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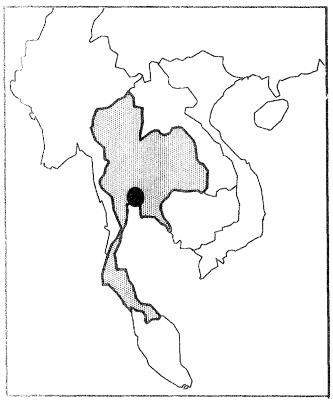

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Summary

This paper describes Bangkok's environmental problems and the government's initiatives to address them. It is drawn from information in *Thailand: Natural Resource Profile* prepared by the Thailand Development Research Institute.

The paper is divided into seven sections. After a brief introduction to the city of Bangkok, Section II is on water resources, land subsidence and flooding, Section III on water quality, and Section IV on domestic and industrial solid wastes. Section V looks at air pollution, Section VI at noise pollution, with a final section on the working environment.

Figures for costs in the paper are given in baht, the Thai currency; in 1988, there were some 25 baht to the US dollar.

I. INTRODUCTION

BANGKOK, CAPITAL AND chief port of Thailand, is located in the centre of the country. The city and its suburbs (which make up Bangkok Metropolis) has a population of over 5 million inhabitants, some 10 percent of Thailand's population.

Bangkok is within Thailand's Central Region which is the most densely populated of the four regions, even when Bangkok's population is excluded. The rich agricultural soils were an important factor in attracting people into the region. Other activities, including commerce and industry, provide the base for several other important urban centres within the region, although all are relatively small compared to Bangkok.

Bangkok is built on alluvial deposits within the delta plain of the Chao Phraya river, some 40 kilometres from the Gulf of Thailand. The land is slowly extending towards the sea, through the continued deposit of water-borne sedimentation. The waterways provided the earliest reliable transportation routes. Bangkok was founded in the late 18th Century, when the national capital was moved there from the ancient capital which was also on the Chao Phraya river, some 69 kilometres to the north of the centre of the new city. Bangkok has a long history as a major city; estimates suggest a population of some 400,000 inhabitants in 1850. But it was after the Second World War that population growth rates were particularly high.

II. WATER RESOURCES, LAND SUBSIDENCE AND FLOODING

WATER RESOURCES ARE vital assets to development. Like other metropolises, rapid industrialization and population growth in Bangkok has resulted in an increase in the demand for water. It has been forecast by the Metropolitan Water Works Authority (MWA) that the demand for water in its service area, which includes Bangkok and two adjacent provinces - Samut Prakan and Nonthaburi, would increase from 2.8 million cubic metres per day in 1987 to 4.1 million cubic metres per day in 1997 and 5.2 million cubic metres per day in 2007.[1]

1. MWA (1987), MWA Annual Report 1987 (in Thai).

The key water resource related problems in Bangkok are insufficient piped water supply, flooding and land subsidence. These problems are very much interrelated. At present, MWA is not able to produce adequate water to supply the increasing demand, especially in the eastern suburbs where housing estates and industrial plants are growing at a very rapid rate. A relatively large amount of ground-water is abstracted by both the private sector and the MWA. In 1986, the total groundwater abstraction rate in Bangkok, Samut Prakan and Nonthaburi was approximately 1.1 million cubic metres per day,[2] which far exceeded the estimated safe yield of 0.8 million cubic metres per day. It is thought that the unlicensed use of ground-water could run as high as 50 percent of the licensed usage.

2. Thailand Institute of Scientific and Technological Research (1987), 'Master Plan of Flood Protection and Drainage System of Eastern Samut Prakan', Report prepared for the Public Works Department, July.

One result of this over-pumping is the falling levels of the aquifers which lie under the city. As the water levels slump, problems emerge. Apart from the obvious fact that wells have to be dug deeper and more effort has to be expended in pumping water from the aquifers using ever-larger pumps, saline water begins to seep into the freshwater aquifers, and the land surface begins to subside.

Monitoring programmes conducted by the Army Survey Department and the Asian Institute of Technology reveal that Bangkok's ground surface has gradually subsided, although the present subsidence rates are remarkedly low compared to those of five or ten years ago. The present land subsidence rates in Bangkok, measured by the Army Survey Department, vary from place to place, ranging from 0.6 to 5.1 centimetres per year.[3]

3. See reference 2.

A combination of a sinking city located almost at sea level and heavy monsoon rains which frequently overtax the capacity of the Chao Phraya river has resulted in frequent flooding. The 1982 flood caused damage valued at 6,600 million baht.

