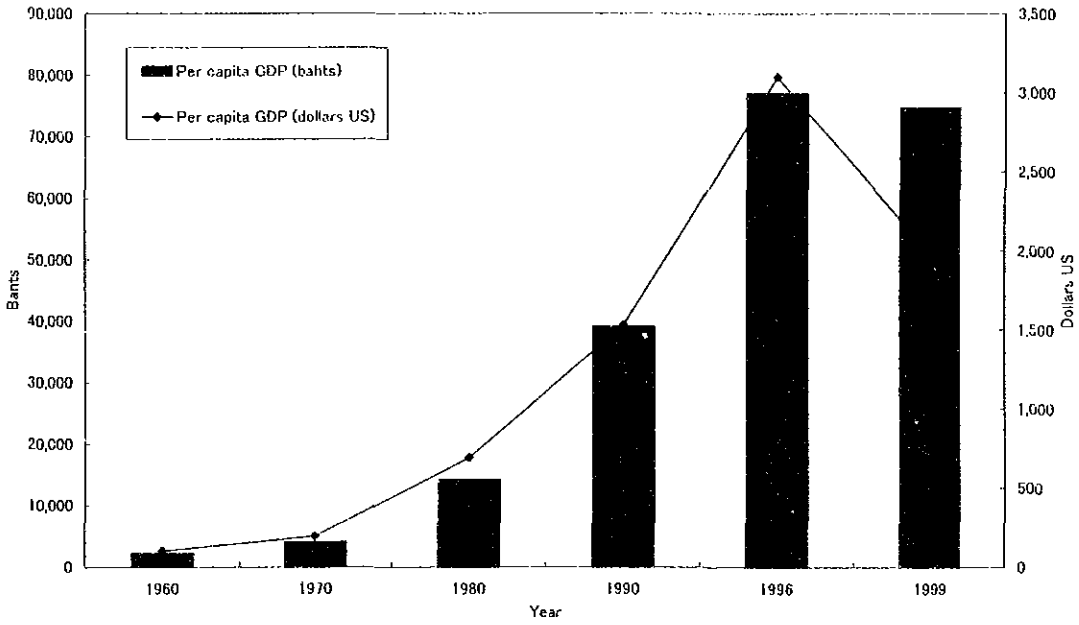


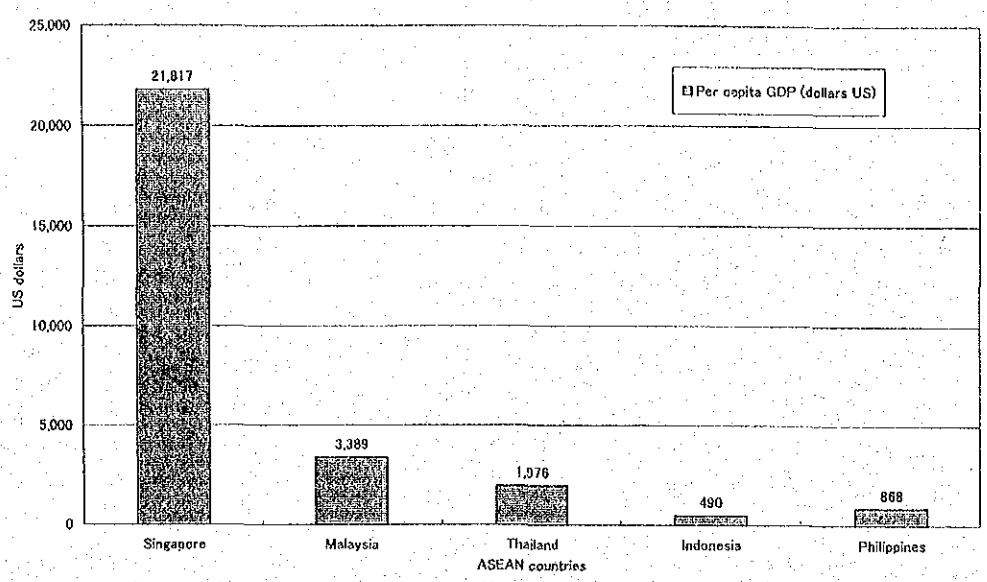
Figure 2-11: Trend of Per Capita GDP in Thailand

Source: NESDB

Comparing the level of per capita GDP among ASEAN countries, Thailand is the third biggest after Singapore and Malaysia as shown in Figure 2-12.

