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ENVIRONMENTAL INDICATORS
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POTENTIAL USES FOR PUBLIC POLICY FORMULATION IN THAILAND

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Yingprattana Keoplung

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# ENVIRONMENTAL INDICATORS

# FOR

# NATURAL RESOURCES MANAGEMENT AND PLANNING:

# POTENTIAL USES FOR PUBLIC POLICY FORMULATION IN THAILAND

By

Yingprattana Keoplung

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## ABSTRACT

ENVIRONMENTAL INDICATORS FOR

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Thailand has faced natural resources depletion and environmental degradation problems over the past several decades. One reason includes the lack of efficient decision-support tools and operational indicators for decision-makers and planners to formulate natural resources management strategies and environmental policies.

Along with sustainable economic development strategies, Thailand needs public policies based on relevant indicators and measurement tools that operationalize the concept of sustainable development, may be used to analyze development objectives impacts of alternatives, and are effective in making informed policy choices. These measures should also be useful in policy modification and be based on well-defined objectives and accepted performance standards.

One of these needs can be met by the use of effective environmental indicators. The environmental indicators proposed are inspired by the Pressure-State-Response framework of the Organization for Economic Co-operation and Development. Six environmental indicator categories are suggested. They include: forest resources; water resources; land uses; waste water; solid waste; and air pollution.

For my beloved parents, Muni and Kanha Keoplung

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## ABBREVIATIONS

| | |
|---|---|
| AARO | The Austin Area Research Organization |
| BOD | Biological Oxygen Demand |
| Cal/EPA | The California Environmental Protection Agency |
| CIAT | The International Center for Tropical Agriculture |
| CIESIN | The Center for International Earth Science Information Network |
| CO | Carbon Monoxide ($mg/m^3$) |
| CTAP | The Illinois Critical Assessment Project |
| DO | Dissolved Oxygen |
| EIA | Environmental Impact Assessment |
| EIS | The Environmental Information System |
| ENTRI | The Environmental Treaties and Resource Indicators |
| EPA | The United States of Environmental Protection Agency |
| FCER | The Florida Comparison of Environmental Risks |
| GIS | Geographic Information System |
| GLWQA | The United States/Canada Great Lakes Water Quality Agreement |
| IISD | The International Institution of Sustainable Development |
| MPN | Most Probable Number |
| MOSTE | The Ministry of Science, Technology and Environment |
| NESB | The National Economic and Social Development Plan |
| NEQA | The Enforcement and Conservation of National Environmental Quality Act |
| NGOs | Non-government Organizations |

| | |
|---|---|
| OECD | The Organisation for Economic Co-operation and Development |
| OEPP | The Office of Environmental Policy and Planning |
| PB | Lead ($mg/m^3$) |
| PSR framework | The Pressure-State-Response Framework |
| SAFE | The Strategic Assessment of Florida's Environment |
| SPM | Suspended Particulate Matter ($mg/m^3$) |
| UNEP | The United Nation of Environmental Programme |
| WRI | The World Resource Institute |

# CHAPTER 1

# PROBLEM DEFINITION

## 1.1 Introduction

When developing countries are making economic progress, they risk repeating the mistakes of emphasizing economic development over environmental protection. Economic growth can be a two-edged sword although it raises living standards and gives people the means to enjoy their environment, it is often accompanied by urbanization, more motor vehicles, and increased energy consumption (World Bank, 1997).

Because unbridled growth can lead to congestion, infrastructure overload, and dangerous declines in air and water quality, growth at the expense of the environment is likely to be unsustainable. Economic and social change is finally putting increasing pressure on the world's environmental resources (The Thai Ministry of Foreign Affairs, 1994). The World Bank (1998) estimates that much of the world's biological diversity is in developing nations and the Asian continents have the highest rate of natural habitat destruction compared to all other regions worldwide. The Indo-Malaya ecosystem has lost 70 percent of its indigenous vegetation and 30 percent of coral reefs in Southeast Asia has been degraded. Wetlands and forests are being lost at 0.3 to 1 percent a year. Presently, Southeast Asia has only one-third of the region area cover by forests (The Thai MOSTE, 1997). In Thailand, during the past 3 decades, forest areas have declined by 50 percent of the previous forest covered area (ibid., 1997). Greenhouse gas emission levels are increasing strongly with increasing economic activity. Reversing these trends will require actions by both developed and developing countries (EPA, 1998).

Many governments in either developed or developing countries are adopting policies for sustainable development (UNEP, 1998). This concept encapsulates the idea of economic development with due care for environment. It preserves the opportunities for well being of current and future generations. In 1987, the Brundtland Commission defined the sustainable development to include " path of human progress that meet the needs and aspirations of the present generation without compromising the ability for future generations to meet their needs. It requires political reforms, and a more just and equitable distribution within and among nations" (qt. in Axinn, 1997, p.67). Several individuals and organizations have offered alternative definitions of sustainable development from the perspective of their disciplines or interests, generally with a view of being more specific. The World Conservation Union and its 2 partner organizations, the World Wide Fund for Nature and the United Nations Environment Programme, provided the definition in 1991 as " improving the quality of human life while living within the carrying capacity of supporting ecosystems." (qt. in Ramphal, 1994, p.680). While the United Nations and international agencies like the World Bank said in 1989 that " In order to achieve sustainable development, we shall ensure the compatibility of economic growth and development with the protection of the environment" (ibid., 1994). Then economic growth and better environmental management can be complementary, because growth provides the resources to improve the environment (World Bank, 1998).

However, the transition to sustainable development requires changed behavior and practice in business, government and everyday life. Such progress requires that people understand and are able to measure the effects of policies and actions affecting the economy, the environment, and people's well being. This sustainable development has

fueled a growing international interest in measurement techniques. Measurement, as an indispensable tool to make the concept of sustainable development operational, helps decision-makers and the public to conceptualize objectives, evaluate alternatives, make policy choices, and adjust policies as well as objectives based on actual performance (The International Institution of Sustainable Development, 1998). Striking a better balance between the costs and benefits of development in economic term will require reliable information/indicators to guide policy design and track progress toward sustainable development (Hammond, 1995). Understanding the environment and its links to economic activity requires a sound base of data and indicators (World Bank, 1998).

The Organisation for Economic Co-operation and Development (1994) stated the demand for environmental indicators for its member countries that

"... Interest in sustainable development and public concern about environment threats have stimulated governments to re-examine their capacity to assess and monitor the state of the environment and detect changing conditions and trends. There is also increasing interest in measurement of environmental performance and evaluating how well governments are doing in their efforts to implement their domestic environmental policies and international commitments. Thus, environmental indicators are increasingly seen today as necessary tools for helping to chart and track the course towards a sustainable future..." (p.8).

The Center of Excellence for Sustainable Development (1999) stated that the well being of a community or nation could be measured in many ways. Traditional measurements often analyze a single issue by itself and do not show any relationship between things. New measurement called "Indicators of Sustainability" is designed to

provide information for understanding and enhancing the relationships between the economic, energy use, environment, and social elements inherent in long-term sustainability.

The World Resource Institute (1998) reports that in 1992, the United Nations held the Conference on Environment and Development in Rio de Janeiro. The Declaration of Rio de Janeiro on Environment and Development emphasized the need for sustainability and introduces the *precautionary principle* to protect the environment; Agenda 21 called for the development of indicators. In Part 40 of Agenda 21, it stated that "Indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated and development system" (p.6).

The OECD (1991) indicated the definition of indicator as a parameter, or a value derived from parameters, which points to, provides information about, describes the state of a phenomenon/environment/area, with a significant extending beyond that directly associated with a parameter value.

During 1990s, there were a series of technical presentations by national and international institutions, a presentation of the baseline document, and a demonstration of information systems. The presentations gave an overall vision of the state of development and use of the environment and sustainability indicators at the regional and national levels, the availability of any needs for environmental data and statistics and the different activities carried out by different organizations and institutions related to environmental indicators.

The UNEP organized the first meeting on environmental and sustainability indicators for Latin America and the Caribbean in November 1994 (International Center of Tropical Agriculture, 1994). The conclusion of the meeting includes the need to develop common methodological frameworks and the need to create and develop the appropriate policies. These frameworks used to reflect regional needs and characteristics within a worldwide context while the appropriate policies will not only permit institutional relation and exchange, but also coordinate and operationalize different initiatives on indicator development and use in the region.

In the regional level, a private organization in the United States named the Sustainable Communities Initiative in Texas launched the Sustainability Indicators Project, which aimed to increase regional awareness and commitment to sustainable community development, in 1998 (The Texas Sustainable Communities Initiative, 1999). This organization defined sustainability indicators as data about our world, which may be used by communities to monitor existing conditions and trends and to set targets for improvement. A particular set of indicators is intended to be a comprehensive list that addresses the most important issues in a particular community, as determined by its residents. Taken collectively, these indicators are intended to provide a fair assessment of the true quality of life in the community and its prospect for continuing. Indicators are used to educate citizens and to call attention to important issues in a community.

Some indicators deal with environmental "good", such as protected areas or biodiversity. Others measure "bad", such as deforestation, soil loss, and air and water pollution. Still others monitor the effects of environmental degradation such as waterborne disease, species loss, and numbers of threatened species (Center for

International Earth Science Information Network, 1998). Such indicators are important because the links between the environment and the people are often direct and immediate. Many relevant indicators are not available because of weaknesses in country coverage and concerns about the quality and comparability of data. Moreover, some environmental indicators are not meaningful at the national level. Although the world is divided into nation-states, air and water pollution do not respect national boundaries, and many other environmental problems are highly localized and location-specific. Thus a comprehensive set of environmental indicators must embrace local, national, regional, and global aspects of environmental problems. (World Bank, 1995)

### 1.2 Description of the Study Area

Thailand is situated in the Southeast Asian from North 5° 30" to 21°and from East 97° 30" to 105° 30" with the total area 321 million rais[1] (51.36 million hectares). Thailand borders the Lao People's Democratic Republic and Myanmar to the north, Cambodia and the Gulf of Thailand to the east, Myanmar and the Indian Ocean to the west, and Malaysia to the south. The population of Thailand is approximately 60 million, with an annual growth rate of approximately 1.3 percent. By that amount, around 10 million live in the capital city, Bangkok. Bangkok Metropolitan is the capital city of Thailand. Besides Bangkok, there are 75 other provinces that are divided into districts, sub-districts, and village.

Thailand is divided into four natural regions: The North is a mountainous region comprising natural forests, ridges and deep, narrow, alluvial valleys; Central Thailand is a

[1] 1 hectare equals 6.25 rais

fertile valley. It is the richest and most extensive rice-producing area; The Northeast is an arid region characterized by a rolling surface and undulating hills. Harsh climatic conditions often result in this region being subjected to floods and droughts; The Southern region is hilly to mountainous area and dense with virgin forests.

The climate is tropical with long hours of sunshine and high humidity. The average low temperature is 20 degree Celsius and high temperature is 37 degree Celsius. The geographic and climatic conditions make the country suitable for the cultivation of a wide range of tropical and semi-tropical agricultural crops.

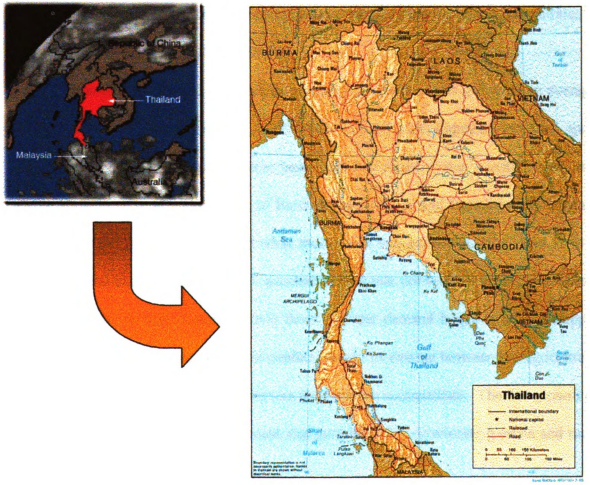


Figure 1 Map of Thailand

For more than 30 years, the Royal Thai Government has prepared a 5-year National Economic and Social Development Plan to help guide the social and economic development of the country. Thailand recently started the 8th National Economic and Social Development Plan (1997 – 2001). The development pattern in Thailand has followed a path common elsewhere in the world, from the agriculture-based economy to agroindustrial and industrial-oriented economy. Thailand started with an economic structure dominated by agriculture with a small import-substitution industry, passed through external shocks and domestic structure changes, toward agriculture diversification and export-oriented industrial development. Changes in the world economic comparative advantages helped the Thailand's economy achieve on of highest economic growth rates in the world in 1992-1995 (MOSTE, 1997).

Over the past several decades, the economy of Thailand has grown at an average rate of about 7 percent a year (ibid., 1997). The country's development depended upon the consumption of its natural resource base, including forest, water, coastal zones, and fertile agricultural land. The Office of Environmental Policy and Planning (1995) stated that the demand for energy increased while more waste was generated. The rapid growth of agricultural-based industry led to accelerate land use conversion: mangrove forests were destroyed to make coastal shrimp farms. Water demand began to exceed supply during the dry seasons, and water use conflicts began to emerge between the agricultural industrial, residential and recreation sectors and between communities. The fast growth of infrastructure and industrial development also contributed to deteriorating urban and rural environment.

At the same time as the Thailand's economic development, Thailand suffered from overexploitation, mismanagement, and encroachment of natural resources and environment pollution. The National Board, Thailand, 1995 stated during the 1980s, the forest area has shrunk to less than 26 percent of total forest area, the water consumption is increased from 20 billion cubic meters to 42 billion cubic meters, the number of factories is increased from 12 thousand factories to more than 31 thousand. The 1990s was the most challenging development decade for Thailand, as the country's economy became more dependent on dynamics of the world economy (OEPP, 1997). Thailand not only faces severely degraded natural resources and increasing environmental problems, but also a declining comparative advantage in the highly competitive world market. The MOSTE stated in 1997 that forestland has declined continuously to a critically low level while competition for water resources has intensified. Air and water quality, especially in the capital city and its vicinity have deteriorated. At the same time, the benefits from economic growth have not been distributed equally. Income disparity between regions, sectors, urban and rural has widened. Environmental control and natural recourse protection have not been sufficient to cope with the impacts from the rapid growth of its economy. Worsening income distribution sets the stage for potential social problems if it is not dealt with adequately (ibid. 1997). Thus Thailand must try to balance a more equitable social and economic development with resource and environmental stability. This is the challenge for Thailand in its efforts towards the sustainable development in the 21st century. One appropriate instrument among several instruments for natural resources and environmental management and development to achieve the goal under the Agenda 21 is the use of Environmental Indicators (ibid. 1997).

There have recently been many calls for the use of environmental indicators in the public and private sector in Thailand to measure the severity of the problem stated above (ibid., 1997). This stems from a concern about the sustainability of Thailand's stock of natural resources and environmental assets associated with human impacts. If natural resources and environmental assets become degraded or depleted, the future flow of benefits for future generations will decrease or disappear, or further deteriorate environmental quality. Thailand needs to use environmental indicators to help the Thai population ward off this kind of situation. To take an example, from the report of the Royal Thai Government (1991), Thailand's forests have diminished from 53 percent of the nation's land area in 1961 to less than 28 percent in 1988. The Royal Thai Government conducted a research through the sustainable management concept and has reached one of the conclusions that " ... For management purpose, Thailand is even more hampered by the absence of a database on standard qualitative and quantitative information. Thailand lacks sufficient detail and standardized comparative information to serve the purpose of the forest production and conservation management... "(p.11). Land degradation is perhaps the best example. Biodiversity loss and surface and/or underground water quality information may not be gathered. Nevertheless, these are true assets, which offer real benefits on an undefined number of people. The non-ownership and difficulties of control are the reasons why we require regular information as to whether the assets are being used in a sustainable manner.

Natural resources and environmental quality include many aspects that are hard to evaluate in monetary terms (Tietenberg, 1996). Consequently, data must be expressed in

physical terms and a large amount of information can result, difficult for even the expert to interpret.

Thailand is a newly developing country in the field of natural resources and environmental management and control. Thailand lacks experienced analysts in both public and private sectors to digest information on basic natural resources and the environmental and formulate and inclement public policy in this regard. Recently, Thailand produced financial or economic indicators on both the public and private sectors and to formulate the National Economic and Social Development Plan. However, no environmental indicators for natural resources, environmental management and development policy exist at this moment. The attractive idea that such information might be condensed in a few easily understood indicators leads some people to feel that there should be similar "headline" measures for the environment as there are for the economy, like national income or consumer prices.