In order to solve the problem of water deficiency in the lower Chao Phraya plain, the government has initiated a transbasin project. Previous studies have shown that there may be approximately 50 cubic metres per second of excess water in the Maeklong basin, which could be diverted to the Chao Phraya plain.[4] The diversion of water from the Maeklong basin will supply an additional 40-50 cubic metres per second for irrigation in the lower Chao Phraya plain and for Bangkok Metropolis.

4. Acres International Limited (1979), 'Chao Phraya - Maeklong Basin Study', Report submitted to the Royal Irrigation Department.

The present governmental strategy is to reduce ground-water abstraction by both public and private users to a level below the natural aquifer recharge rate; to cut the loss in water-supply from 40 to 30 percent by 1991; and to increase water production capacity by 0.5 million cubic metres per day.

Several studies were carried out to find the most effective means of flood protection for the Bangkok Metropolitan Area. Two of these studies have reached the preliminary design stage: the City Core

Project (NEDECO) and the Eastern Suburbs Project (JICA). In the City Core Project, it was planned that approximately 98 square kilometres covering the most densely populated and most commercially developed areas of Bangkok would be divided into six polders. A flood barrier system, improving the conveyance capacity of the canals and the installation of 10 new pumping stations was recommended. In the Eastern Suburbs Project, it was planned that the eastern suburban area of 260 square kilometres be protected by a system of polders which would discharge water, by pumping when necessary, into major canals. These two projects are well-conceived and the urgent measures recommended are awaiting final decision by the government.

III. WATER QUALITY

THE RAPID GROWTH of Bangkok and the industrialization of outlying areas has resulted in a deterioration of the water quality in canals and the lower section of the Chao Phraya river. At present, only two percent of Bangkok's population is connected to the city's existing sewer network. The majority of houses discharge water from sinks, laundries, baths and kitchens into storm drains which, in turn, normally discharge into nearby canals, thus creating water pollution problems. The extent of this pollution is now beginning to have an impact on the Chao Phraya river, into which the canals discharge.

At present, there are more than 90,000 legal factories in Thailand. Wastes discharged from these factories are mainly in the form of air pollutants and waste-water. A large part of the country's manufacturing activity is located in the Bangkok Metropolis and the surrounding provinces.

All private polluting factories have to install suitable waste-water treatment facilities in order to obtain their annual operating permits from the Industrial Works Department (IWD). Proposed treatment facilities of new factories must be approved by the department prior to the issuance of permits. Waste-water plants must treat effluents to a standard defined by the Ministry of Industry. Some government-owned factories are also in the process of installing treatment facilities. Smaller factories typically do not have their own treatment facilities, due to a lack of space, a lack of funds, or both.

Although materials such as heavy metals and pesticides are clearly important as far as water quality is concerned, the main problem in most of Thailand's rivers is the biochemical oxygen demand (BOD) imposed by organic effluents. In terms of water quality, the dissolved oxygen (DO) level is probably the best single indicator of the state of the river's health. The recorded DO levels of the Chao Phraya river have shown depressed sag curves for nearly 20 years, with the area affected showing a tendency to spread. Despite the somewhat higher DO curves recorded for 1979 and 1980, the evidence suggests that DO levels will remain depressed during low flow conditions for the foreseeable future. During high flow conditions, the area of depressed DO levels is shifted downstream.

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Since the 1960s, there has been concern that these low DO levels would finally result in the formation of anaerobic conditions along extended lengths of the river. In fact, it is likely that anaerobic conditions already occur in the river, after the first major rainfall following the dry season flushes organic deposits into the river from the canals and drains. But the DO records suggest that there may have been a number of competing trends at work. Since the river has not yet become anaerobic for significant periods of time, it might be

...there is no point in building sewage collection facilities if there are no trunk sewers to carry the sewage to a treatment plant.

that the increasing treatment of high BOD industrial effluents has, to some extent, compensated for the growing volumes of untreated sewage discharged by Bangkok's rapidly growing population.

Over the years, many reports have been commissioned by the Bangkok Metropolitan Authority (BMA) on how Bangkok should deal with its sewage problems. However, due partly to the BMA's limited budget and partly to the lack of political will, none of the proposals have been fully implemented.