An important issue to be addressed in Thailand is the disparity in wealth among regions. In terms of GDP, Bangkok and its vicinity earns 48.4% of the country total in 1998. Per capita GDP in Bangkok and its vicinity is 4,990 dollars US annually while the average in the Northeastern Region only reached 638 dollars US.

There is also a big gap in household income among regions. Figure 2-13 below compares the average monthly income per person between regions.



Remark: The data given above are those of 1998 or 1999, depending on the availability of data in each nation.

Figure 2-12: Comparison of Per Capita GDP among ASEAN Countries

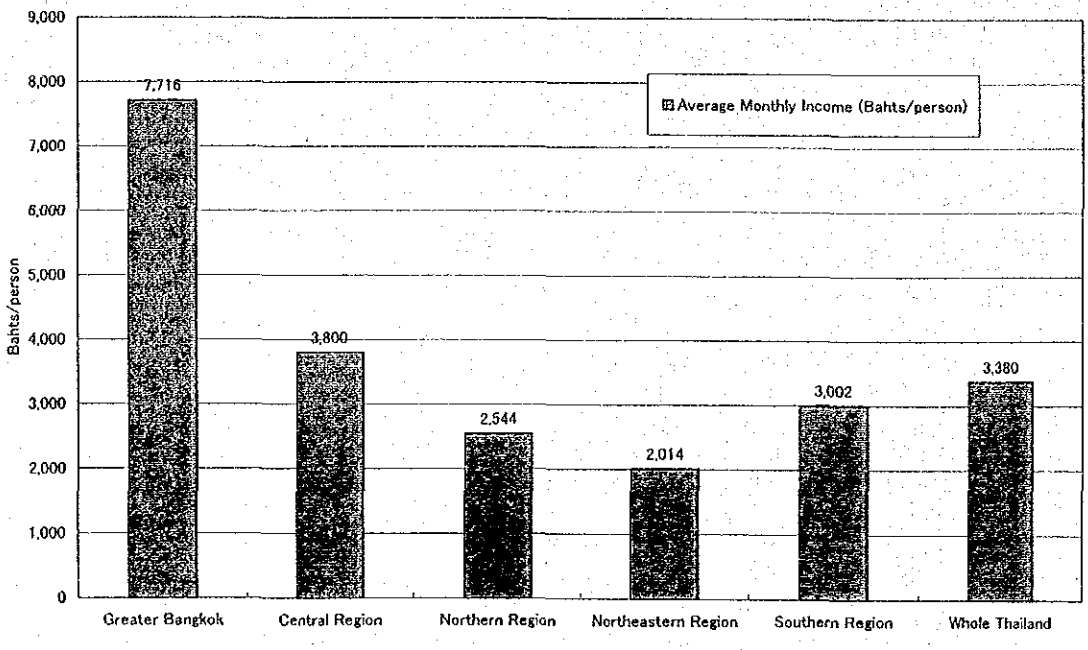


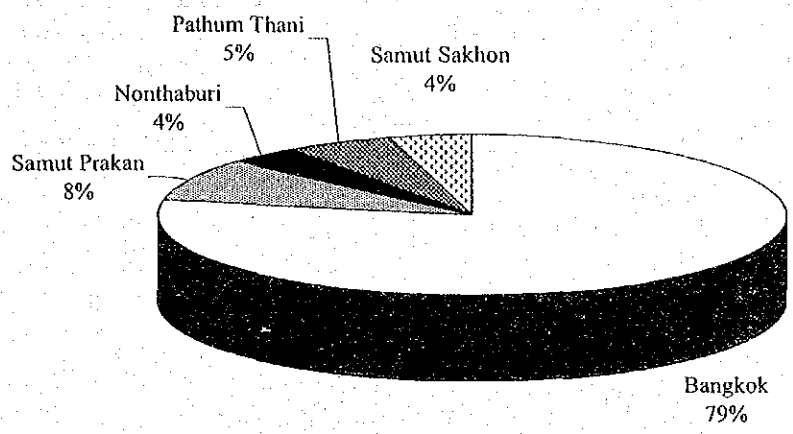
Figure 2-13: Disparity in Average Monthly Income among Regions in Thailand

Source: Statistical Yearbook Thailand 2000.

Solution to this disparity in wealth among regions will be a key to the further development of the national economy in Thailand.

2.3.2 Regional Economy

The Study covers the Bangkok and its vicinity including Samut Prakarn, Nonthaburi, Pathum Thani, and Samut Sakhon Provinces. In terms of GDP, the study area covers 48.4% of the national total. Figure 2-14 showed the percentage distribution of the gross regional product (GRP) by regions of Bangkok and its Vicinity, the study area.



GRP Bangkok and Vicinities: 2,178,684 million Bahts

Figure 2-14: Distribution of GRP by Provinces of Bangkok and its Vicinity

Source: Statistical Yearbook Thailand 2000.

Bangkok covers 79% of the GRP in the study area. In terms of GDP in Thailand, the percentage covered by Bangkok reached around 37% in 1998. The total GRP of Bangkok and its vicinity accounts for about a half of Thai GDP.

On the other hand, Figure 1-8 below compares the per capita GRP in 1998 at current market prices by provinces in the study area. Bangkok recorded the largest per capita GRP of approximately 231 thousand Bahts, which was followed by Samut Sakhon's 222 thousand and Pathun Thani's 211 thousand bahts. Per capita GRPs of the remaining two provinces are 186 thousand Bahts in Samut Prakan and 110 thousand Bahts in Nonthaburi respectively. These figures indicate the difference in the scale of economy among the provinces in the study area.