Indicators for natural resources and environment may be set differently in a particular country or region. Indicators suitable for one function or one country may be totally inappropriate for others. Effective indicators have a format, which is designed with an explicit target group in mind (Braat, 1991; Notter and Liljelund, 1993). Different characteristics between two countries will response differently in particular environmental indicator (UNEP, 1998). There is no such a thing as a universal set of environmental indicators (Bakkes, Born, Helder, Swart, Hope, and Parker, 1994). Thailand could borrow the theme idea of indicators for natural resources and environment from experienced countries, however, there are problems due to the uniqueness of the biophysical and socio-economic characteristic of Thailand, Thailand has to develop the

environmental indicators suitable to her unique conditions. Recently, most of the indicators in Thailand deal with economic terms such as financial indicators of the National Economic and Social Development Board, the National Bank of Thailand, and several private banks. These include the national income accounts in agriculture, manufacturing, construction, transportation and communication, wholesale and retail, banking and insurance and real estate, services, and others; and the GDP by sector such as agriculture, public administration, banking and insurance, wholesale and retail, electricity and water, construction, and manufacturing; the population by age groups; the Labor force; the money supply and price movements; the imports classified by manufacturing, mining, fisheries, agriculture, and others sections; the imports by economic classification; commercial banks' loan and deposits; stock market performance; government finance; government expenditure budget; currency exchange rates; and external debt and service ration. Some natural resources-related authorities tried to create natural resource indicators but these have not yet been achieved.

### 1.3 Problem Statement

In Thailand, indicators for natural resources and environment have not been identified and analyzed to formulate public policy related to natural resources uses and the status of the environment. Therefore, the major goal of this study is to use environmental indicators as a framework and a tool for decision-makers and policy planners to establish plans to improve natural resources and environmental quality and quantity. Environmental indicators will be used to analyze and project trends, provide early warning information, and assess conditions in the realization of goals and targets.

Thailand's environmental indicators presented in this paper are derived from the set of environmental database of the Thailand Office of Environmental Policy and Planning. Since 1994, the OEPP has started to collect natural resources and environmental data, annually, from every province except Bangkok[2]. This is called the "Environmental Information System" (EIS). The process starts with the questionnaire distribution by the OEPP in January to every provincial authority (except Bangkok), such as the provincial forestry departments, land departments, and water departments. The questionnaire comprises 4 main sections, including water resources, forest resources, land uses, waste water/ solid waste/ air pollution (Appendix 1). Each provincial authority has 6 months to complete the form and return it to the OEPP. The OEPP takes 3 months to input all information into the computer database. After input, the database for every provincial authority is kept at the OEPP. The OEPP distributes a corresponding computer database back to its owner. Each provincial authority receives only its own database. This database is expected to be a tool to help the provincial's decision-makers and policy-planners to formulate the public policy and planning. The EIS can be envisioned as a large array of environmental related data series and other types of information, collected through the questionnaires. The content of an EIS contains various kinds of quantitative and qualitative information, including geographic and non-spatially referenced data, summary statistics, maps, and other kinds of model outputs useful for risk analysis and decision-making. However this computer database is not complete. Some information is missing due to the incompleteness of field data collected by the provincial officers. Though the data gaps were identified, the expected environmental indicators in this

[2] The Bangkok Metropolitan Authority is in charge of and maintains its own Bangkok environmental information database.

research will be carried out from this existing computer database, not only to utilize the existing database, but also to reduce the expensive cost and time-consuming task of primary data collection.

# CHAPTER 2

# RESEARCH PROCESS

## 2.1 Research Objectives

The need for sustainable development inspired Thailand to search for tools to evaluate and monitor the status and use rates of evolution and tendencies of natural resources and monitor environmental quality. An environmental indicator has been recognized by several organizations worldwide as useful in assessing the state of environment, formulate public policies for environmental and natural resources management and development, and monitor the outcomes of those policies resulting from key legislation. The aim of this research is to use environmental indicators as guidelines for Thailand's natural resources and environmental policy formulation. Therefore the major research objectives are:

1. To review current literatures related to environmental indicators and particular use for natural resources development and environmental assessment
2. To assess the current state of Thailand's environmental indicators for public policy formulation
3. To develop a prototype environmental indicator framework for policy formulation relating to resources management and environmental planning

## 2.2 Research Process

1. Review related literature on the pressure-state-response and environmental indicator frameworks and usage from various sources. These include publications in the

format of textbooks, reports, papers, and electronic documents of international organizations such as the Organisation of Economic Co-operation and Development, the World Bank, the International Center for Tropical Agriculture, and the International Institution of Sustainable Development; the national organizations such as Canadian government, the United States of America Environmental Protection Agency, and the United States/Canada Great Lakes Water Quality Agreement; the local organizations such as the Austin Area Research Organization, the California Environmental Protection Agency, the Illinois Critical Assessment Project, and the Strategic Assessment of Florida's Environment

2. Evaluate the current practice of environmental indicators assisting Thailand's policy formulation by reviewing the current process of Thailand's natural resources and environmental policy formulation of the government sectors.

3. Assess the existing Environmental Information System of the OEPP in order to provide enough useful basic information for establishing the six prototypes of environmental indicators for natural resources and environmental policy formulation including forest resources, water resources, land uses, waste water, solid waste, and air pollution.

4. Create a prototype of environmental indicators for natural resources and environment from the existing Environmental Information System for supporting the policy-makers and policy planners in both public and private sectors in Thailand by following the guideline of pressure-state-response framework as developed by the OECD in 1994.

4.1 Apply the PSR framework to the natural resources and environmental situation in Thailand

4.2 Provide a qualitative summary of environmental conditions, and pressure on the environment

4.3 Use the indicators and interpretation to show trends

4.4 Develop baseline indicators and threshold levels that may be used for public policy formulation

4.5 Formulate recommendations that will strengthen Thailand's natural resources and environmental policy formulation based on the use of environmental indicators

## 2.3 Expected Outcome

The indicators for natural resources and environment will be applied directly by policy-makers in both central and regional units of the Office of Environmental Policy and Planning, Ministry of Science, Technology, and Environment in order to assess environmental conditions and trends on a provincial, regional, and national level to support the formulation of Environmental Quality Management Policy and Planning; and to provide early warning information to the public.

## 2.4 Target Audience

The direct beneficiaries of this research are the policy- and decision-makers of the Office of Environmental Policy and Planning, Thailand's Ministry of Science, Technology and Environment by using the outcomes of this research as a guideline for natural

resources and environmental policy formulation. Moreover the policy-planners and decision-makers can use the outcomes of this research to monitor the use of natural resources and the state of environment.

The indirect beneficiaries are the other Thai organizations including NGOs, public sector, private sector, and the Thai people. The outcomes of this research can help NGOs, public and private sector organizations know the trend of the natural resources and environment's quality and quantity to help either change their economic activities or personal behaviors. Thai people also will have rigid natural resources and environmental policies to control the current utilization of natural resources and environment in the way that will not lessen the consumption abilities of the future generation.

# CHAPTER 3

# USES OF INDICATORS FOR NATURAL RESOURCES MANAGEMENT AND ENVIRONMENTAL POLICY FORMULATION

The OECD, based on the framework of the Pressure-State-Response, developed the concept of environmental indicators in 1994 from the initial work of the Canadian and Dutch governments. Since then, Environmental indicators have been applied and elaborated in many places around the world (EPA, 1997). Many countries, worldwide, adopted and applied this concept for their natural resources and environmental problem remedies.

## 3.1 Pressure-State-Response Approach

Hamilton (1991) illustrated the PSR approach with the three sub-systems that are the socio-economic, the environment, and the population. The relationship can occur within one sub-system. The state of a sub-system is changed by processes belonging to the sub-system itself and by the driving forces from the other sub-systems. Moreover, each of them has a two-way relationship with the others. The environment is the physical living space for the population, in which space people are exposed to physical, chemical, and biological factors. Population causes disturbances to the environment directly and through the socio-economic system. The environment provides space, raw materials and energy to the socio-economic system and receives physical changes and pollution in return. Societal response leads to recycling and repair. The population receives goods and services from the socio-economic system, in exchange for human resources and organization.

The UNEP (1994) explained the PSR approach as the relationship between the object, such as the environment and the socio-economic system, and two-way interactions between objects, and the processes that relate to one object only. The interaction between the environment and the socio-economic system can be occurred through use and management of resource and by the restructuring the environment through physical, biological and chemical changes, depositing waste, and counter-measures against earlier disturbances (the social response). The human presence is the center of important and specific relationships with the environment and with other socio-economic factors. If the natural restoration processes of the environment and the carrying capacity of the supporting ecosystem are not able to outweigh the human disturbances, sustainable development cannot be attained.

Dumanski (1996) clarified The Pressure-State-Response (PSR) framework as a convenient representation of the linkages among the pressures exerted on the natural resources and environment by human activities (pressure); the change in quality of the resource (state); and the response to these changes as society attempts to release the pressure or to rehabilitate the natural resource and environmental situation, which has been degraded (response). The PSR framework is use to explain the relationship among key indicators and international, national, and regional response strategies.

The EPA (1998) used the PSR approach to support the development and the use of environmental information for decision-making. EPA gave the direction of the PSR study as human activities are seen as producing *pressures* (e.g. pollutant releases) which may affect the *state* of the environment, to which societies then *respond* if the resultant changes are perceived to be undesirable. In the proposed framework, "Pressure" includes

factors of human and non-human origin, because of the growing synergy between the impacts of natural processes and anthropogenic forces on the environment. Pressures have been divided into three sub-categories: underlying, indirect, and direct pressures. Underlying pressures include social and demographic forces, technological change, and policies that stimulate economic activities. Indirect pressures include human activities (mostly but not exclusively economic activities) intended to benefit human welfare, as well as some "natural" processes and forces, such as nutrient cycles, volcanic eruptions, earthquakes, and meteorological events and cycles. Direct pressures include actual biophysical stressors on the environment, such as pollutant releases, resource extraction, and exotic species introductions. The "State" category is organized to reflect the "spatial nesting" of ecosystems at global, regional, and local scales, with an additional sub-category for environment-related human health and welfare. Societal "Responses" are sub-divided by type of entity making the response: governments, the private sector, households and individuals, and cooperative efforts. Response do not tell us directly what is happening to the environment but data to construct indicators is usually most available for pressure indicators and sparsest for response indicators.

The International Center for Tropical Agriculture incorporated with the UNEP (1994) signed an agreement to carry out the project of Environmental and Sustainability Indicators: A Perspective from Lain America and the Caribbean by using one of the best known models, the PSR model. The project's objective is to develop a regional proposal for indicators and information, integrated and harmonized with the worldwide international initiatives and to make these indicators available to national and regional decision makers. To meet these objectives, UNEP and CIAT organized a second

Regional Workshop on the Use and Development of Environmental and Sustainability Indicators in 1996. One of the main objective of this meeting was to define a methodological framework for the use and development of environmental and sustainability indicators for the region, within a worldwide context. The result for the methodological conceptual frameworks for the development and the use of environmental and sustainability indicators was to use the PSR model. The CIAT stated that the PSR model does not necessarily establish cause-and-effect relations, but does help organize the information and permits setting up environmental indicators. Moreover CIAT said that this model is operative and can serve as a take-off point without interfering in later refinement. It is quite open and can be used in several ways and its interpretation can vary according to realities. The management indicators will be incorporated in the PSR model in the Response column that is called " Response-Management" column. Each country and specific situation can adopt and combine those that is considers most convenient. However, at the level of the CIAT, the availability of environmental information leads to work preferably with the ecological and political-administrative levels.

The European Commission (1999) published a book entitled " Towards Environmental Pressure Indicators for the EU" focusing on the most important human activities that have a negative impact on the environment. As a baseline, this book used a concept of Driving force-Pressure-State-Impact-Response model. The European Commission stated that this model has been adopted as the most appropriate way to structure environmental information by most Member States of the European Union and by international organizations dealing with environmental information.

## 3.2 Importance of Indicators Use for Natural Resources Management and Environmental Planning

The Government of Canada (1995) reported The State of the Great Lakes by using some related Environmental Indicators. The purpose of the United States/Canada Great Lakes Water Quality Agreement (GLWQA) is the restoration and maintenance of the chemical, physical and biological integrity of the waters of the Great Lakes basin ecosystem. By doing so, it had a conference aimed to promote better decision-making through improved availability of information, and to review current information and find out where there were data gaps. Six papers were prepared as background for the conference: aquatic community health, human health, habitat, contaminants, nutrients and the economy. These papers form the background of this report. Discussions have been incorporated into this report as appropriate. The condition of the living components of the system, including humans, is the ultimate indicator of its health, reflecting the total effect of stresses on the system. Measures of the physical, chemical and biological stresses that affect the system are equally important in describing the state of the Lakes and providing vital information for programs that restore and protect the integrity of the ecosystem. For purposes of this report, a small number of indicators have been chosen. These simple indicators are intended to summarize the state of the ecosystem and progress made to date in addressing the many sources of these stresses. Conditions shown by the indicators were rated in four categories by a panel of technical experts: poor, mixed/deteriorating, mixed/improving and good/restored.

The World Resource Institute (1995) mentioned about the work of the Dutch government on environmental indicators in the book entitled " Environmental Indicators:

A Systematic Approach to Measuring and Reporting Environmental Policy Performance in the Context of Sustainable Development". The WRI referred that the Dutch government has made good use of indicators based on strong national goals to curb such environmental problems as ozone depletion, climate change, and acid rain. Since 1991, the Dutch government has published indicators showing how the nation's contribution to such problems has changed from one year to the next. When combined with targets for future performance, these indicators showed Dutch how effectively current policies are helping to improve both the Dutch environment and global conditions, and how far they have yet to go. In the Dutch government report as mentioned in the WRI book, the Dutch experience showed that when conditions do not improve, indicators stimulate the search for improved policies.

Scott S., Nolan B., and Fahey T. (1996) defined that the goal of environmental indicators is to communicate information about the environment in ways that highlight emerging problems and draw attention to the effectiveness of current policies. Indicators must tell us whether things are getting better or worse. To tell this story, an indicator must reflect changes over a period of time keyed to the problem. It must be reliable and reproducible. Also it should be calibrated in the same terms as the policy goals linked to it.

The Consortium for International Earth Science Information Network, The Socio-economic Data and Application Center for the U.S. National Aeronautics and Space Administration (1997) collected the useful information for national resource indicators called "the environmental treaties and resources indicators". The ENTRI system provided a set of nine specific "issue areas" that are widely recognized by scholars and

policy-makers as being critical to understanding the human dimensions of global change: Biodiversity; Deforestation; Desertification and Drought; Ocean; Population; Ozone Depletion; Trade and Environment; Air Pollution. The discussion of each issue follows the pressure-state-response (PSR) framework. ENTRI used the following criteria to identify relevant indicators: functionality; measurability; data quality and availability of data (from remote sensing and ground truth sources); relevance to treaties; and potential to measure national response strategies.

The Organisation for Economic Co-operation and Development (1997) studied about Environmental Indicators under the purposes to keep track of environmental progress; to ensure integration of environmental concerns into sectored policies (e.g. transport, energy and agriculture); to ensure integration of environmental concerns into economic policies; to use indicators to measure environmental performance and to help determine whether countries are on track towards sustainable development. The results of the study aim to the OECD countries and OECD itself. To achieve the goals, all OECD countries and OECD itself should agree to use the pressure-state-response (PSR) model as a common harmonized framework; identified sets of indicators based on their policy relevance, analytical soundness and measurability; measured these indicators on a country by country basis.

Schultink (1999) presents public policy formulation that relies on the identification of economic development potential based on resource production capacity and environmental constraints as identified by a hierarchy of indicators and composite indices (figure 2).