There are a number of reasons for this slow rate of progress. One is that sewage systems have to be built as a whole. For example, there is no point in building sewage collection facilities if there are no trunk sewers to carry the sewage to a treatment plant. At the same time, the population of Bangkok has not shown any great dissatisfaction with the existing system of septic tanks and cesspools, which has meant that there is less momentum behind the project. Furthermore, the BMA has made flood control its top-ranking priority. Flooding problems are much more obvious to the average citizen, even if the causes are not, so the city's sewage plans have experienced a further setback.

A more recent study on water pollution control in Bangkok has been carried out by the Thailand Development Research Institute (TDRI). In order to reduce the cost of sewer construction, the TDRI has suggested that intercepting sewers be constructed to receive dry weather flow from public storm-drains which would otherwise discharge into the canals. The collected waste-water would be treated prior to being discharged into the receiving water. The pre-feasibility study estimates that the total investment cost for this system would be about 11,000 million baht (1988 prices). The government is seriously considering the proposal.

IV. DOMESTIC AND INDUSTRIAL SOLID WASTES

SOLID WASTE COLLECTION and disposal in Thailand is the responsibility of the BMA and local district offices. At present, some 80 percent of the population is served with refuse collection and the municipal authorities use a combination of 'station', 'door-to-door' and 'block' collection. The first of these systems is the most common and involves residents bringing wastes to a central communal container. With the 'door-to-door' system, residents leave garbage at the kerbside for collection. 'Block' collection is used in neighbourhoods which are inaccessible to the refuse lorries.

Most Thai communities rely on open dumping and occasional open-air burning for solid waste disposal. In Bangkok, however, composting processes and small incinerators are also used, although only a small proportion of the collected waste is processed by such facilities at present. This is due to an usually high downtime at some of the facilities. At present, three dump sites at On-Nuj, Nong Khaem and Ram Intra are in use.

Up to 15 percent of the solid waste collected in Bangkok is sent to four composting plants, at three different locations, while the rest is piled in open dump areas. It takes about six months for the composting process to yield a soil conditioner with a fertilizer value (expressed as the percentage N: percentage P: percentage K available) of 1.5:1.3:1.5, and a pH of eight.[5] This product, if mixed with dried nightsoil, will produce a soil conditioner with an N:P:K ratio of 1.8:2.5:1.0 and the same pH value.

A recycling system operates at three different levels to separate

5. Suttapreeyasri, B. (1985), 'Bangkok Solid Wastes Disposal', Department of Public Cleansing, BMA (in Thai).

goods for re-use. First, residents store and sell the most valuable items such as large glass bottles. Secondly, the municipal collection crew (primarily workers in the refuse truck) will remove items of potential value. Thirdly, as in many other Third World cities, some people make their living scavenging in the refuse sites. It is estimated that each collection crew worker receives an extra 1,500 baht a month from recycling activities.

In 1987, an estimated 5,100 tons of solid waste were generated daily by Bangkok's population. Of this, 3,900 tons were collected and some 110 tons recycled. The remaining 24 percent was dumped, mostly onto vacant areas or directly into the canals and rivers. One way or another, there is an ultimate impact on the quality of the receiving water resource.

Solid waste management consumes a large proportion of local government revenues. About 10 percent of the costs are covered by direct user charges, (a family of six is estimated to pay about 48 baht a year). Street markets are a particular problem and often the charges collected cover only a small proportion of the cost of clearing the site. Other large users do not pay the costs incurred by their activities and the collection of fees is incomplete. The 1985 Ministry of Public Health notification enables local governments to raise the fees they charge for refuse collection by as much as 10-15 times in certain circumstances. With these increases it is expected that solid waste collection may become profitable in the near future and private companies may wish to enter the market.

With regard to industrial solid wastes, most of Thailand's heavy manufacturing industry is located in Bangkok and the five surrounding satellite towns. The overwhelming bulk of the toxic organic chemicals used in manufacturing processes in Thailand consist of solvents. While such materials can cause problems when released into the environment, the evidence suggests that, at least so far, they are not a major problem with regard to air or water pollution.

The wastes which cause greater immediate concern are those in the inorganic chemical or heavy metal category. Five of the country's seven lead smelting plants are found in and around Bangkok, along with 83 percent of fluorescent lamp manufacturing plants, and between 90 and 97 percent of the chemical, dry cell battery, paint, pharmaceutical and textile manufacturing plants. Between 1970 and 1986 the number of registered plants using and disposing of toxic chemicals rose from 78 to 615. Accident prevention, particularly along transportation routes and in congested communities, has become a priority which is gaining recognition.