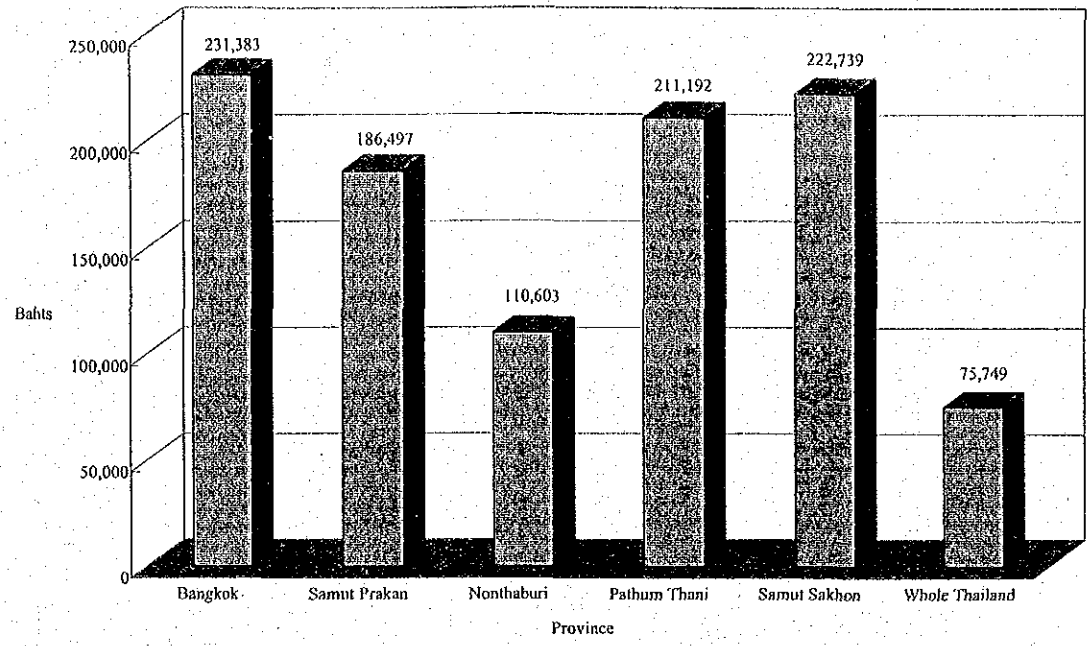


Figure 2-15: Comparison of per capita GRP among the regions of Bangkok and its Vicinity

2.3.3 Industries

a. General

Manufacturing industry is the second largest after service industry in terms of GDP in Thailand, accounting for 35.5% in 1999. According to the industrial statistics in 1998 provided in the Statistical Yearbook of Thailand 2000, Bangkok and its vicinity, the study area, covers about 63 % in terms of the number of manufacturing establishments. The study area can be defined as the center of manufacturing industry in Thailand.

Figure 2-16 compares the scale of manufacturing industry between Bangkok and its Vicinity in terms of number of establishments, employed persons, and gross output value. Although the number of establishments is bigger in Bangkok, employed persons and gross output value of manufacturing industry is much bigger in the vicinity. This is mainly due to the concentration of large-scale industries in the vicinity resulting from the active development of industrial estate and parks.