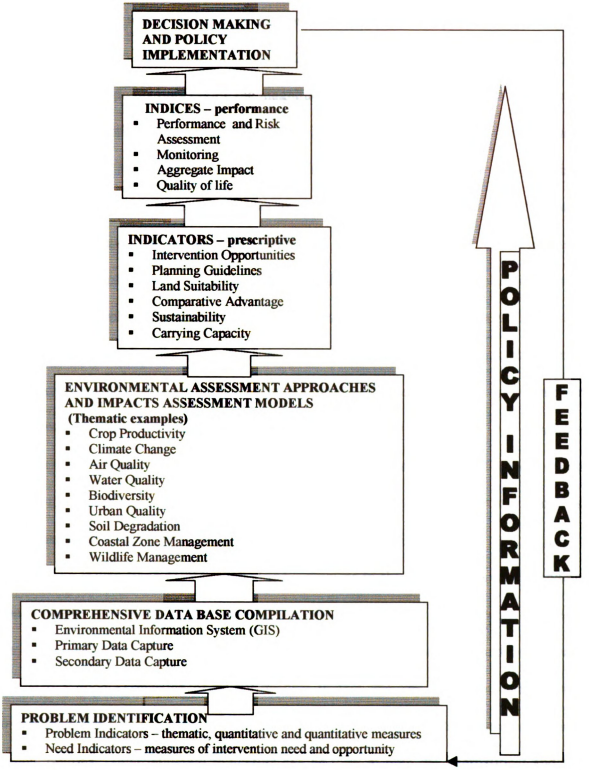


Figure 2 Hierarchical information flow and use of basic data, indicators and indices in development planning and public policy formulation (connecting arrow size signifies relative information content) (Source: Schultink, 1999)

Resource production capacity and environmental constraints can be identified using environmental indicators and derived biophysical and socio-economic indices. Those indicators do not only define the magnitude and nature of environmental problems, but also derive action alternatives and information for decision analysis, forecasting, and policy analysis. Those indicators can help reduce uncertainty and risk in public policy formulation by helping the policy-makers to understand more of the facts, including base line environmental conditions, current use trends and impacts, and relevant assessment practices and models. He presented three sets of indicators that are useful to identify problems and problem-solving scenarios. The first one is diagnostic or need indicators, which are used to describe problem characteristics in quantitative and qualitative terms and may be used to outline general intervention needs. The second one is opportunity or prescriptive indicators, which may be used to specifically identify and evaluate alternative solutions. The last one is performance and monitoring indicators, which define the desired outcomes, the operational characteristics of implementation, and its performance success using biophysical or socio-economic indicators.

The World Bank (1997) studied the indicators in the book entitled "Expanding the Measure of Wealth". The World Bank explained that the development of useful environmental indicators requires not only an understanding of concepts and definitions, but also a good knowledge of policy needs. In fact, the key determinant of a good indicator is the link from measurement of some environmental conditions to practical policy options. Environmental indicators can be used at both the international and the national level as a tool for state-of-the-environment reporting, measuring environmental performance, and reporting on progress toward sustainable development. At the national

level they can also be used for clarifying objectives and setting priorities. This book explores a number of indicators of environmentally sustainable development that include the links between environmental quality and economic growth and between the use of resources and the quality of the resource stock. This book also focused on the land quality indicators since land resources form the most basic natural asset of most countries. It is important to maintain and even enhance the productivity of this resource.

The Ministry of Environment, Land, and Park of British Columbia (1998) set environmental indicators as the tools to measure progress towards long-term sustainability. They focus on answering four basic questions about the environment: what is happening? why is it happening? why is it significant? What are we doing about it? They are analogous to the economic and social indicators used daily by governments, business, and private citizens in their decision-making.

The International Institution of Sustainable Development (1998) designed indicators of sustainable development as a communication tools between communities and decision-makers. Those indicators translate scientific information into policy influencing tools. At the same time, indicators help translate public expectations to measurable components, like targets or benchmarks.

The Center of Excellence for Sustainable Development (1999) reported about new measurement, Indicators of Sustainability, that are designed to provide information for understanding and enhancing the relationship between economic, energy use, environment, and social elements in long-term sustainability. Many communities such as Seattle, San Francisco, and Toronto are using indicators to gather and evaluate information to gather and evaluate information on both current energy use and future

alternatives for the residential, commercial, industrial, and transportation sectors. This information will support the sustainable development. The role of an indicator in this paper is to make complex systems understandable or perceptible. An effective indicator or set of indicator helps a community determine where it is, where it is going, how far it is from chosen goals. Indicators of sustainability examine a community's long-term viability based on the degree to which its economic, environmental, and social systems are efficient and integrated.

Schultink (1999) states that to accomplish the most effective of the policy formulation alternatives, 3-tiered segmentations of data collection would be required (Figure 3). First, the comparative indicators of resource production capacity and potential which represent the potential and efficiency to meet the demand for public goods and services, including the potential generation of income and employment opportunities. Second, environmental quality and degradation indicators that measure the environmental stress resulting from poor resource utilization, renewable resource-depleting management practices, or environmental pollution. Last, the indicator related to development and management of environmental resources to ensure or enhance the long-term productive capacity of the resource base with the goal to improve long-term societal wealth and well being.

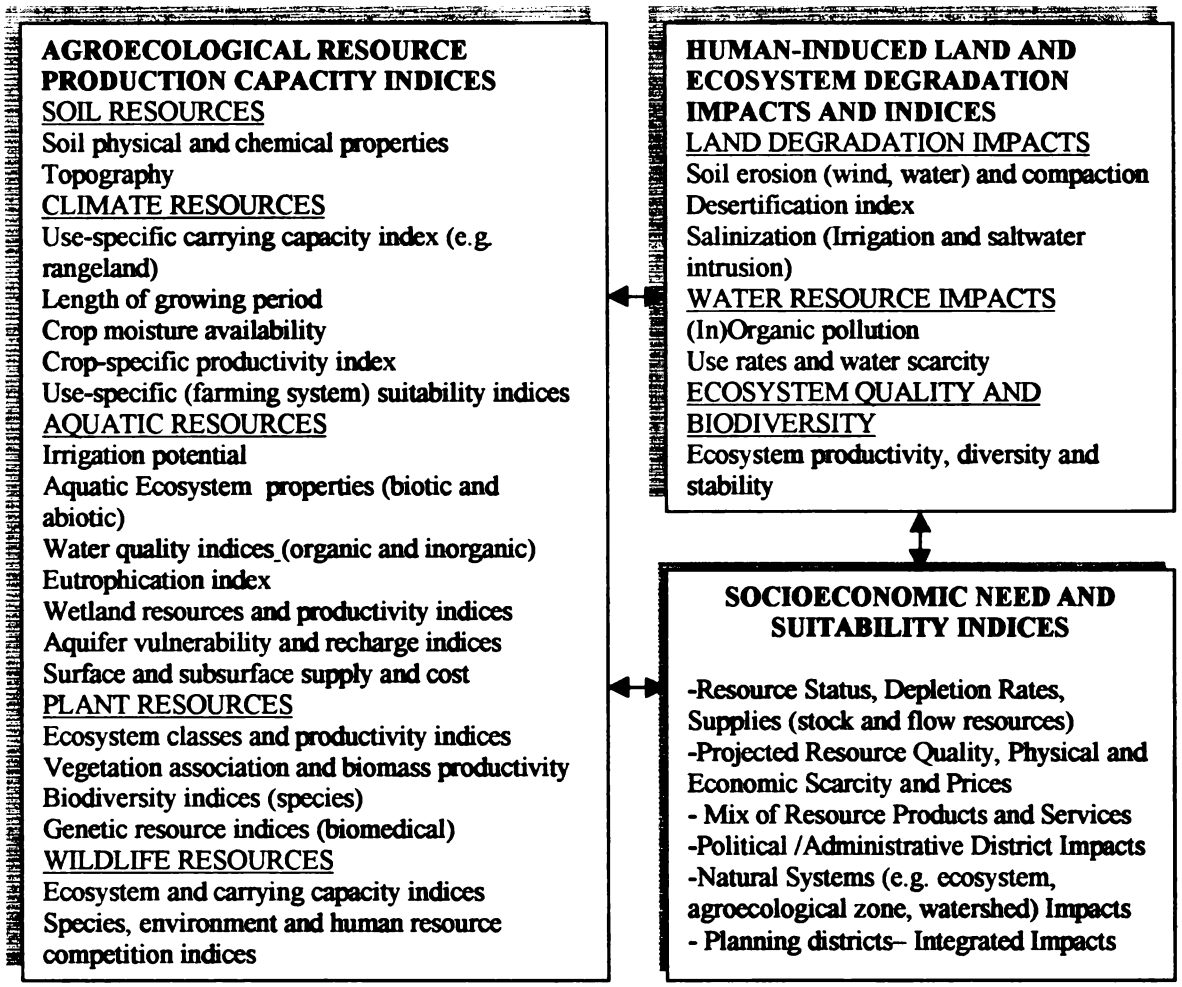


Figure 3 Relevant indicators, derived indices and linkages in natural resource productivity assessment (Source: Schultink, 1999)

In the United States, a number of state environmental agencies incorporate presentations of environmental indicator data in annual or occasional reports to the public describing progress made in their environmental protection programs, an opportunities and needs for future environmental protection. (EPA, 1997)

The Kentucky Environmental Quality Commission (1992) produced State of Kentucky's Environment: A Report of Progress and Problems, a 300-page comprehensive review of trends in the quality and quantity of the commonwealth's

resources and related issues. Developed over year, the report contains a listing of environmental indicators and measures for those indicators as an appendix to the report. The State of Kentucky's Environment: 1994 Status Report, is presented in the same format of text, charts, and graphs.

The Florida Center for Public Management (1994) updated Florida's indicator project, Strategic Assessment of Florida's Environment. SAFE is defined as a measurement system of key indicators of environmental trends and the current status of Florida's environment to support planning and management decisions affecting Florida's future. The Florida Department of Environmental Protection as a component of its strategic planning process developed the SAFE system over the past four years. The current version of the 287-page SAFE is comprised of 87 indicators grouped in categories that reflect the 13 issue areas developed by the Florida Comparison of Environmental Risks (FCER), Florida's comparative risk assessment project, and a series of other issues of concern. The indicators were selected for the purpose of providing a current and comprehensive snapshot of the condition of Florida's environment, a historical perspective on how the state arrived at its present status, and some idea as to where the state's environmental future is heading. The format of the report is that each indicator is explained, listed in a hierarchy of administrative to environmental results indicators, the data source is identified, the data characteristics are described, the indicator is assessed for its validity, and the indicator is analyzed and displayed graphically.

The Minnesota Pollution Control Agency (1995) produced the 1994 Biennial Report of the Legislature as a collection of measurements reflecting the progress made in environment protection and emerging issues that have yet to be addressed. Graphic

representations of indicators for air quality, hazardous waste, and water quality are presented.

The North Carolina Prevention and Environmental Assistance (1995) published the North Carolina Environmental Indicators in June 1995. This effort were to present and interpret information regarding the environmental quality of the state as a condensed overview that accounts for the dynamics of change over time presenting most data for the years 1989 through 1993. This paper contained with air, water, waste, and natural resources sections.

The United Nations (1995) presented the indicators of sustainable development through the Work Programme on Indicators of Sustainable Developments adopted by the Commission on Sustainable Development at its Third Session in April 1995. 134 indicators and related methodology sheets has been developed to assist decision-makers and policy-makers at all levels and to increase focus on sustainable development. The aim of the Commission on Sustainable Development with respect to Indicators of Sustainable Developments is to have an agreed set of indicators available for all countries to use by the year 2001.

The California Environmental Protection Agency (1996) produced a 15-page Environmental Indicators Report for Earth Day 1995 as a means of utilizing the agency's information systems to define the environmental indicators that are currently use. Cal/EPA used the report to assist in the identification of relevant indicators that are not supported by adequate data. Ultimately, Cal/EPA intends to move from environmental indicators to an environmental index or a set of indices that can simply and effectively communicate the overall status of California's environmental quality. The Cal/EPA

environmental indicators are presented in areas that parallel the structure of the agency's constituent organizations: air, pesticides, hazardous and solid waste, and water. Additionally, a multi-media perspective is represented by California Toxic Release Inventory data. The indicators presented address only to those environmental quality areas that are within the regulatory scope of Cal/EPA's authority.

The Office of Research and Planning, Illinois Department of Natural Resources (1996) launched The Illinois Critical Assessment Project in 1996 in order to describe changes in ecological conditions in Illinois. CTAP adopted a source-receptor model as the basis for analysis. The results are contained in a seven-volume technical report and a 90-page project summary volume: The Changing Illinois Environment: Critical Trends published in late 1994. CTAP has begun to use geographic information systems and satellite imagery to map changes in Illinois ecosystems and to develop ecological indicators that can be evaluated for their use in long-term monitoring.

In 1998, A non-affiliated volunteer group in Hays, Williamson, and Travis counties in Texas incorporated with the City of Austin's Sustainable Communities Initiative, the Graduate Program in Community and Regional Planning at the University of Texas at Austin, the Austin Area Research Organization, and Tate Austin (1998) launched the sustainability indicators project in order to increase regional awareness and commitment to sustainable community development. This project is being facilitated by a diverse group of residents who are committed to the sustainability of the Austin Region. They recognized that business, and environment, and social interests are interrelated and should be addressed as such in order to improve quality of life in an equitable and just manner. The limited numbers of indicators, which will be produced by this project, tend

to address causes rather than symptoms and can effectively influence individual and community action.

# CHAPTER 4

# CRITICAL REVIEW OF INDICATORS' USES FOR ENVIRONMENTAL POLICY FORMULATION IN THAILAND

The process of Thailand's natural resources and environmental policy and planning formulation follows the same general course as in other countries. However, there is considerable variation in the setting of policy, law, and administration. Due to the uniqueness social and economic characteristics of each country, the most appropriate methods and techniques for the formulation of natural resources and environmental policy and planning should be fit its conditions such as government, history, traditions, customary practices, and legal system.

## 4.1 The Development of Thailand's Environmental Policy Formulation Process[1]

The primary objective of the first three five-year National Economic and Social Development Plans (1961 – 1976) emphasized economic growths. The rich natural resource base was viewed largely in terms of its economic potential. Development activities focused on the construction of infrastructure, such as roads and railways, to improve access to rural areas and allow natural resources to be utilized. The general outcome was an expansion of cultivable areas or, meanwhile, a rapid decrease in forestlands. In general, the emphasis of the development plans during the 1960s and early 1970s was to promote growth and economic productivity in the short term, while

[1] The conclusion derived from the Eighth Thailand NESD Plan, the Enhancement and Conservation of National Environmental Quality Act B.E. 2535, the Thailand's Action for Sustainable Development, the Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality, 1997-2016, and the Thailand Environmental Quality Management Plan

the long-term environmental impacts of natural resources consumption were given relatively little attention.

However, a depletion of forest resources, deterioration of soil quality, and shortage in water supply in mid 1970s led to the introduction of resource protection and rehabilitation strategies under the Fourth NESD Plan (1976 – 1981). In particular, the Thai government began to compile data on various natural resources and environment concerns, preparing for the natural resources management and environmental policy and planning formulation.

The Fifth NESD Plan (1981 – 1986) introduced a more integrated approach to natural resources development. Planning strategies were coordinated with local social-economic development with the aim of increasing the efficiency of natural resources utilization and restoration.

The Sixth NESD Plan (1986-1991) showed the turning point on natural resources management and environmental policy and planning in the government's strategies. While the previous plans viewed the country's natural resources as an unlimited stock contributing to overall economic growth, this plan viewed that the intensifying depletion and degradation of the natural resources base should be considered as a constraint to economic development.

At the same time, the urban environmental problems drastically increased. Air and water pollution, hazardous waste reflected the negative impact of increasing industrialization and energy consumption. Natural resources depletion was one of the major problems that caused urban environmental problems. Sustainability on economic and social development concept was raised at the end of this plan.

The Seventh NESD plan (1991 – 1996) focused on sustainable development by keeping a balance among growth and income distribution, industrialization and the protection of environmental quality, urbanization and support for rural population. The national economic and social development base on the acceleration of economic growth utilizing comparative advantages in terms of natural resources and low-cost labor to produce goods and services for export. This plan emphasized 5 major areas including environmental management policy, natural resources management, environmental quality, energy and environment, industry and environment, and urbanization and environment.

This plan also brought a major change in legal and institutional arrangements governing environmental protection. The Enforcement and Conservation of National Environmental Quality Act (1992) and the Environmental Quality Management Act (1992) were launched under this seventh NESD plan. They created several new tools and powers to aid and force the clean-up and long-term improvement of the country's environmental situation. Those tools and powers were including

- The recognition of the urgency of environmental issues in Thailand. It empowers policy and planning agencies with enforcement authority
- Decentralization and delegation of environmental authority to provincial and local governments. This facilitates local people participation who are directly affected by changes in their environmental conditions
- The recognition of the public's right to know and to participate in national environmental affairs and the constructive role of the private sector and NGOs in environmental rehabilitation

- The human resource development through training in many aspects of natural resources and environmental management and development

Under the new environmental law, new government departments are established with the mandate to promote public awareness and public participation in pollution abatement, to enforce environmental standards based on the Polluter Pays Principle, to protect and conserve natural resources for future use, and to regulate the current allocation of natural resources uses. Those government departments include the National Environment Board, the Office of Environmental Policy and Planning, the Pollution Control Department, and the Department of Environmental Quality Promotion.

The Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality was adopted according to the Enhancement and Conservation of National Environmental Quality Act of 1992. The period for implementing the Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality is 20 years. This was followed by the approval of the National Environment Board, a national action plan called the "Environmental Quality Management Plan" and a provincial action plan called "Provincial Environmental Quality Management Action Plan". The Ministry of Science Technology and Environment takes actions to give advice to government agencies and state enterprises on the implementation of the Environmental Quality Management Plan to ensure that actions are taken to achieve the objectives and goals as prescribed.

After the Environmental Quality Management Plan has been published in the Government Gazette, it is the duty of all government agencies and all state enterprises concerned to take actions within their powers and function as necessary for effective

implementation. The governor of each province is responsible for the formulation of a Provincial Environmental Quality Management Action Plan, and submits the plan to the National Environment Board for approval. In preparing a Provincial Environmental Quality Management Action Plan for provinces designated as pollution control areas, the governor incorporates a detailed plan for mitigation and elimination of pollution into the action plan and the local action plan forms an integral part of the Provincial Environmental Quality Management Action Plan.

The Seventh NESD plan strategy is suitable for the needs of the time and consistent with the economic and social situation of Thailand. However, the success in economic growth and material progress to date does not mean that all Thai people are enjoying greater wealth and a substantially improved quality of life. On the contrary, rapid economic growth had negative effects on Thai culture, traditional ways of life, community and societal values. The impact on natural resources and the quality of the environment has also given cause for serious concerns.

The Eighth NESD plan (1997 – 2001) brought Thai people to the two new sets of key strategic approaches. The first one is the establishment of good governance. This involves the strengthening of a truly harmonious relationship between the government and the people, through collaborative and participatory efforts of all parties in the society, the provision of guarantees for freedom, human rights and equity, and the settlement of conflicts through peaceful means. The second strategy is to reform the development administration for more effective plan implementations. This requires a development system based on the area approach, the integration of functions and participation of all stake-holders, improvement of the budget and personnel management efficiency of public

government agencies at the central level, together with the development of indicators suitable for he monitoring and evaluation of holistic development.

For the natural resources and environmental matters, the Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality over the period 1997-2016, are essential policy guidelines for implementation within a twenty-year period, that later will be divided into four five-year plans for environmental quality management. A five-year plan consists of programs, roles, and functions of concerned agencies. This plan established guidelines for systematic environmental administration and management to facilitate the reaping of benefits from efficient national development. This plan includes essential strategies to accelerate rehabilitation of renewable resources and application of mitigation measures to address water pollution, air pollution, noise and vibration pollution, solid waste and night soil pollution, and hazardous materials and waste.

## 4.2 Application of Methods and Techniques for use in Natural Resources Management and Environmental Planning in Thailand

### 4.2.1 Economic and Social Indicators

The indicators, which are expected to be established in the Eighth NESD plan, serve as important tools for future planning and managerial improvements. The main objectives are to develop indicators that increase the efficiency of a monitoring and evaluation system and provide the various groups concerned with a true picture of the outcomes of national development and highlight progress, weakness, and obstacles.

To create an effective and efficient monitoring and evaluation system, the Eighth NESD plan identifies the following issues:

- Database Construction—especially a central development administration database covering all levels: national; provincial; and local. This database collects population statistical standards classified by gender.
- Information Network Construction—A system that links existing databases and new database via information technology.
- Formulation of Economic and Social Indicators—Indicators which principal aims are to depict a reliable picture of the success and impact of the plan's implementation. This includes not only population statistical standards, but also indicators that cover external influences on economic and social development, operational processes and the success of effects of national development.

  There are 5 levels of those indicators:

  1. Indicators of the Final Results of Development. These indicators measure human development, social development, economic development, natural resource and environmental development
  2. Indicators of the Efficiency of Development by Sectors. These indicators help monitor and evaluate national development in the various sectors against the plan's major strategies.
  3. Indicators of the Efficiency of Development Strategies (EDS). These indicators are used to monitor and evaluate the success of the development strategies proposed in the Eighth NESD plan.

4. Indicators of Organizational Efficiency. These indicators emphasize the delegation of administrative authority to local and regional agencies, together with the cooperation of all parties concerned in national development for better performance.
5. Indicators of Actual Situation. These indicators show the success and effectiveness of national development.

4.2.2 The Environmental Information Systems (EIA)

EIA have been established and improved by OEPP. EIA in Thailand is required for big projects such as Drainage/Irrigation, Mining/Quarrying, Dams/Reservoirs, Thermal Power, Land Transport, Railways, Airports, Ports/Harbors, Tourism/Resort Development, Industrial Estates, and Industries. In the small projects, the environmental quality standard is applied.

4.2.3 The Environmental Quality Standard (EQS)

EQS is established by the OEPP. It includes three major sets of standards:

1. the national ambient air quality standards
2. the marine water quality standard in Karon Bay, Phuket province
3. the quality of inland surface water in Chao Phraya River basin.

Moreover, it has a standard for industrial effluent and emission, drinking and groundwater, smoke emission from motor vehicles, industrial waste treatment, and product and technology.

4.2.4 The Environmental monitoring system

This system has been considerably improved by controlling, monitoring and management of water quality.

4.2.5 The Environmental database

This database owned by the OEPP providing the numeric, descriptive, and GIS data of natural resources and environmental situation of 75 provinces (except Bangkok).

4.2.6 The Polluter-Pays-Principal concept (PPP)

This concept is being used by the Pollution Control Department. This concept uses as a fundamental allocation of costs but not automatically as a principle of allocation of responsibility. Costs incurred to avoid, remove and compensate damage should be allocated to the parties responsible. This also serves to avoid distortions in competition. Where no allocation of costs is possible because the individual polluter cannot be identified, the costs must, exceptionally, be borne by the community as a whole in line with the principle of "common burden."

# CHAPTER 5

# CONCEPTUAL FRAMEWORK FOR NATUAL RESOURCES MANAGEMENT AND ENVIRONMENTAL POLICY FORMULATION

There are many approaches that could use as communication tools to simplify information. One of them is indicator. Indicator mediates between scientific communities and decision-makers/policy-planners. One might say that science provides the supply side while decision-makers or policy-planners provide the demand side of indicator work. Scientific data are too complex and remote for public and private decision-makers and policy-planners. Indicators translate scientific information into policy influencing tools. At the same time, indicators help translate public needs into measurable components. Indicators will draw the best available information including traditional knowledge locally derived as well as the results of more strictly defined scientific studies.

Environmental indicators are indicators that use to communicate information about the environment and draw attention to the effectiveness of current policies. They are now widely used in many public and private organizations worldwide. The demand for environmental indicators originated by the Organisation for Economic Co-operation and Development in 1980s. The growing concern over environmental issues led to the needs for more comprehensive and reliable environmental information. The Canadian government initiated to develop environmental indicator concept in late 1980s. In 1987, Dutch government launched similar work. However to interpret the large quantities of environmental data was not easy. The OECD's member countries called for a more

systematic and effective integration of environmental and economic decision-makings as a means of contributing to sustainable development. This request was further reinforced at the G-7 Economic Summit in Paris in July 1989 and in Houston in July 1990.

In 1991, the OECD Council approved a Recommendation on Environmental Indicators and Information to "further develop sets of reliable, readable, measurable, and policy-relevant environmental indictors". This commitment was reiterated at the meeting of OECD Environment Ministers in February 1996. The indicator work in the OECD is being undertaken in close co-operation with member countries, and in conjunction with similar efforts in other international institutes, as a follow-up to the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, in June 1992. The discussion on this work among OECD member countries have noted that it is important for OECD to give a lead in establishing a key set of environmental indicators. In establishing indicators, the OECD was fostering the development of broadly consistent indicator definitions and methods of measurement among member countries and encouraging countries to share in their experience of developing indicators for policy analysis.

Meanwhile the World Resources Institute initiated the environmental indicator researches in the late 1980s. In 1992, WRI held an international workshop on environmental indicators to discuss concepts, methods, and tentative approaches. By 1994, the number of conferences and workshops on environmental indicators had grown enormously.

The very fundamental concept of environmental indicator arise from the pressure-state-response framework in which human activities are seen as producing pressure

which may affect the state of the environment, to which societies then response if the resultant changes are perceived to be undesirable. To clearly understand of how indicators can provide us the answer of what is happening to the sate of the environment or natural resources? Why is it happening?, and what are we doing about it?, the Pressure-State-Response Framework should be mentioned in advance.

### 5.1 The Pressure-State-Response Framework

The PSR framework initiated by the Organisation for Economic Co-operation and Development. This framework is based on a concept of causality. The causality can explain in the reasonable way that human activities exert pressures on the environment and changes its quality and the quantity of natural resources. Society responds to those changes through environmental, general economic and sectoral policies. The baseline concept of the PSR framework can be explained by the concept of the environmental cycle that developed by Hamilton (1991) as shown in Figure 4.

This cycle consists of objects (socio-economic system, the environment, and the population) and two-way interactions between and/or within objects. In this concept, the environment is a physical living space for the population, in which space people are exposed to physical, chemical, and biological factors. Population causes disturbances to the environment directly and through the socio-economic system. The environment provides space, raw materials, and energy to the socio-economic system and receives physical changes and pollution in return. Societal response leads to recycling and repair. The population receives goods and services from the socio-economic system, in exchange for human resources and organization. Those driving forces can change environmental

conditions. One-way interaction is a communication that happens only within object itself. One-way interaction can be shown as the demographic process for population, the natural restoration for the environment, and investments and technological changes for the socio-economic system.

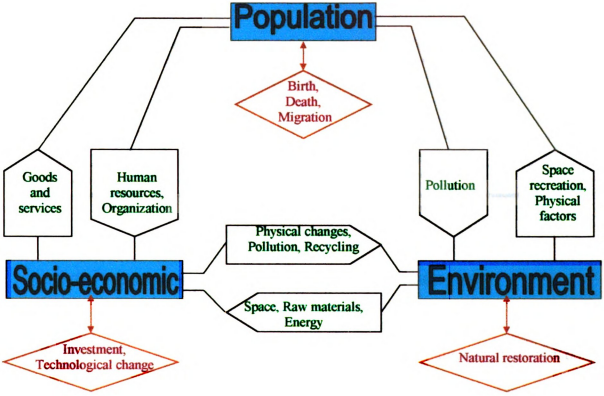


Figure 4 Environmental, Socio-Economic, and Population sub-systems

(Source: UNEP, 1994)

From this fundamental concept of the interaction between objects (population, environment, and socio-economic system), the pressure-state-response framework is well established.

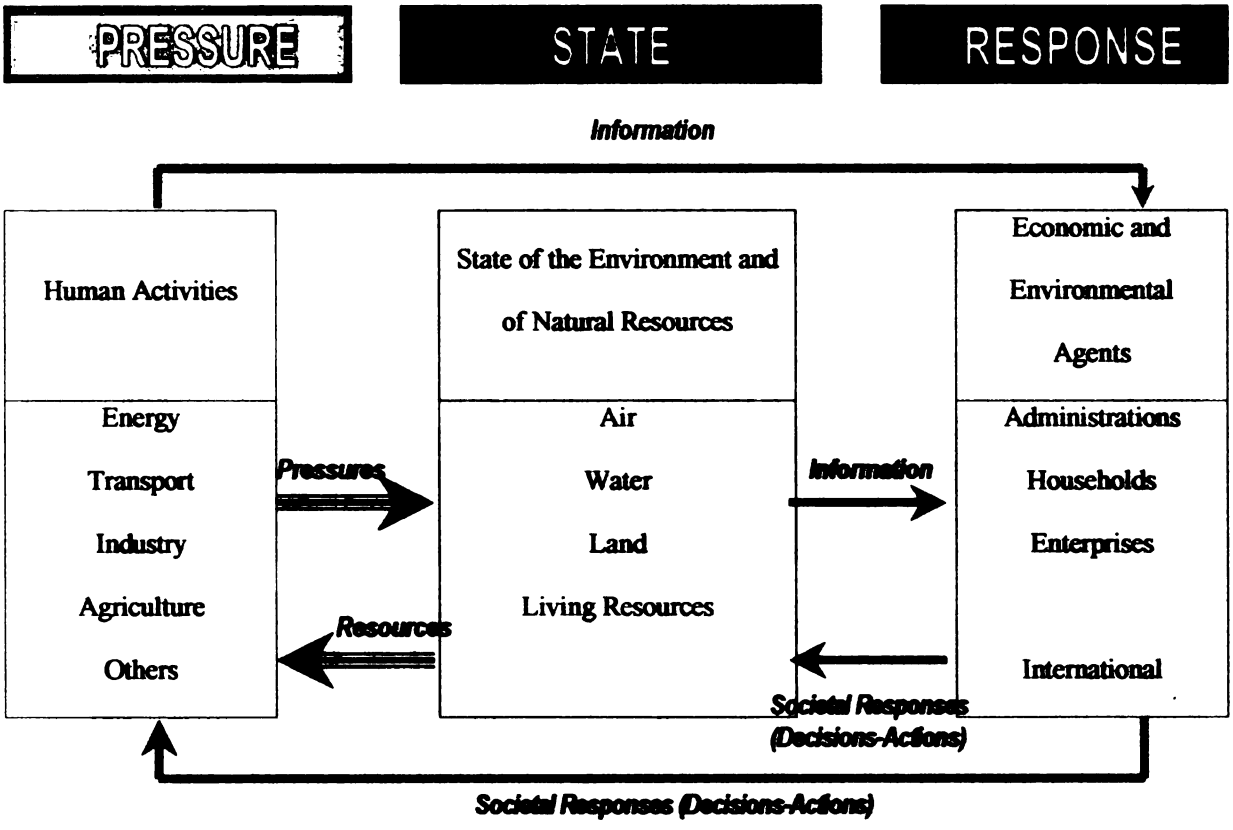


Figure 5 The Pressure-State-Response Framework (Source: OECD, 1994)

From figure 5, human activities such as energy consumption, transportation, industry, and agriculture are seen as sources of stresses[1] to the state of environment. The water contamination, land degradation, and living resources deteriorate will be occurred if the contamination or use exceeds the nature's carrying capacity. The economic and environmental agents such as government, communities, enterprises, or international organizations will examine all information happened and produce public policies to be used as a response of the society.

[1] Stresses are direct and indirect pressures. Direct pressures are, for example, emissions or discharges of pollutants. Indirect pressures are, for example, population growth and economic development.

In this research, the PSR framework will be applied to the OEPP's Environmental Information Database to categorize all information to fit into the PSR framework. The pressure will be extracted from the main problems reported in the questionnaires as a qualitative information. Those problems relate to the negative human activities on the natural resources and environment. The state will be extracted from the number or quantitative information from the computer database to show the situation happened over time. And the response will be formulated from the idea of Thailand's National Economic and Social Development Plan, The National Quality Conservation and Promotion Act, Thailand's Action for Sustainable Development for Agenda 21, and the Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality, 1997 – 2016. All those policies have reflected the societal responses in the way they need to have those problem solved

**5.2 The Indicators framework**

The word "indicator", from the Latin verb *indicare*, means to disclose or point out, to announce or make publicly known, or to estimate or put a price on. Several organizations defined a definition of indicator, mostly in the same way. The booked entitled "Environmental Indicators: A systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development" published by the WRI, 1995 defined a meaning of indicator as " something that provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable". While the book entitled "Environmental Indicators" published by the OECD, 1994 defined indicator as " a parameter, or a value derived from

parameters, which points to, provides information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value".

Indicators and aggregated indices lie on the top of the information pyramid. Indicators extract from analyzed data, which come from the base of the pyramid, primary data.

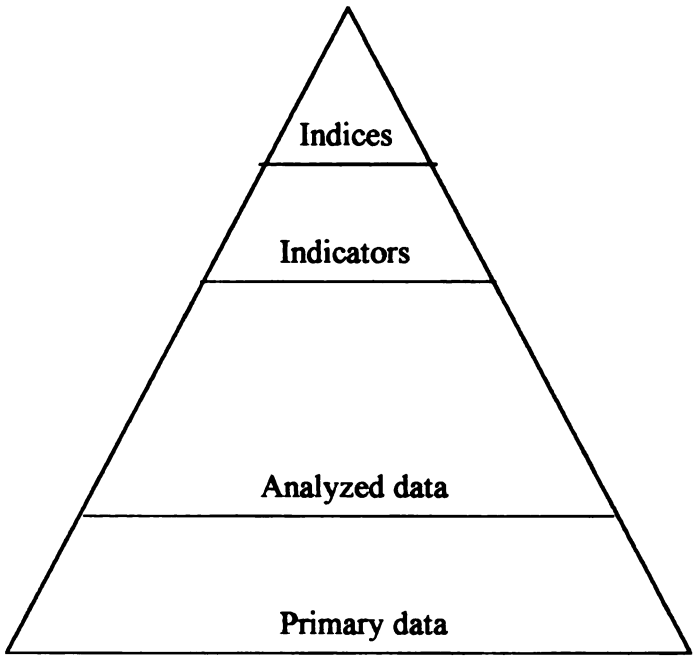


Figure 6 The information pyramid (Source: Hammond, 1995)

Schultink (1999) elaborates a hierarchical information flow using various indicators for development planning and public policy formulation as shown in figure 2.