Hazardous waste disposal is a subject of considerable concern in Thailand. The chemical precipitation techniques generally used result in chemical sludges or solids which themselves require disposal. Often they are passed on to private contractors, who may dump them on sites unknown either to the industrial waste producer or to the authorities. The Department of Industrial Works has therefore initiated a joint programme for handling toxic liquids, sludges and solid wastes in and around Bangkok.[6] One treatment centre has been built at Bang Khun Thian and is now in operation. Two others at Samut Prakan and Rangsit are being planned. The toxic wastes will be converted into an environmentally inert substance and the resulting material will be disposed of in a landfill site.

In recent years, considerable quantities of chemicals imported into Khlong Toei port have not been claimed and have been left as solid or liquid residues. In some cases, the Customs Department has found that the imported products were not active chemicals as labelled but

6. Lohwongwatana, B. (1986), Industrial Hazardous Wastes Treatment Centres for Industries in Greater Bangkok', Office of Industrial Services and Wastes Treatment, IWD, Bangkok.

chemical wastes. For example, 177,000 kilogrammes of hazardous waste labelled as cupric chloride were imported from Singapore in 1983. The chemical residues remained at the port and caused many problems. The Port Authority of Thailand has lost its limited storage space and requires some budget for treatment and disposal. The disposal of these wastes might create new environmental problems.

IV. AIR POLLUTION

THE EFFECTS OF air pollution in Bangkok are mitigated by the dispersion of air pollutants. The flat plains allow free air movements and Bangkok's coastal location gives the added benefit of a land sea-breeze. The north-east and south-west monsoons are dominant throughout Thailand and determine the direction of pollutant dispersion in a particular season. The Bangkok Metropolis is geographically located off the north-east/south-west axis from the industrial city of Samut Prakan. This reduces the adverse effects upon the environmental quality of the capital city. There is also the green area of Bangkrajao which is kept as a buffer zone to trap air pollutants blowing towards Bangkok.

Motor vehicles are the major emission source of carbon monoxide (60 percent) and are also solely responsible for high ambient carbon monoxide concentrations along busy streets. Emissions from motor vehicles are also largely responsible for photochemical smog formation due to the reaction of hydrocarbons and nitrogen oxides in sunlight. Power generation sources and industrial sources together account for 82 percent of sulphur dioxide emissions and 54 percent of particulates (these figures assume no emission controls). Whilst the siting of some of these plants away from major cities has helped reduce adverse effects on air quality, two power plants (which together have a generating capacity equal to 11 percent of the national total) are situated within the Bangkok Metropolitan Area.

National ambient air quality standards were promulgated in 1981 to protect human health. Six pollutants were specified: carbon monoxide, ozone, sulphur dioxide, suspended particulates, nitrogen dioxide, and lead. Most of the ambient air quality monitoring work in Thailand has been conducted in Bangkok, where there are two separate networks of permanent air monitoring stations. One is run jointly by the Ministry of Public Health (MPH) and the University of Chulalongkorn, and the other by the Office of the National Environment Board (ONEB).

Data on suspended particulate matter from all ONEB stations during 1983-86 showed that the yearly geometric means varied between 0.09 and 0.19 microgrammes per cubic metre.[7] These values were above or very near those for ambient air quality standards for suspended particulate matter (0.1 microgrammes per cubic metre as an annual average).

Due to its relatively large size, fugitive dust does not pose a serious health hazard since it cannot penetrate deep into the respiratory system. However, particulates do cause irritations and allergies. The ill-effects of breathing in particulates and black smoke are evident enough to warrant rectifying measures.

Lead analysis by ONEB during 1983-86 showed that the concentrations of lead in Bangkok ranged from 0.1 to 1.0 microgrammes per cubic metre and the annual means from 0.19 to 0.66.[8] Lower lead emissions have been brought about indirectly by increasing the use of LPG and diesel oil, which are cheaper than leaded gasoline. Direct

7. ONEB (1987), 'Air and Noise Pollution in Thailand 1987', NEB-PUB, 1987-017.

8. See reference 7.

lead emission control was initiated by the Ministry of Commerce in 1984, with the reduction of the lead limit for gasoline from 0.84 to 0.45 grammes per litre. This caused a further drop in ambient lead concentrations.