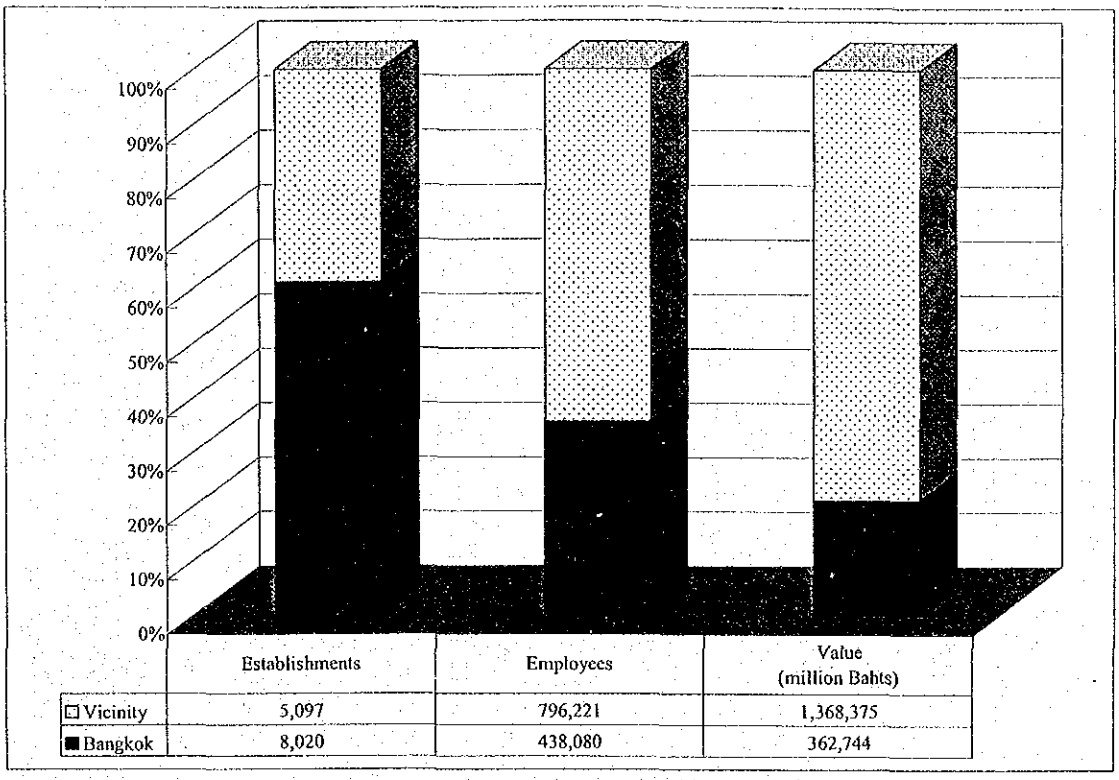


Figure 2-16: Comparison of the Scale of Manufacturing Industry Between Bangkok and its Vicinity

Remark: The vicinity given above includes Nakhon Pathom Province, which is not included in the Study area.

b. Number of Registered Factories

Industrial Statistic 1999 indicates that the highest number of registered factories of 21,309 is found in Bangkok while it is 5,589 and 2,710 in Samut Prakarn and Samut Sakorn respectively. Comparing with the number in the year 1991, the highest increasing rate is recorded by Samut Sakorn, followed by Pathum Thani and Nonthaburi. Table 1-13 shows the details.

Table 2-12: Number of Factories Registered in Accordance with the Factory Act, 1992

Province	Number of factory			% increased-decreased in 1999 comparing with 1991	% increased-decreased in 1999 comparing with 1993
	1991	1993	1999		
Bangkok	20,378	22,269	21,309	+4.5	-4.3
Nonthaburi	954	996	1,454	+52.4	+46.0
Pathum Thani	929	992	1,677	+80.5	+69.1
Samut Prakarn	3,822	4,186	5,589	+46.2	+33.5
Samut Sakorn	1,364	1,616	2,710	+98.7	+67.7
Total/Average	27,447	30,059	32,739	+19.3	+8.9

Source: Department of Industrial Works, 2001

c. Characteristics of Manufacturing Industries in the Study Area

In terms of number of establishments and employees, sub-sector of textiles and wearing apparels is the largest among the sub-sectors of manufacturing industry in Bangkok and its Vicinity. Sub-sector of metals and their products is the second largest in the number of establishments while food and beverage sub-sector is the second largest in the number of employees.

Regarding the gross output value, electronic machinery and equipment manufacturing is the largest, accounting for 20% of the total of manufacturing industry in the Study Area. Food and beverage manufacturing industry is the next largest and followed by textiles/wearing apparels and transport machinery and equipment sub-sectors.

Looking into the value-added of each sub-sector of manufacturing industry, food and beverage sub-sector is the biggest, accounting for 23% of the total value-added produced by the manufacturing industry in the study area. Next biggest is the transport machinery and equipment sub-sector, covering about 17%.