From figure 2, precise primary data lead to the more accurate natural resources and environmental situation the indicators can provide. Indicators help providing information in more quantitative form than only words or pictures. Those information are in the form that simpler and easier to understand than complex statistics or other kinds of economic or scientific data. Indicators also imply a model or sets of assumptions that relates the indicators to more complex phenomenon. Moreover indicators also imply a metric against which some aspects of public policy issues can be measured. Indicators must reflect changes over period of time related to the environmental problems. They must be reliable, reproducible and calibrated in the same terms as the policy goals linked to them.

From the statement above, indicators have 2 characteristics, quantify and simplify information. Indicators quantify to make significance information more readily apparent and simplify to make information easily to understand. However WRI (1995) pointed out that indicators could play a useful role to serve the social purpose of improving communication only if communication is welcomed and decision-making is responsive to information about new social issues of the effectiveness of current policies.

Moreover there are 3 more indicators characteristics mentioned by Hammond A., Adriaanse A., Rodenburg E., Bryant D, and Woodward R., 1995:

1. User-driven. Indicators must be useful to their intended audience. They must transport meaningful information to decision-makers in a readily understandable form. Indicators must be crafted to reflect the goals a society needs to accomplish.

2. Policy-relevant. Indicators must be fit to policy concerns. Not only just technically relevant, but also easily interpreted in term of environmental trends or progress toward national policy goals.
3. Highly-aggregated. The final indices must be few in number otherwise decision-makers and the public will not readily to absorb them. How much indicators should be aggregated depends on who is to use them and for what.

From the meanings and characteristics of indicators, their goals can identify as to communicate information about the environment particularly the problems and their related effectiveness current public policies.

There are 3 types of indicators retrieving from the PSR framework:

1. Indicators of environmental pressure: as shown in the pressure box of figure 5. These indicators illustrate causes or pressures from human activities that directly and indirectly affect the environment in both quality and quantity. In other hand, these indicators measure environmental stresses and also policy effectiveness. They provide direct feedback on whether or not policies meet stated goals because they are based on measures or model-based estimates of actual behavior. These indicators are very useful in formulating policy targets and in evaluating policy performances.
2. Indicators of environmental conditions: as shown in the stated box of figure 5. These indicators represented the observable changes of the environment in both quality and quantity or showed the "state" of the environment particularly the declining as a result of human activities such as deforestation,

fishery overexploitation. Meanwhile these state indicators showed the causes of environmental problems such as air pollution, water contamination, and natural resources depletion. These indicators measure environmental stress.

3. Indicators of societal responses: as shown in the response box of figure 5. These indicators showed the need to which society is responding to environmental changes and concerns or the effort of society to improve environment or mitigate degradation. These indicators measure how policies are implemented by, for example, tracking budget commitments, treaty agreements, and regulatory compliance.

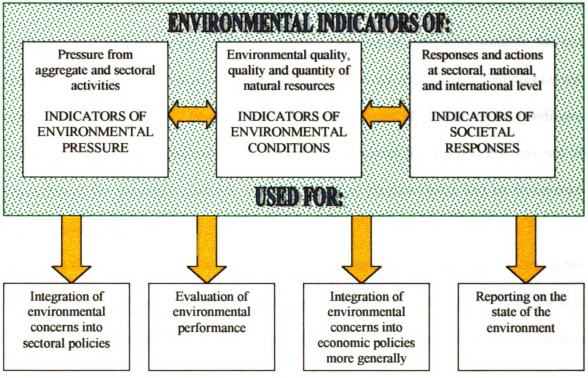


Figure 7. Environmental Indicators (Source: OECD, 1994)

From the 3 questions mentioned earlier; what is happening to the state of environment or natural resources? Why is it happen? And What are we doing about it?, we now discover that the indicators of environmental conditions answer the first question, indicators of environmental pressure answer the second , and indicators of societal responses answer the last.

Indicators should be as simple as possible so a single measurement is usually selected for each major environmental issues. A list of issues was identified to form a matrix of environmental indicators. A list of issues is neither necessarily final nor exhaustive. The list is flexible and new issues can be added or old issues can be abandoned according to their environmental relevance. Example as shown in table 1.

The appropriate set of indicators depends on its particular use. Different users of environmental indicators have different needs. One set of indicators suitable for one function may be totally inappropriate for others such as indicators of environmental conditions may not be fully fitted to the needs for indicators of environmental conditions or environmental of societal responses. Moreover indicators for one country may not be appropriated for the other countries due to the unique characteristics and environmental conditions of each country.

In this research, only the indicators of environmental pressure will be developed because the pressure indicators are particularly useful in formulating policy targets and in evaluating policy performances. They can also used to evaluate environmental impacts of socio-economic scenarios and proposed policy measures. The results are communicated in numbers as well as in graph. It the graph, it may show the time series for a particular issue in which we can see the annual volume changes in each issues.

Table 1. Matrix of environmental indicators (Source: OECD, 1994)

| Issues | PRESSURE | STATE | RESPONSE |
|---|---|---|---|
| Climate change | | | |
| Ozone layer depletion | | | |
| Eutrophication | | | |
| Acidification | | | |
| Toxic contamination | | | |
| Urban environmental quality | | | |
| Biodiversity | | | |
| Landscapes | | | |
| Waste | | | |
| Water resources | | | |
| Forest resources | | | |
| Fish resources | | | |
| Soil degradation (desertification & erosion) | | | |
| General indicators | | | |

# CHAPTER 6

# DEVELOPMENT OF A CONCEPTUAL INDICATORS FRAMEWORK FOR NATURAL RESOURCES MANAGEMENT AND ENVIRONMENT POLICY FORMULATION

Environmental indicators framework proposed in this chapter is inspired by the Pressure-State-Response Framework, initiated by the Organisation for Economic Co-operation and Development. These six environmental indicator frameworks include: forest resources; water resources; land use; waste water; solid waste; and air pollution. These frameworks would identify state of the natural resources and environment, provide an overview of the pressure of human activities on natural resources and environment, and monitor the outcomes of environmental policies and key legislation. Moreover, the environmental conditions and trends that are shown by these frameworks raise a key issue for the future natural resources management and environmental policy formulation.

The environmental indicators established in this chapter are expected to be used as a framework and a tool for decision-makers and policy planners, and assist in the establishment of plans to improve natural resources and environmental quality in Thailand. The data used in this chapter are based on information available from the Environmental Information System that mainly drawn on the replies to the Thailand office of Environmental Policy and Planning's State of the Environment questionnaire. Supplementary data have been taken from other government sources such as the Royal Forestry Department and the Royal Irrigation Department as well as from selected

national reports such as the 1994 – 1996 State of Environment. Selected updates were made to ensure consistency with ongoing data.

## 6.1 Forest Resources

### 6.1.1 General information

Forest resources in Thailand can be classified into five types: evergreen forest, mixed deciduous forest, dry dipterocarp forest, and mangrove forest. The dominant type of evergreen forest is tropical rain forest covering 43 percent of total forest area. Its concentration lies in the highest rainfall zone such as in the southeast, east coasts, and along the peninsular.

The Royal Forestry Department is the major organization that takes a responsibility on Thailand's forest management. The RFD has started to develop the national forestry master plan since 1992. Besides the master plan at national level, the RFD has formulated management plans for individual protected areas since 1986. Presently, thirty-eight protected areas have management plans developed. However, not many of those management plans have been implemented.

### 6.1.2 Deforestation

The deforestation and encroachment of Thailand's forest has occurred for many reasons including:

- Forest land conversion for agricultural, industrial production use, domestic consumption, expansion of areas to fulfill expanding domestic and foreign demand;

- Widespread speculative purchase of land from local people and farmers, causing further forest encroachment;
- Pressure from increasing demand for agriculture land, due to agricultural and rural population expansion;
- Shifting cultivation;
- Certain inappropriate and unclear measures of the public sector such as infrastructure development, ecotourism promotion without appropriate ecological control, ineffective implementation of the watershed classification;
- Lack of clear forest demarcation by the concerned agencies, causing inappropriate use of forest land such as ;
- Inefficiency in forest conservation and rehabilitation of the related agencies such as ineffective enforcement of natural resource management laws and regulations, conflict between national forest policy and national land policy, and;
- The limited participation of local community and the public, due to the lack of legal support and promotion by the government such as non-systematic and non-standardize information on forest cover.

Those are the pressures that put the forest resources into the critical situation.

During 1977 – 1981 (the Fourth NESD plan), the target of maintaining forestland was revised, and protection and rehabilitation of watershed areas intensified. More extensive and comprehensive forest management plans were drawn up, and a National Forest Policy Committee was established under the fifth National Plan. A National Forest Policy was approved in 1985.

Though the policy guidelines and increasing efforts to protect the remaining forest resources, deforestation continued. At the end of the sixth National Plan (1987-1991) the country's forest area was reduced from 53 percent (170 million rais or 27.2 million hectares) of total country area in 1961 to 27 percent (85.43 million rais or 13.67 million hectares) in 1991. It is expected to decline continuously in the future, even though the logging concessions were revoked and logging banned nationwide in 1989, about 6.18 million rais (1 million hectares) of forest were destroyed within 4 years (1989 - 1991).

At the beginning of the seventh National Plan (1992-1996), the forest cover area decreased from 26 percent (83 million rais or 13.28 million hectares) in 1993 to 25.62 percent (82 million rais or 13.12 million hectares) in 1995, eventually. Thailand lost about around 50 percent of her forest area within 34 years from 1961-1995 or 2.58 million rais per year (0.41 million hectares). In this planning period, the government revised its target of conservation forests from 30 percent of the total land area to 40 percent.

Thailand now is in the eighth National Plan (1997-2001). The government still maintains the target for forest area at 40 percent of the country's total area.

### 6.1.3 Reforestation

The history of reforestation in Thailand begins in 1906. In that year, the Royal Forest Department established its first teak (Tectona grandis) plantation by dibbling seeds on a shifting-cultivated area in the north. Sixty years later, the Forest Industry Organization and Thai Plywood Co. Ltd., which are state enterprises, started their own forest plantations for commercial purposes. The same activity has been undertaken by

the private sector in the last decade. In 1993, the total area reforested of which 83 percent is owned by the state and state enterprises and only 17 percent by the private sector. Based on area planted, the four most important tree species are teak (T. grandis), followed by two local pines (Pinus kesiya and P. merkusii), and an eucalypt (Eucalyptus camaldulensis).

Due to the rapid decline of the forest cover area and unsuccessful of the prior reforestation program under the manipulation of public sector, the Royal Golden Jubilee of His Majesty the King's Accession to the Throne's Reforestation Project was launched in 1994. The project will last for 3 years (1994 – 1996). The aim of this project is to restore the forest area as a well-wishing present to H.M. the King on his Royal Golden Jubilee in 1996. The target amount of the reforestation area is 5 million rais (0.8 million hectares) by 1996, 1.5 million rais (0.24 million hectares) in each 1994 and 1995 and 2.0 million rai (0.32 million hectares) 1996. There were many public and private organizations, NGOs, communities, and local people participate in this program. By the end of 1996, around 1 million rais were restored.

Beside the Royal Golden Jubilee of H.M. the King's Accession to the Throne's Reforestation Project, the Royal Forestry Department's project aimed to reforest 160,000 rais (25600 hectares) per year during 1993 – 1994.

Table 2 The forest areas from 1991 – 1999 (Source: The Thai Royal Forestry Department)

Unit: million rais

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Target area | 96.30 | 96.30 | 128.4 | 128.4 | 128.4 | 128.4 | 128.4 | 128.4 | 128.4 |
| Existing forest area | 85.43 | 84.13 | 83.47 | 83.03 | 82.75 | 81.9 | n.a. | 81.07 | n.a. |
| Deforestation area | 1.5 | 0.86 | 0.65 | 0.65 | 1.19 | n.a. | n.a. | n.a. | n.a. |
| Reforestation area | 0.20 | 0.20 | 0.21 | 0.37 | 0.34 | 0.30 | 0.04 | 0.05 | n.a. |

### 6.1.4 Forest Resources Indicators

To maintain the greatest sustainable benefit of forest resources for future generations, humans should economically harvest forest while maintaining an ecological balance between forest demand and depletion. The excessive use of forest affects the long-term production and restoration capacity. The OECD (1994) said "to be sustainable, forest management will have to strive for optimal harvest rate" (p.106). The forest indicator presents in this research relies on the sustainable forest management concept, the deforestation rate should not exceed the restoration capacity.

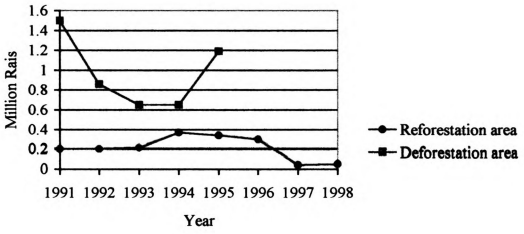


Figure 8 The comparison between reforestation area and deforestation area from 1991 – 1998 (Source: The Thai Royal Forestry Department)

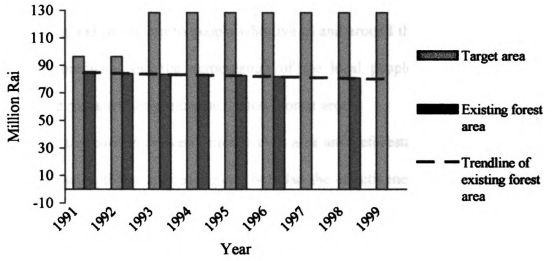


Figure 9 The comparison between the existing forest area and the target from 1991 – 1999 (Source: The Thai Royal Forestry Department)

Thailand deforestation rate during 1990s is still high compare to the reforestation rate. Deforestation rate is decreasing in the first 4 years while the reforestation rate is increasing. In 1991, the gap between deforestation area and reforestation area is large but after the RFD started developing the national forestry master plan in 1992, combined with the Royal Golden Jubilee of His Majesty the King's Accession to the throne's Reforestation Project in 1994, the gap is getting smaller. Unfortunately the deforestation is getting higher in 1995 and expected to be higher for the rest of 1990s. From that result, the trendline of the existing forest area shown in figure 9 is declining.

The gap between the target forest area and the existing forest area is getting larger. Not only the strong enforcement for administration and management of forest resources, but also the accelerated reforestation and rehabilitation of degraded forest area could be needed. The extension of national parks, wildlife sanctuaries and no-hunting areas are necessary to meet the target. Moreover the training program on forest conservation and protection to people who live in and around the forest area, the use of non-wood products, and the participation of the local people in formulation forest policies and plans will help increase the total forest area.

The comparison between reforestation area and deforestation area represents not only the existing forest area each year, but also the effectiveness of forest policies and regulations. Though the Thai government has launched several directed and related laws concerning the forest area, the deforestation rate is still increasing while the reforestation rate is decreasing. The reviewing and revising of all plans could be done promptly. The allowance of all utilization of national reserve forests by private sector individuals or

companies and the problem of people occupying the protected areas could be reconsidered.

## 6.2 Water Resources

### 6.2.1 General information

Water is a renewable resource, though it is replenishable but depletable resources. Water is used for many purposes and is considered essential to most human endeavors. Human needs water approximately 2 liters per day and it is much more consumption rate in developing countries, 45 liters per person per day (Eblen A., 1994). Moreover human utilizes water in many ways such as agriculture, industry, and power generation.

The major source of the fresh water resources in Thailand is precipitation. However, only some precipitation is stored in the natural and artificial water reserve areas. Most losses occur as a result of evapotranspiration flow directly into the sea or ocean. The major uses of fresh water for Thai people are consumption, irrigation, hydroelectric power generation, industrial and commercial use, recreation, and agriculture. Agriculture consumes the largest portion of the fresh water supply. During the dry season, the limited supply of water has to be allocated between different uses, including agriculture, power generation, prevention of seawater intrusion, and raw water supply for piped water production. There are no standard criteria for water allocations during the dry season but normally the typically priority is given to power generation and urban uses.