Carbon monoxide concentrations result mainly from vehicle emissions. Monitoring during 1983-86 by ONEB indicated that there were no violations of ambient air quality standards for carbon monoxide. The monthly average values of maximum one-hour levels of carbon monoxide during 1983-86 were within the range of 1.0-9.5 microgrammes per cubic metre, which is still lower than the ONEB standard of 50 microgrammes per cubic metre for a one-hour average.[9]

9. See reference 7.

In Bangkok, ambient sulphur dioxide is usually very low due to the widespread use of low-sulphur fuels in energy-consuming sectors. Data from ONEB stations during 1983-86 shows that the 24-hour average levels are about 0.03 microgrammes per cubic metre, much less than the ambient air quality standard of 0.30 microgrammes per cubic metre.[10]

10. See reference 7.

Ozone levels in Bangkok, as measured at ONEB stations during 1983-86, are lower than the ambient air quality standard of 0.20 microgrammes per cubic metre for a one-hour average. The highest levels (0.15 microgrammes per cubic metre) were found during March-May, when solar radiation is strongest, but in the rainy season (June-October) the levels declined to 0.05 microgrammes per cubic metre. The highest concentrations were always found around noon.[11]

11. See reference 7.

Nitrogen dioxide levels in Bangkok were found to be only about 0.02 microgrammes per cubic metre for a one-hour average, as compared to 0.32 microgrammes per cubic metre for the ambient air quality standard.[12]

12. See reference 7.

VI. NOISE POLLUTION

THE NOISE PROBLEM in Thailand results from traffic and industry. At present, there is no community noise level standard, but there are vehicle noise emission standards as well as working standards.

During 1983-1987, ONEB monitored noise levels at many locations near busy roads in Bangkok and other cities. Many of the locations in Bangkok were found to have noise levels greater than 70 decibels, which is the US EPA standard for long-term hearing protection. This results from noise emitted from trucks, buses and motor-cycles.[13]

13. See reference 7.

ONEB has received numerous complaints about noise nuisance from traffic, construction and industry. For example, Thepsirin School classroom noise level is within the range 76-95 decibels, and a house in Soi Ruamrudi recorded noise levels of 77.9 decibels. Whilst there is no community noise standard, the findings from many OECD countries suggest that in order to comply with desirable limits for people's well-being indoors, the outdoors noise level should never exceed 65 decibels.[14]

14. OECD (1985), 'The State of the Environment', Paris.

Waterway transportation is an essential part of the Thai life-style. Noise nuisance from commuter boats inevitably has an impact on those living alongside the canals and rivers. One survey found that the average noise level equalled 72.8 decibels plus or minus 5.2 decibels, with louder noise being experienced along small canals rather than on the Chao Phraya river.[15]

15. Chulalongkorn University (1983), 'Noise Levels from Water Transportation' NEB, publication number: 1983-003.

In 1985, the Bureau of University Affairs found that more than 21 percent of motor-cycles violated the noise standard. The survey also found that 80 percent of motor-boats surveyed exceeded the noise standard of 90 decibels at 7.5 metres, set by the Harbour Department.

(In 1985 this standard was raised to 85 decibels).

Such noise levels clearly impact most heavily on those forced to spend long hours under such conditions. An examination of the 85 motor-boat operators found that 80 percent had hearing loss. The extent of this loss related directly to the length of time they had been driving the boats.

The noise source standards for both land and water vehicles have now been set at 85 decibels at a distance of 7.5 metres from the vehicle. Whilst new vehicles achieve these standards, this is not the case for as many as 20 percent of those currently in use.

VII. THE WORKING ENVIRONMENT

MANY STUDIES HAVE revealed that Thai workers are generally exposed to poor working environments and have poor welfare facilities, especially those working in small and medium-sized undertakings.[16] Occupational accidents and diseases impose a burden on workers both directly, in terms of material damage and medical costs, and indirectly, in the form of intangible costs such as the misery inflicted on workers and their families, loss of future earnings, loss of advancement, mental changes and need for retraining.

Major factors that contribute to work-related injuries have often been attributed to dangerous working conditions, lack of efficient production machinery and safety equipment, inadequate attention given by both the employers and employees to safety, and the shortage of government safety inspectors.[17]

The most injury-prone industries are the basic metal industry, the manufacturing of transport devices, and construction. The industries with the greatest numbers of fatalities are construction, transportation, and mining.