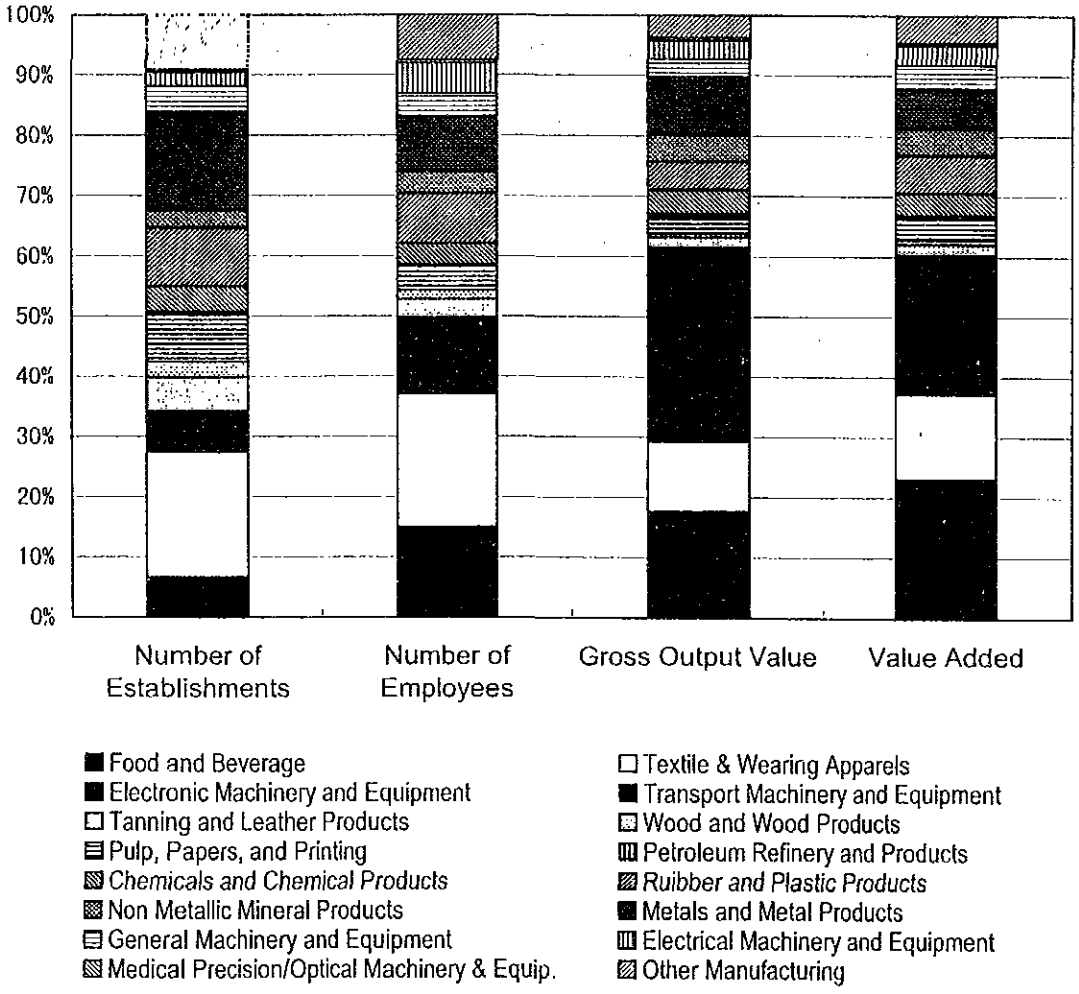


Figure 2-17: Structure of Manufacturing Industry in Bangkok and its Vicinity

The structure of manufacturing industry by sub-sectors in Bangkok and its Vicinity are shown in Table 2-13.

Table 2-13: Gross Provincial Product by Sub-Sector of Industry at Current Market Prices (1998)

Industrial Origin	Bangkok	Nonthaburi	Pathum Thani	Samut Prakarn	Samut Sakhon	Total	Percentage
Agriculture	10,152	2,283	3,460	21,296	15,958	53,149	2.44
Mining and Quarrying	0	0	140	0	138	278	0.01
Manufacturing	529,559	28,656	82,800	104,819	58,586	804,420	36.92
Construction	76,151	7,637	1,457	3,304	763	89,312	4.10
Electricity and Water Supply	29,178	2,933	4,735	8,799	4,007	49,652	2.28
Transportation and Communication	227,131	6,033	2,742	7,617	2,339	245,862	11.28
Wholesale and Retail Trade	337,119	10,485	6,497	13,310	4,094	371,505	17.05
Banking, Insurance and Real Estate	117,800	7,800	3,278	10,725	2,417	142,020	6.52
Ownership of Dwellings	34,494	2,511	1,933	2,514	1,090	42,542	1.95
Public Administration and Defense	54,474	1,894	1,560	1,847	897	60,672	2.78
Services	284,378	13,715	6,920	10,775	3,484	319,272	14.65
Total GPP	1,700,436	83,947	115,522	185,006	93,773	2,178,684	100.00

Source: Office of the National Economic and Social Development Board.
Compiled by: Statistical Data Bank and Information Dissemination Division, National Statistical Office.

d. Development of Industrial Estates/Parks

According to the 'Y2K Factory Directory & Map, there are 11 industrial estates and parks in the study area. Bangkok and its vicinity area is designated by the Board of Investment (BOI) as Zone 1, in which investment is strongly promoted by providing special economic incentives to the investors as shown in Table 2-14 below.