The pressure of excess need on water lead to water use conflicts. There are many organizations responsible for water supplies. The Royal Irrigation Department in

Ministry of Agriculture and Cooperatives is the agency responsible for irrigation management. The Department of Mineral Resources, the Office of Accelerated Rural Development, the Department of Civil Works, and the Department of Health are agencies responsible for groundwater.

Thailand does not yet set any targets for fresh water resource need and supply. However the goal for water resources development mentioned in the Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality, 1997 - 2016 is to systematically develop, conserve, and rehabilitate water resources, both surface and ground water, in all watersheds in order to ensure sufficient quantity and acceptable quality, and of sustainable use.

### 6.2.2 Water Supply

Each year Thailand obtains an average of more than 800 billion cubic meters of rainwater. Runoff produces 200 billion cubic meters of surface water. Thailand has 26 large dams and reservoirs that have total storage capacity of 66 billion cubic meters but in reality, the maximum storage capacity of those dams and reservoirs is only 43 billion cubic meters. Meantime the potential to develop additional large dams and reservoirs is now very limited due to the physical limitations and growing environmental concerns.

The volume water from rainfall is unpredictable. In Thailand, the precipitation during 1989 – 1993 declined continuously from the mean rainfall amount of 1961 – 1993 periods. Moreover the volume of water from the river is not stable throughout the year, with about 85 percent of stream flow during in the wet season, but only 15 percent in the dry season. Water need for all sectors is at its peak during water shortages during the dry

season and has become increasingly severe. Water use conflicts have now become evident. The water supply has to be allocated between different uses, including agriculture, power generation, prevention of seawater intrusion, and water supply for piped-water production. Priority has thus far been generally given to power supply and urban uses.

Thailand defines availability of drinking-water supply as the ability of household to gain access to safe drinking water within one kilometer from the village. The groundwater availability varies from more than 100 – 300 cubic meters per hour in the central region of the country to less than 5 cubic meters per hour in some areas of the Northeast. Ground water is the most important source of clean water drinking for many villages in Thailand. Though rural households are encouraged to store rainwater for domestic use, in 1992 more than 28,000 villages suffered from drought and acute shortages of drinking water.

### 6.2.3 Water Need

While development of water supply is reaching its limit, need for water constantly increases. Due to the rapid economic and population growth in the past few decades, water consumption both surface water and ground water increased instantly from 21 billion cubic meters in 1980 to 43 billion cubic meters in 1990. Of this, 40 billion cubic meters was used in agriculture, 2 billion cubic meters for domestic uses, and 1 billion cubic meters for industries.

The water need trend is increasing year by year while the potential of surface and ground water development in natural and artificial areas is decreasing. The amount of

rainfall each year is expected to recline while the need for domestic use of water, for both rural and urban sectors, is expected to be between 4 to 4.5 billion cubic meters in the year 2000. Moreover, need for water in industrial sector will reach about 2.4 billion cubic meters in the same period. Though economic and social structure changes will result in water consumption pattern, irrigated areas will remain important to increased agricultural productivity. Unless there is a change in land use in irrigation areas, demand for water in agriculture will remain high. Thus, competition for water for different uses will intensify in the next century.

Table 3 The water resource need and supply from 1991 – 1999 (Source: The Thai Royal Irrigation Department)

Unit: billion cubic meters

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Need | 43.00 | n.a. | 52.60 | n.a. | n.a. | 75.43 | 87.00 | n.a. | n.a. |
| Supply | 21.63 | n.a. | 14.87 | 73.11 | 29.23 | 41.10 | 37.74 | n.a. | n.a. |
| Difference | 21.37 | n.a. | 37.73 | n.a. | n.a. | 34.33 | 49.26 | n.a. | n.a. |

### 6.2.4 Water Resources Indicators

Human population and their activities related to water are increasing over time. Unfortunately usable water supply for human is limit due to the water storage capacity. The water use conflict is becoming more severe.

The fundamental idea for a water resources indicator suggested here is, therefore, the rate of withdrawal of water not to exceed the renewal of the stocks over an extended period.

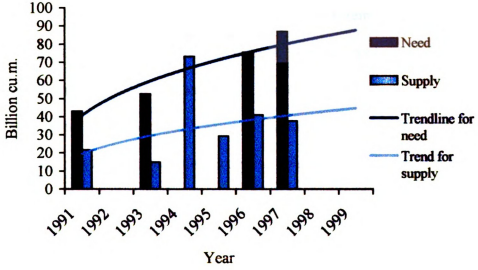


Figure 10 Water need and supply from 1991 –1999 (Source: The Thai Royal Irrigation Department)

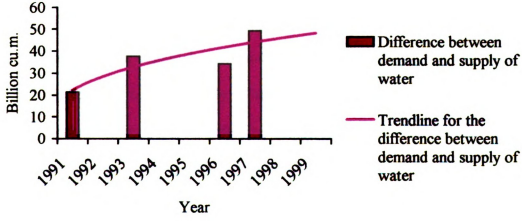


Figure 11 The difference between demand and supply of water from 1991 – 1999 (Source: The Thai Royal Irrigation Department)

The gap between water need and supply is rapidly increasing during the 1990s. At the supply side, rainfall is the ultimate source of water. The more people can store water from rainfall, the more supply of water people have. The amount of water available for human use depends on the availability of water containment system such as forest and natural ponds as well as on man made system such as dams, dikes, pools, and reservoirs. Because of the deterioration of the water containment system, the infiltration capacity has declined. The man made system has reached its peak because suitable sites for building big dams were exhausted. Moreover, environmentalists have continuously protested big dam construction projects. Water supply from both systems has reached their limit.

The water need in 1997 is doubled from that of 1991. The water need trendline is increasing. There are three main sources of water need: agriculture; industry; and household uses. While industry and household water need continues steadily throughout the year, agriculture water need occurs only during planting season. Though the level of water need for agriculture is low during dry season but the total need increases over time.

Thailand clearly needs a more efficient water management system. Water resources allocation among 3 major activities: agriculture; industry; and household uses could be allocated more efficiently. The water fee reconsideration is necessary to use the price mechanism to promote effective water use. However water production cost, categories of users, and opportunity cost of water resources could take into account. Recycling of water is another way to help increase water use efficiency and decrease water need. Meanwhile, public awareness of the value and importance of water resources and their responsibility for its efficient utilization could be enhanced. Improvement of

agricultural management practices that do not degrade ground water could be encouraged. Integration of measures for the protection and conservation of potential sources of water supply, including inventorying of water resources, with land use planning, forest resource utilization, protection of mountain slopes and riverbanks and other relevant development and conservation activities could be implemented. In combination, they will lead Thailand to sustainable development, management, and use of water resources in the future.

## 6.3 Land Uses

### 6.3.1 General Information

Thailand has land area of approximately 321 million rais or 51.4 million hectares. Half of its total area used for agriculture. While supply of land is limited, Thai population is constantly increasing. Not only the inappropriate and in efficient uses of land, but also physical soil deterioration are the pressure on land use. These problems with the lack of knowledge on land use planning and management have resulted in the problems of food production and food security, deforestation, encroachment on wetland and land that is marginally suitable for cultivation, inequality of land occupation, etc.

Until recently, nearly all the new population in Thailand was absorbed into the agricultural sector. Expansion of agriculture was mainly through clearing forests to create new farmland. This led to serious land pressures, starting in the late 1960s and early 1970s. Since the 1960s, Thailand promulgated many laws intending to conserve the

remaining forests.[1] Enforcement has been problematic. Forest areas in Thailand declined steadily while agricultural land is increasingly overexploited and degraded.

Increasing scarcity of new agricultural land and deterioration of land already being used forced the country to seek more efficient utilization of the resources. Over a decade ago, Thailand introduced several policies to increase efficiency of land use and conservation. They include:

- Land security

Three major programs are being implemented in the 1990s to enhance land security:

1. Accelerated land-titling to encourage more efficient land use and to increase long-term productivity. Thailand has been implementing an accelerated land-titling project with the World Bank loans since 1985. This project aims to provide land titles for all privately held non-forest land within 20 years. In the first 10 years, the land-titling project completed work on about 20.1 million rais (3.22 million hectares) out of 87 million rais (13.92 million hectares) of land requiring titles. Though still short of the target, the area covered by land titles in past decade came to more than one-third of that allocated in the previous 100 years.
2. Land acquisition. In 1990 Thailand set up a land acquisition fund with the objectives to purchase land for the landless. The landless will then repay the owner over a long-term period at low interest rates. Since

[1] The Wildlife Reservation and Protection Act of 1960 (revised 1992), the National Park Act of 1961, and the National Reserved Forest Act of 1964

the commencement of the program in 1991, about 27,000 rais (4,320 hectares) of land for 1,000 landless farmers in 41 provinces have been acquired.

3. Land reform. Thailand agricultural land reform program began in 1975. Initially intended to help tenant farmers become owners of the land they farmed. It soon became apparent that few of the original owners were willing to sell their land voluntarily at low rates, and few of the tenant farmers could afford to buy the land. The land reform program then turned its attention to another serious land problem, forest encroachment. To keep people settle and prevent further encroachment, the land reform program began to provide usufruct rights[2] to the small holders who were working in degraded forest area. By 1994, usufruct rights to about 8 million rais (1.28 hectares) were allocated. Under government policy, all 44.5 million rais (7.12 hectares) of degraded reserve forest land will be degenerated as forest area and transferred from the control of the Royal Forest Department tot he Agricultural Land Reform Office to survey and distribute usufruct rights tot he farmers.

- Land Use Planning

The major land use planning in Thailand is classification of land and soil surveys used to support agricultural economic zoning to identify crop potential. Land classification in Thailand was completed in 1988 and soil surveys in 1991.

- Land development

  There are many inappropriate land use and land quality problems widespread in Thailand. One of the major problems is soil erosion. The Department of Land Development is responsible for soil surveys and analysis to assess natural fertility and crop potential, carry out rural land classification, implement rural land development projects, and conduct rural land censuses and economic assessments.

His Majesty the King has long been concerned about land use. In 1994, His Majesty the King delivered his thoughts on a " New Theory of Integrated Farming" to the public. This concept is simple and effective type of sustainable agriculture. Land resources are allocated carefully to ensure full exploitation of their capacity. On a small farm, all necessities for the family are produced: rice, fish, fruit, and meat. The system improves soil fertility by mixing crop production with livestock raising, including trees and fruits trees. Where conditions are adequate, a small farm of 15 rais (2.4 hectares) can provide a family's nutritional requirements, and cash income can be earned from various farming activities. Land is divided for paddy, field crops, horticultural crops, and water pond. A pond having the size of 3 rais (0.48 hectares) with 4 meters depth can collect water up to 10,000 cubic meters in the dry season. This amount is enough to grow rice, field crops, and horticultural crops, and for home use. The new concept has been demonstrated and disseminated in the appropriated areas. Monitoring and assessment of its implementation are being conducted.

At present, all land suitable for agriculture has been used. Fifty seven percent has soil quality problems such as saline soil and desertification, resulting in significant

[2] Legal right to use and enjoy the benefits and profits of land belonging to the government

investment costs; difficulties in soil management; and soil degradation. Those problems lead farmers to find new productive agricultural land, which turns to be a forest area.

Table 4 Land uses from 1991 – 1999 (Source: The Thai Royal Forestry Department)

Unit: million rais

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Forest area | 85.43 | 84.13 | 83.47 | 83.03 | 82.75 | 81.9 | n.a. | 81.07 | n.a. |
| Farm holding area | 133.27 | 132.57 | 131.55 | n.a. | 131.87 | n.a. | n.a. | n.a. | n.a. |
| Other land | 102.30 | 104.30 | 105.98 | n.a. | 106.38 | n.a. | n.a. | n.a. | n.a. |
| Total | 321.00 | 321.00 | 321.00 | 321.00 | 321.00 | 321.00 | 321.00 | 321.00 | 321.00 |

Remark: 1. Farm holding area means housing area, paddy land, field crop, fruit tree and tree crop, flower and vegetables crop, and livestock farm.

2. Other land is the balance of land area taken from total land minus Forest area and Crop land, there are degraded national forest reserves, swamp land, sanitary district area, municipal area, railroads, highways, real estate, public area, etc.

### 6.3.2 Land Uses Indicator

Land use choices are made by people or institutions who own or control the lands, but those choices may be affected by a number of factors. These include the physical and biological qualities of the land themselves, the cultural of land use, the economic situation, the legal and institutional framework for controlling land use. As these factors

change, people tend to adjust land uses. Over the long term, it is critical that land uses remain consistent with the physical and biological capacity of the land itself to be sustainable over the long-term.

Growing population is another factor that leads to ineffective land use. Increasing human requirements on land and economic incentives are placing an increasing pressure on land resources, creating competition and conflicts in land uses. Therefore, the land use indicators suggested here addresses land use changes over time.

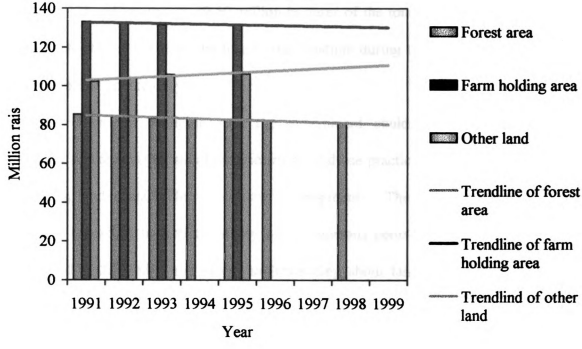


Figure 12 Land uses from 1991 – 1999 (Source: The Thai Royal Forestry Department)

Farm holding area[3] occupies the most land used in Thailand in the 1990s and the trendline is slightly declined. The trendline of the other lands comprises of degraded forest area, swampland, sanitary district area, municipal area, highways, real estates, and public area, is increasing in a slow rate. Meanwhile, the forest area is decreasing over time.

From the figure 12 above, there is slightly change between forest area and the other type of lands. It is possible that forest areas are converted to be the other land use such as residential, commercial, and industrial areas or even turned to be degraded forest areas and agriculture areas, eventually. While the government set the target area of forest at around 128 million rais or 20.50 million hectares of the total area of the country, 321 million rais or 51.4 hectares, the forest area trendline during the 1990s is decreasing at the rate around 5 percent a year.

To slow the changing rate, the government could pay more attention on promoting and supporting suitable agricultural land use practices based on soil capacity, economics, and sustainable agriculture development. The promotion of land use efficiency according to land capability and indigenous people's requirement could be encouraged. Knowledge and proper understanding about land use and land resources management could be delivered to local people. Land suitability could be carried out promptly along with the revision of land classification. Reforestation and forest rehabilitation program could be accelerated.

However one of the fundamental constraints that may affect the effectiveness of land use is overlapping responsibility among agencies or institutes. Land resources are

[3] Farm holding area means housing area, paddy field, fruit tree and tree crop, flower and vegetable crop, and livestock farm

basic input for most economic activities so the mandates of different agencies often overlap. The problem becomes more severe when the institutional objectives are contradictory. While an integrated approach among related agencies is required, Thailand unfortunately has shown a relative lack of coordination in land resource development and planning.

Another constraint to land use planning and management is the lack of long-term interest of the poor farmers. Basic needs and poverty dominates their decision making, emphasizing short-term economic benefits over concerns for long term sustainability.

### 6.4 Waste Water

#### 6.4.1 General Information

Waste water presented in this paper refers to contaminated or polluted water that degraded of natural water quality. Waste water increases substantially owing to the increasing of human population, greater per capita use for manufacturing, the use of natural waters of disposal of an increasing array and amount of waste products, and increasing use of natural resources.

The waste water indicators represented in this research focus on river water quality and present the Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), and coliform bacteria content as a degree of water quality. Each river is a representative of river in each region of Thailand: the Ping river from the northern; the Chao Phraya river from the central; the Moon river from the Northeastern; the Chantaburi river from the Eastern; and the Songkhla Lake from the southern. The Chao Phraya river that runs through Bangkok, is separated into 3 parts: upper; middle; and lower.

All living creatures under water require oxygen that is dissolved in water to survive. The amount of oxygen dissolved is usually measured as milligrams of oxygen per liter of water (mg/l). The maximum amount that will dissolve is between 8 – 11 mg/l. Thailand set the DO at the level that not less than 6.0 mg/l while most fish require at least 2 mg/l. If oxygen content drops below that value, fish killed will result. It addition, water with a very low level of oxygen is usually associated with offensive odors. The most important mechanism that lowers DO is the breakdown of organic matter. When organic waste such as sewage is discharged into water, bacteria in the water use the organic as food. If DO is present, the bacteria breakdown the waste by combining the organic molecules with oxygen yielding energy for growth. In a water body, this bacterial respiration depletes the oxygen in the water.