Of particular concern to Bangkok is the potential danger of an accident at one of the factories dealing with hazardous chemicals. Seventy-five percent of such plants are located in Bangkok and the five surrounding provinces. In 1986, the Thailand Development Research Institute conducted a study of 27 chemical factories in Thailand; 20 of these factories used chemicals classified as major hazards according to the World Bank's 'List of Hazardous Substances Requiring a Major Hazard Assessment'. In most of these plants, emergency and contingency plans for hazard control are totally absent.

Yet, the number of workers reported as suffering from occupational diseases is small. In 1984, this number was about one percent of the 39,000 reporting some industrial injury. However, this may be a reflection of the difficulties of linking disease to working conditions rather than revealing a satisfactory condition. Moreover, the records of the Department of Labour reveal that the most reported occupational diseases are dermatitis arising from direct contact with chemicals or heat, which can be diagnosed readily, whereas diseases due to chronic exposure to chemicals are rarely reported. At present there is no systematic recording of the working history of the employees, so establishing the cause of a disease is very difficult, especially if the exposure took place long ago.

In a recent survey of 107 enterprises in Bangkok,[18] it was found that most enterprises provide basic welfare facilities like toilets, washing facilities and drinking water. Problems related to ergonomics and accident hazards were found in nearly all enterprises. Personal protective equipment was only occasionally provided and used.

To provide compensation for employees who are injured at work or

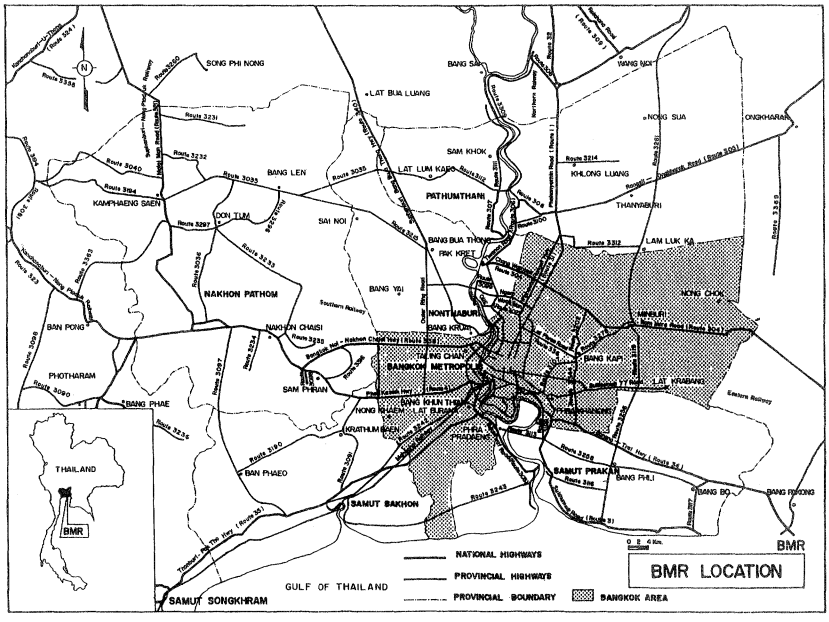
16. Wongpanich (undated), 'Current Situation of Occupational Health and Safety in Thailand', a condensed paper for USAID.

17. Thosuwonchinda, V. (1985), 'A Report on Occupational Safety and Health Situation in Thailand', *Asian Regional Tripartite Seminar on Occupational Safety and Health Policies*, ILO/PIACT, Bangkok, January.

18. Hasles, P., et al (1986), 'Survey of Working Conditions and Environment in Small-Scale Enterprises in Thailand', NICE Project, Technical Report no.12.

who become ill with occupational diseases, the Workmen's Compensation Fund (WCF) was established in 1972. In 1986, the WCF was in force in 56 out of 73 provinces. All undertakings having 20 or more employees, except those in agriculture, fishery, governmental enterprises and non-profit organizations, are required to join the WCF. The contribution rate to the WCF by employers varies from 0.2 to 4.5 percent of the employee's income, depending on the type of undertaking. Undertakings with good performance records are entitled to reductions in contribution rates.

Accident prevention at major hazard installations is a relatively new area of activity. The several recent international industrial accidents such as the explosion at a liquid petroleum gas (LPG) facility in Mexico City, the leakage of methyl isocyanate from a pesticide manufacturing plant in Bhopal, and the accident at the Chernobyl nuclear plant in the USSR have all made the Thai public increasingly concerned about major hazard installations.



Bangkok Metropolitan Region