Table 2-14: Investment Incentives in Zone 1

	Investment outside industrial estate/park	Investment inside industrial estate/park
Zone 1	- 50% reduction of import duty on machinery. - One-year exemptions of import duty on raw materials for the products to be exported.	- 50% reduction of import duty on machinery. - One-year exemptions of import duty on raw materials for the products to be exported. - Exemption of corporate income tax for 3 (three) years.

Source: Chamber of Commerce, Japan, Thailand Office, 2001

In Thailand, there are three types of industrial estates in terms of their developers, i.e. direct development and operation by the Industrial Estate Authority of Thailand (IEAT), joint development and operation between IEAT and private sector, and development and operation solely by private sector. Investment in the IEAT affiliated industrial estates can obtain the following incentives:

- Both domestic and foreign companies can freely acquire the land (In the case of non-IEAT estates, BOI's approval is necessary for land acquisition by foreign company.),
- Employment of the experts of foreign citizenship is freely allowed
- Remittance of capital outlay or dividend to abroad is allowed.

In terms of the levels of incentives, BOI categorizes the industrial estate into three types, namely, General Industrial Zone (GIZ), Export Processing Zone (EPZ), and Free Trade Zone (FTZ). Although there is no FTZ realized, EPZ is further strengthened to include some of the functions and incentives in FTZ and renamed to EPZ-Plus. The following additional incentives are provided to the investment in EPZ-Plus:

- Exemption of the import duty and value-added taxes (VATs) on the building materials for the factory,
- Exemption of the import duty and VATs on the production machinery and equipment,
- Exemption of the import duty and VATs on raw materials,
- No taxation on the business transaction between the enterprises located in EPZ.
- Exemption of export duty on products and semi-products.

In the case of EPZ, the above incentives are permanently provided to the enterprises without any specified duration.

In the context of above encouraging incentives, industrial estates and parks were actively developed and operated in Thailand. Bangkok and its vicinity area is among the most actively developed areas of industrial estates and parks.

Table 2-15 shows the composition of manufacturing industries for each industrial estate and park located in Bangkok and its Vicinity.

Table 2-15: Composition of the Manufacturing Industry in the Industrial Estates/Parks in Bangkok and its Vicinity

Name of Industrial Estate	Bangchan I.E.		Bangkadi I.P.		Bangplee I.E.		Bangpoo I.E. (G.I.Z.)		Bangpoo I.E. (E.P.Z.)		Gemopolis I.E.	
	Number of Factory	%	Number of Factory	%	Number of Factory	%	Number of Factory	%	Number of Factory	%	Number of Factory	%
Food and Beverage	8	14%	2	5%	4	4%	10	4%	1	2%	0	0%
Textile & Wearing Apparels	2	3%	0	0%	4	4%	14	5%	7	16%	0	0%
Tanning and Leather Products	0	0%	0	0%	0	0%	5	2%	1	2%	0	0%
Wood and Wood Products	5	8%	0	0%	4	4%	0	0%	0	0%	0	0%
Pulp, Papers, and Printing	3	5%	0	0%	6	6%	11	4%	3	0%	0	0%
Petroleum Refinery and Products	0	0%	0	0%	0	0%	4	2%	0	0%	0	0%
Chemicals and Chemical Products	10	17%	3	7%	19	18%	78	30%	4	9%	0	0%
Rubber and Plastic Products	4	7%	2	5%	14	13%	25	10%	3	7%	0	0%
Non Metallic Mineral Products	4	7%	1	2%	5	5%	9	3%	2	5%	34	92%
Metals and Metal Products	3	5%	2	5%	11	10%	24	9%	5	11%	0	0%
General Machinery and Equipment	4	7%	0	0%	4	4%	4	2%	0	0%	0	0%
Electrical Machinery and Equipment	7	12%	15	35%	7	7%	21	8%	7	16%	0	0%
Electronic Machinery and Equipment	2	3%	9	21%	7	7%	6	2%	5	11%	0	0%
Medical, Precision, and Optical Machinery and Equipment	0	0%	7	16%	4	4%	9	3%	0	0%	0	0%
Transport Machinery and Equipment	4	7%	1	2%	8	7%	13	5%	1	2%	0	0%
Others	3	5%	1	2%	10	9%	26	10%	5	11%	3	8%
Total	59	-	43	-	107	-	259	-	44	-	37	-