This bacterial respiration is so important that a standard measure of the strength of an organic waste is the amount of oxygen that bacteria will consume in breaking down the waste. This measure is called the bio-chemical oxygen demand or BOD of a waste. To protect the living creature under water and ensure minimum dissolved oxygen levels, limits are set on the amount of BOD that a sewage plant can discharge to a water body. These limits vary by the size of the water body, the amount of dilution that takes place, how fast the particular water degrades, and the temperature of the water. Thailand set the BOD at not higher than 1.5 milligrams per liter of water.

Coliform bacteria indicate presence of animal waste products. The bacteria are not necessary harmful in low concentrations but their presence is an indicator that other harmful bacteria may be present and thus water is considered polluted. Thailand set the

Coliform bacteria count at not higher than 20,000 Most Probable Number (MPN)/100 ml of water.

The Enhancement and Conservation of National Environmental Quality Act 1992 defined the term "pollution" in Thailand as "the state of environment that has been affected, changed or contaminated by pollutants, resulting in deterioration of environmental quality". Wastewater was defined as "waste in liquid state including polluting or contaminating substances contained in such liquid".

At the present time, water quality in various water sources throughout Thailand, particularly in crowded communities and developmental activities, is deteriorating due to contamination by toxic substances from human activities, including activities as a result of economic growth and industrial, agriculture, and tourism development. The physical and biological characteristics of water resources have changed, due to impacts from resource utilization, pollution, or other causes. This includes a loss of dissolved oxygen (DO), presence of bio-chemical oxygen demand (BOD), and total coliform bacteria.

The Thai government has prepared plans and already implemented the treatment and disposal of polluted water all over the country. Bangkok has constructed 7 wastewater treatment plants to serve the central part of the city. For the municipalities and important public health areas through out the country, there are 16 wastewater treatment plants under the supervision of the Public Works Department.

The OEPP had issued a mandate that polluted water should pass through the treatment process and should be reused for watering trees and grasses. Furthermore, in some areas such as Pattaya city should have water system to pump treated polluted water and to be used for irrigation purposes.

The National Housing Authority is basically responsible for the development and solving rehabilitation problems with emphasis on public utilities and public welfare of small-scale communities. Eighteen central wastewater treatment plants were constructed in the settlement areas through out the country.

The Pollution Control Department has created a policy, measures, and action plan for the management of community sewage for the whole country. Those instruments will be used in the short-term guideline (1996 – 1998), medium-term guideline (1999 – 2001), and long-term guideline (2002 onward). The Pollution Control Department also announced the Pollution Control Zone. Those areas are affected by water pollution problems and have a tendency that water pollution may cause health hazards to the public or impact on the environmental quality. These include five provinces namely Bangkok, Pattaya, Phuket, Hat Yai, and Phi Phi Island.

In 1995, a public enterprise called the "Waste Water Management Organization" was established to run a comprehensive wastewater management system in Bangkok and other areas designated by the government. In the same year, the water quality of the main rivers measurement, namely the Chao Phraya, the Tha Chine, the Mae Klong, the Bangpakong, and those in other regions, were found to be in a deteriorating state and all were below acceptable standards. The DO and BOD rates are still low and the bacterial coliforms count is very high. However when compared to the quality of water in the previous year, the situation has not significantly changed.

In 1997 the Pollution Control Department undertook a water quality survey of the country and found 14 percent of water resources in good condition, i.e., suitable for aquatic animals and general human consumption. From the survey, 49 percent of water

resources are in average condition and usable for agriculture and general consumption. The remaining 37 percent are of low quality. Water resources in Central Thailand are the most degraded, containing high levels of chloroform bacteria (especially the Chao Phraya Rivers where population and industry are concentrated). Another increasing concern is the rise of ammonium nitrates in water, indicating filth and poison from putrid foods that endangers aquatic ecosystems.

Table 5 Water Pollution in the Chao Phraya River, Central Thailand from 1991 – 1999 (Source: The Thai Pollution Control Department)

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Upper Chao Phraya River | | | | | | | | | |
| BOD (mg/l) | 1.9 | 2.3 | 1.7 | 0.8 | 1.6 | n.a. | n.a. | n.a. | n.a. |
| DO (mg/l) | 5.6 | 5.6 | 5.9 | 6.3 | 6.5 | n.a. | n.a. | n.a. | n.a. |
| Coliform Bacteria (MPN/100ml) | 23000 | 210000 | 39700 | 228000 | 402000 | n.a. | n.a. | n.a. | n.a. |

Table 5 (cont'd).

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| **Middle Chao Phraya River** | | | | | | | | | |
| **BOD (mg/l)** | 2.3 | 1.7 | 2.3 | 1.4 | 1.4 | n.a. | n.a. | n.a. | n.a. |
| **DO (mg/l)** | 1.3 | 3.8 | 4.9 | 5.0 | 5.7 | n.a. | n.a. | n.a. | n.a. |
| **Coliform Bacteria (MPN/100ml)** | 18000 | 207000 | 248700 | 144000 | 76000 | n.a. | n.a. | n.a. | n.a. |
| **Lower Chao Phraya River** | | | | | | | | | |
| **BOD (mg/l)** | 7.5 | 8.2 | 2.7 | 2.4 | 3.5 | n.a. | n.a. | n.a. | n.a. |
| **DO (mg/l)** | 0.4 | 0.3 | 1.5 | 2.2 | 1.0 | n.a. | n.a. | n.a. | n.a. |
| **Coliform Bacteria (MPN/100ml)** | 1650000 | 2020000 | 257700 | 770000 | 959000 | n.a. | n.a. | n.a. | n.a. |

Remark:

1. Standard BOD for surface water quality is not higher than 1.5 mg/l
2. Standard DO for surface water quality is not less than 6.0 mg/l
3. Standard Coliform Bacteria is not higher than 20,000 MPN/100ml

Table 6 Water Pollution in the Moon River, Northeastern Thailand from 1991 – 1999 (Source: The Thai Pollution Control Department)

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| BOD (mg/l) | 3.3 | 3.0 | 1.5 | 1.3 | 1.2 | n.a. | n.a. | n.a. | n.a. |
| DO (mg/l) | 5.5 | 7.7 | 6.6 | 5.6 | 5.1 | n.a. | n.a. | n.a. | n.a. |
| Coliform Bacteria (MPN/100ml) | 30000 | 35000 | 7200 | 70000 | 17000 | n.a. | n.a. | n.a. | n.a. |

Remark:

1. Standard BOD for surface water quality is not higher than 1.5 mg/l
2. Standard DO for surface water quality is not less than 6.0 mg/l
3. Standard Coliform Bacteria is not higher than 20,000 MPN/100ml

Table 7 Water Pollution in the Chantaburi River, Eastern Thailand from 1991 – 1999 (Source: The Thai Pollution Control Department)

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| BOD (mg/l) | n.a. | n.a. | 0.4 | 0.9 | 1.0 | n.a. | n.a. | n.a. | n.a. |
| DO (mg/l) | n.a. | n.a. | 5.7 | 7.0 | 5.5 | n.a. | n.a. | n.a. | n.a. |
| Coliform Bacteria (MPN/100ml) | n.a. | n.a. | 8900 | 11000 | 29000 | n.a. | n.a. | n.a. | n.a. |

Remark:

1. Standard BOD for surface water quality is not higher than 1.5 mg/l

2. Standard DO for surface water quality is not less than 6.0 mg/l

4. Standard Coliform Bacteria is not higher than 20,000 MPN/100ml

Table 8 Water Pollution in the Ping River, Northern Thailand from 1991 – 1999 (Source: The Thai Pollution Control Department)

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| BOD (mg/l) | 0.4 | 1.1 | 1.1 | 0.7 | 1.1 | n.a. | n.a. | n.a. | n.a. |
| DO (mg/l) | 7.0 | 7.0 | 6.4 | 6.4 | 7.1 | n.a. | n.a. | n.a. | n.a. |
| Coliform Bacteria (MPN/100ml) | 2300 | 24400 | 67500 | 13000 | 46000 | n.a. | n.a. | n.a. | n.a. |

Remark:

1. Standard BOD for surface water quality is not higher than 1.5 mg/l

2. Standard DO for surface water quality is not less than 6.0 mg/l

3. Standard Coliform Bacteria is not higher than 20,000 MPN/100ml

Table 9 Water Pollution in the Songkhla Lake, Southern Thailand from 1991 – 1999 (Source: The Thai Pollution Control Department)

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| BOD (mg/l) | 2.1 | 3.9 | 6.0 | 0.6 | 1.3 | n.a. | n.a. | n.a. | n.a. |
| DO (mg/l) | 7.0 | 5.0 | 6.0 | 6.8 | 6.1 | n.a. | n.a. | n.a. | n.a. |
| Coliform Bacteria (MPN/100ml) | 1000 | 600 | 760 | 1000 | 16000 | n.a. | n.a. | n.a. | n.a. |

Remark:

1. Standard BOD for surface water quality is not higher than 1.5 mg/l
2. Standard DO for surface water quality is not less than 6.0 mg/l
3. Standard Coliform Bacteria is not higher than 20,000 MPN/100ml

### 6.4.2 Waste Water Indicators

The fundamental concept of waste water management concept presented in this paper is that the water quality measured in the major rivers in Thailand should not exceed the Water Quality Standard.

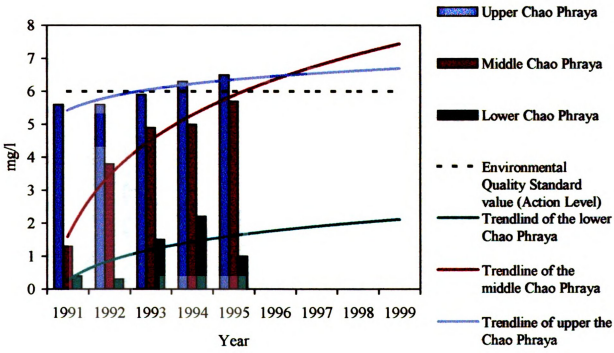


Figure 13 the DO of the Chao Phraya River from 1991 – 1999 (Source: The Thai Pollution Control Department)

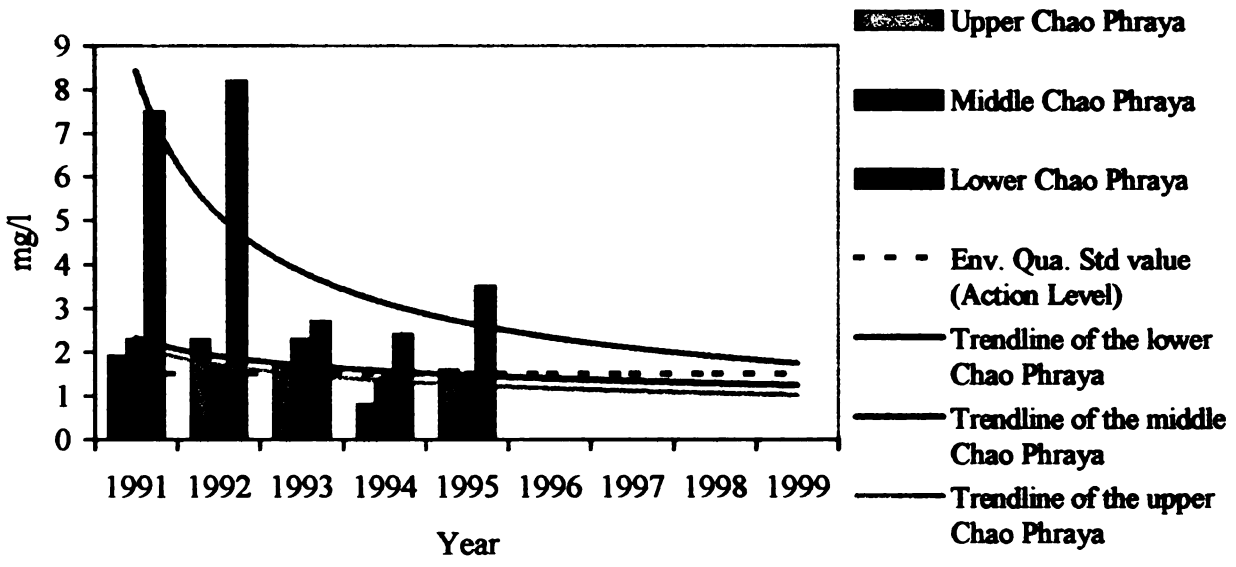


Figure 14 the BOD of the Chao Phraya River from 1991 – 1999 (Source: The Thai Pollution Control Department)

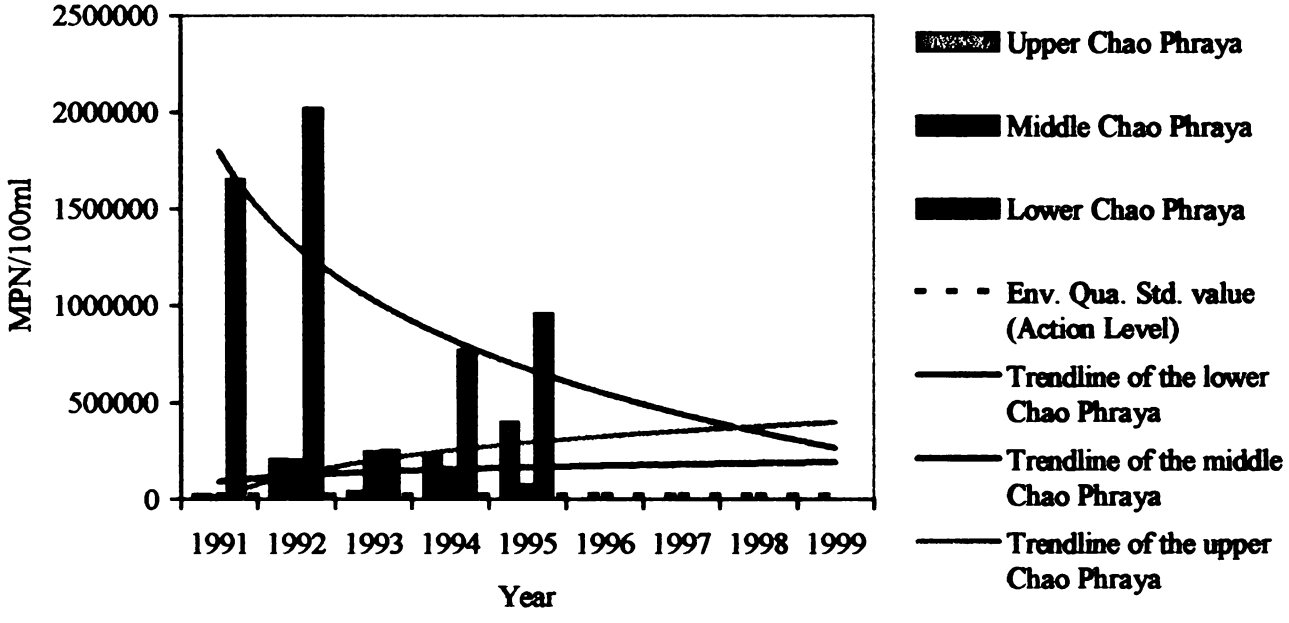


Figure 15 Coliform Bacteria of the Chao Phraya River from 1991 – 1999 (Source: The Thai Pollution Control Department)

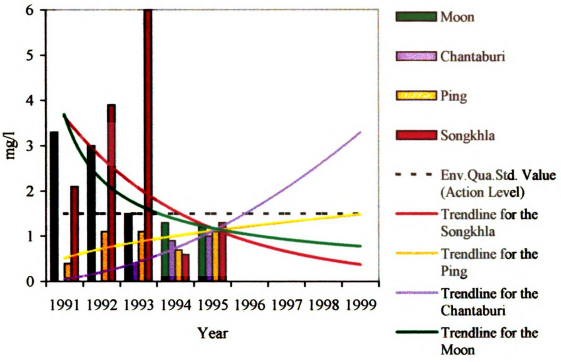


Figure 16 the BOD of major rivers from 1991 – 1999 (Source: The Thai Pollution Control Department)

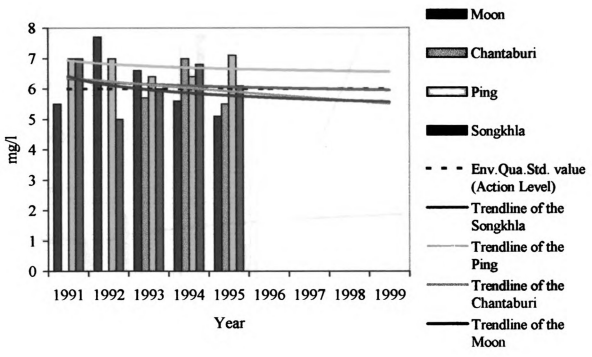


Figure 17 the DO of major rivers from 1991 – 1999 (Source: The Thai Pollution Control Department)

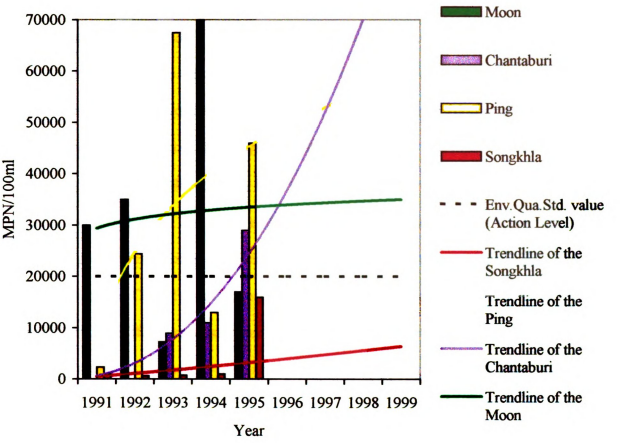


Figure 18 the Coliform Bacteria of major rivers from 1991 –1999 (Source: The Thai Pollution Control Department)

The water quality of upper, middle, and lower Chao Phraya River is good, moderately good, and bad respectively because of the crowded communities and industrial areas along the lower Chao Phraya. For the lower Chao Phraya River, BOD, which should lower than 1.5 mg/l, is much higher the standard value and the trendline is about to increasing over time. The DO, which should higher than 6.0 mg/l, has been lower than the standard value since 1992 and the trendline is decreasing through the end

of 1999. The Coliform bacteria count, which should lower than 20,000 MPN/100ml, is much higher than the standard value though the trendline is going down.