(Continued)

(Continued)

Name of Industrial Estate	Ladkrabang I.E.(G.I.Z.)		Ladkrabang I.E. (E.P.Z.)		Nava Nakorn I.P.		Samut Sakhon I.E.		Theparak I.P.	
	Number of Factory	%	Number of Factory	%	Number of Factory	%	Number of Factory	%	Number of Factory	%
Food and Beverage	8	10%	1	1%	11	7%	12	17%	6	14%
Textile & Wearing Apparels	1	1%	10	11%	3	2%	12	17%	2	5%
Tanning and Leather Products	0	0%	13	14%	3	2%	1	1%	1	2%
Wood and Wood Products	2	3%	0	0%	3	2%	1	1%	0	0%
Pulp, Papers, and Printing	1	1%	0	0%	8	5%	2	3%	0	0%
Petroleum Refinery and Products	0	0%	0	0%	0	0%	3	4%	0	0%
Chemicals and Chemical Products	22	28%	4	4%	19	12%	6	8%	4	9%
Rubber and Plastic Products	8	10%	4	4%	12	7%	10	14%	3	7%
Non Metallic Mineral Products	2	3%	12	13%	11	7%	0	0%	4	9%
Metals and Metal Products	0	0%	1	1%	12	7%	8	11%	2	5%
General Machinery and Equipment	5	6%	5	5%	9	6%	1	1%	1	2%
Electrical Machinery and Equipment	5	6%	5	5%	9	6%	1	1%	2	5%
Electronic Machinery and Equipment	4	5%	12	13%	25	15%	1	1%	1	2%
Medical, Precision, and Optical Machinery and Equipment	5	6%	14	15%	11	7%	5	7%	4	9%
Transport Machinery and Equipment	7	9%	4	4%	6	4%	3	4%	8	18%
Other Manufacturing	10	13%	9	10%	21	13%	5	7%	6	14%
Total	80	-	94	-	163	-	71	-	44	-

e. Further Progress of Industrialization and Industrial Waste

With the recent recovery of economy in Thailand, its industries will also restart their further growth and technological development. Looking into the industrial estates/parks in the Study area, chemical, metal product processing, electric/electronic machinery and its components manufacturers recently dominate their locations. Particularly the high-tech industries are expected to increase with the growth of foreign capital investment in Thailand.

The high-tech industries manufacture high value-added products by utilizing advanced technologies and processes while they generate the industrial wastes that require specific treatment processes for their detoxification. Generation of these types of waste is expected to increase with the technological advancement of industries in Thailand.

Therefore, it is the key of sustainable economic and industrial development in Thailand to establish proper industrial waste management system, starting from legal and regulatory mechanism to the development of industrial waste recycling, treatment and landfill facilities.

Furthermore, considering the importance of export processing industries in Thai economy, implementation of proper industrial environment management in these industries will be the key of sustaining their presence in the international market in the current trend of standardization of environmental management system under ISO 14001 as well as the environmental compliance under the multi-national free trade agreement. In this respect, industrial waste management in Thailand is the policy issue of primary importance that may determine the future success or failure of its economy.