For Middle Chao Phraya River, the DO average value is over 4.0, which is considered moderately good. The BOD average is over standard and the Coliform bacteria count is high. From the report of the Pollution Control Department, the Coliform bacteria count is quite high especially from the waste water of communities and industrial areas. The trendlines of the BOD and the Coliform bacteria are quite stable but the trendlines of DO is increasing that indicate the improvement of the water quality.

For Upper Chao Phraya River, the DO average is below the standard until the year 1994. The BOD average is higher than the standard. The Coliform bacteria count is increasing due to an increase in agriculture activities along the Upper Chao Phraya River. However the DO and BOD trendlines show the improvement of water quality.

For the BOD of major rivers, only the average BOD of the Chantaburi and the Ping River are below the standard though the BOD trendlinds of both rivers are increasing over time. For the Moon and the Songkhla Lake, the BOD is much higher than the standard. However, due to the trendlins of both rivers, there are a good sign of water quality development.

For the DO of major rivers, only the average DO of the Ping River is higher than the standard. However the trendlines of those four rivers are decreasing over time, which is a bad sign for water quality conditions over time.

For the Coliform Bacteria, the Songkhla Lake shows the best condition among the others while the Moon and the Ping River show the worst condition. Trendlines of those

four rivers show the deterioration of water quality. The overall water quality of all major rivers indicates that the situation is getting worse.

From the interpretation of waste water indicators shown above, the acceleration of the rehabilitation of water quality is an important environmental quality concern that could be addressed promptly. Water pollution from communities, agriculture, and industry could be reduced. Water quality monitoring system could be applied in every major river and evaluations could be performed regularly.

The government could introduce the waste water treatment or recycling process to every community along the river. A waste water treatment plant for factories could be strongly encouraged by the government, especially with economic incentives or assistance while comparative studies on the suitability of waste water treatment methods could be conducted. The building of central waste water collection and treatment systems in every community could be encouraged and their effectiveness monitored on a regular basis.

## 6.5 Solid Waste

### 6.5.1 General Information

The amount of solid waste produced by communities nationwide in 1994 accounts for 33,000 tons per day, which increased to 34,000 and 36,000 tons per day in 1995 and 1996, respectively. Solid waste produced in Bangkok total 8,100 tons per day and the remaining waste is produced by communities within municipalities and sanitary districts nationwide. By 1999, the total solid waste produced in Bangkok are expected to be collected and disposed almost 100% while solid waste from municipalities and sanitary

districts nationwide is expected to be collected and dispose more than it used to. As a result, the amount of uncollected solid waste is expected to be diminished. Most of the disposal methods are still not hygienic and the solid waste left from the disposal process is the pressure on the solid waste situation in Thailand. Approximately seventy percent of solid waste is disposed in landfills. Twenty percent is composted to produce organic fertilizer and ten percent remaining at factories to decompose.

The amount of solid waste in Thailand has increased every year, particularly the proportion of waste, which is difficult to process. In 1997, Thailand produced approximately about 37,102 tons of solid waste each day, of which 24 percent came from Bangkok, 35 percent from other urban areas and the remaining 41 percent from rural areas.

The management of solid wastes in Thailand is being intensified to cope with the increase in waste load. The Pollution Control Department has been the main agency in developing the policy, measures, and action plans for solid waste management.

The Environmental Quality Promotion Act promulgated in 1992 is the main framework to integrate the dispersed process of domestic waste management to a more systematic approach. Several solid waste management regulations have been promulgated. Waste disposal area for each province provided by the government has been declared. All hospitals have to separate contaminated waste from domestic waste, and appropriate waste treatment facilities have been established. Municipalities are encouraged to set up waste management action plans.

The government has a policy to decentralize administrative and management authority to the province and the local to deal with the solid waste problem by utilizing

their own capacity with financial support from the government. Decentralization of resource and environmental management is the principle, which Thailand has been pursuing since the Sixth NESD plan. In the Seventh NESD plan, local administrations were encouraged to prepare sites for sanitary landfills, which were to last for not less than 5 years. The grass-roots administration unit such as the Tumbon Councils has authoritative power within their jurisdictions.

Thailand promoted solid waste management efficiency by improving existing public solid waste management and promoting private sector operation of solid waste management. The private sector also operates a pioneer industrial solid waste treatment plant. In 1996, treatment plans for hospital wastes were in operation in 333 hospitals nationwide. This accounts for about forty percent of the hospitals of the country.

Table 10 Waste Disposal from 1991 – 1999 (Source: The Thai Pollution Control Department)

Unit: million tons per year

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Waste Production | n.a. | 10.63 | 11.03 | 11.88 | 12.59 | n.a. | n.a. | n.a. | n.a. |
| Waste Treated | n.a. | 10.05 | 10.32 | 10.49 | 10.63 | n.a. | n.a. | n.a. | n.a. |
| Waste left | n.a. | 0.58 | 0.71 | 1.39 | 1.96 | n.a. | n.a. | n.a. | n.a. |

### 6.5.2 Solid Waste Indicators

Generally there are two options for solid waste disposal: long term storage systems (landfill); and conversion systems with storage for residues such as recycling, composting, energy recovery, and curbside collection system. In Thailand, the remainder of solid waste from the disposal process is left to decompose by itself. The most crucial problem with solid waste management in Thailand is that of disposal, especially the limitations of landfill sites and the problems from the solid waste left from the disposal process.

To help sustain a good quality of life, the solid waste indicators presented in this research are suggested.

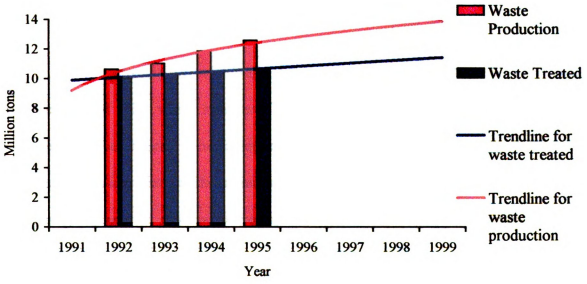


Figure 19 The amount of solid waste production and treated from 1991 – 1999 (Source: the Thai Pollution Control Department)

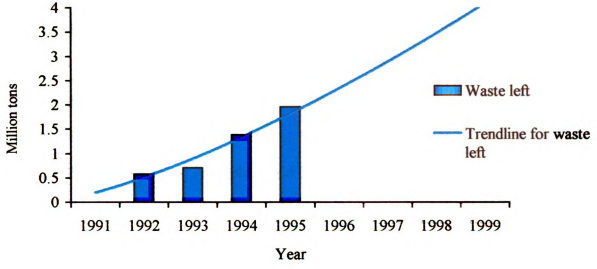


Figure 20 The amount of solid waste left from the disposal process from 1991 –1999 (Source: the Thai Pollution Control Department)

The capacity of solid waste treated is quite stable during the 1990s and the trendline of solid waste treatment is also quite stable. The amount of solid waste production each year is much higher than the amount of solid waste treated and the trendline is increasing at the increasing rate over time. The gap between the solid waste production and the solid waste treated or called the solid wasted left presented in figure 20 shows the drastic increasing rate. The solid waste to be left from the disposal process in 1999 is about fourth time the amount of 1991 and to increase rapidly over time.

Due to the limitation of the landfill sites, the generation of solid waste by the public and promote recycling of solid waste needed to be controlled. However, the development of adequate sanitary landfills and/or other solid waste management process such as incineration to serve the future disposal needs of cities is necessary. Every local

organization could prepare suitable land for the long-term disposal of solid waste including designated reserved areas for disposal. Government could take a major role in financial support on this matter such as supporting some budgets to local government to implement their solid waste management plan and providing incentives to the private sectors in solid waste management.

The Polluter Pays Principle could be applied for both the public and private organizations that generate solid waste that contributes to creating public health hazards and causes environmental degradation. The Government could encourage the private sector to take a part in the solid waste management system such as collection, transportation, and disposal by mean of contracting, joint ventures, or concessions for controlling solid waste disposal system.

Central solid waste disposal facilities are useful to provide services to several communities in close proximity to one another. The existing unhygienic solid waste disposal areas in communities throughout Thailand could be improved and rehabilitated.

## 6.6 Air Pollution

### 6.6.1 General Information

Air pollution is concerned with potentially harmful substances that are released into the air. Air pollutants can be gases, liquid droplets, solid particles, or fibers. Air pollution can arise from many different sources. Naturally occurring materials include volcanic ash, products of combustion, silica, and molds. Many natural pollutants are enhanced in concentration by human activities such as a range of materials arising from incomplete combustion. These include carbon dioxide, carbon monoxide, carbonaceous

particulate material, volatile organic compounds, oxides of nitrogen, and sulfur compounds.

Many pollutants or gases have contributed to the greenhouse effect phenomenal. The most important gases are Carbodioxide, methane, and nitrogenoxide. These gases will be accumulated in the atmosphere, increase the world temperature, and cause the change in climate. At the international scale, the Ministry of Science, Technology and Environment (1997) reported that total Carbondioxide emissions from Thailand were mainly from energy consumption and forests. It was estimated at 170 million tons or 0.65 percent of total global emission. Methane emission from Thailand was calculated at 2.9 million tons or 1.5 percent of global emissions. Thailand strongly supports global effect to protect atmosphere. Thailand contributes relatively less Green House Gases to the atmosphere by switching from fossil fuels to gases, improving mass transit systems in urban areas, implementing demand-side management of power use, accelerating reforestation of degraded forest lands, protecting conservation forests and watershed areas, and public campaigns on global environmental protection. However there are several constraints inherent in the implementation of the government's policies to protect atmosphere. The main problems are:

- Shortage of appropriate technology to apply appropriate substitution,
- Lack of sufficient studies to guide the development of local parameters for Green House Gases inventory estimates,
- The need for additional technological support to improve energy efficiency in industries, and

- Impact of policies and measures to mitigate climate change on the national economy is still unknown

Along with the rapidly expanding economy, the air pollution in Thailand has escalated during the past two decades especially major provinces in Thailand such as Bangkok, Chiang Mai, and Khon Kaen. Dust from construction, black smoke, sooth from fuel combustion, carbon monoxide, nitrogen oxides from the transport sector, and sulfur dioxide cause air pollution. These can be a health threatening. Dust in crowded communities with traffic congestion can be three to five times greater than standards. The amount of air pollutants exceed the standard are the pressure on the air quality in Thailand.

At the local level, Thailand took a very aggressive approach in the fight against air pollution in the last decade. The government launched several standards and regulations, including Ambient Air Quality Standards; Emission Standards; Fuel Quality Standards; Lubricant Quality Standards; promotion of use of unleaded gasoline; Installation of smoke filtration equipment in vehicles; examination of pollutants emit from vehicles before extending registration; and control of air pollutants from industrial factories by establishing categories of industry subject to air pollution control.

Table 11 National Ambient Air Quality Standard (Source: The Thai Department of Environmental Quality Promotion)

| Pollutant | Average Value Standards ($mg/m^3$) | | | | | Method of Measurement |
|---|---|---|---|---|---|---|
| | 1-hour | 8-hour | 24-hour | 1-month | 1-year | |
| CO | 34.2 | 10.26 | - | - | - | Non-Dispersive Infrared Detection |
| Pb | - | - | 0.01 | 0.0015 | - | Wet Ashing |
| Photochemical Oxidant | 0.20 | - | - | - | - | Chemilum-inescence |
| Nitrogen Dioxide | 0.32 | - | - | - | - | Gas Phase Chemilum-inescence |
| Sulfur Dioxide | 0.78,1.3[1] | - | 0.30 | - | 0.10[2] | Pararosaniline |
| SPM (10 micron) | - | - | 0.12 | - | 0.15 | Gravimetric-High volumn |
| SPM (100 micron) | - | - | 0.33 | - | 0.10[3] | Gravimetric-High volumn |

The National Ambient Air Quality Standards are set differently depend on the need of the public to protect their health and welfare. The United States of America Environmental Protection Agency provided the National Ambient Air Quality Standards as shown in Table 12.

[1] means 1Hour Average Standard Value = 1.30 $mg/m^3$ for area of Tumbon Nasak, Bandong, Sobpad, Jangnua, Maemao, Amphur Maemao, Lampang Province
[2] means Geometric mean value

Table 12 National Ambient Air Quality Standard of the United States of America (Source: The Environmental Protection Agency)

| Pollutant | Average Value Standards ($mg/m^3$) | | | | | |
|---|---|---|---|---|---|---|
| | 1-hour | 8-hour | 24-hour | 1-month | Quarterly | 1-year |
| CO | 40 | 10 | - | - | - | - |
| Pb | - | - | - | - | 0.0015 | - |
| Ozone | 0.235 | 0.157 | - | - | - | - |
| Nitrogen Dioxide | - | - | - | - | - | 0.1 |
| Sulfur Dioxide | - | - | 0.365 | - | - | 0.008 |
| SPM (10 micron) | - | - | 0.15 | - | - | 0.05 |
| SPM (100 micron) | - | - | 0.065 | - | - | 0.015 |

The burning of oil contributed to air pollution. With the discovery and exploitation of petroleum as a source of kerosene, the problem was exacerbated. This was followed by the use of gasoline and diesel fuels in internal combustion engines. When lead was added to gasoline to enhance the octane rating and performance, airborne lead from vehicle exhaust became an air pollution issue. Thailand indirect measures on air pollution control met with considerable success of the lead removal from gasoline in 1996.[3] The response from oil companies and the public is very favorable. Maintenance

[3] The lead removal helps fuel reformulation to control levels of aromatics and benzene, smoke, and carbon monoxide through the use of oxygenates, and lower distillation temperature.

and inspection of vehicles are important measure used in Thailand. Thailand now requires vehicles of more than seven years old in Bangkok to undergo annual inspection. The same requirement applies to motorcycles over 5 years old, and to all trucks and buses.

Tax incentives for air pollution control equipment has been used for the industrial sector and vehicle manufacturers. Subsidy of unleaded gasoline as incentive to users was practiced successfully during the introduction of unleaded fuel in 1993 – 1995. Condensed natural gas operating buses were introduced since the early 1990s. Low sulfur diesel oil has been used for public transports in Bangkok.

At the end of 1999, a mass transit system using electric trains will be in service in Bangkok. This lead to the significant air emission reduction. Expressway has now been planned for major regional cities to ensure efficient transportation systems.

Demand for electricity was met by the construction and use of coal or oil-burning power plants, major sources of pollutants. Thailand has various energy sources to generate electricity, including hydropower and fossil fuels such as lignite, coal, and gas. Fossil fuels remain the major source of power supply throughout the country. Thailand recently emphasized the use of least carbon content sources of energy supply, such as natural gas and imported electricity. The impact of power plants is controlled partly by the regulations of emission standards and other environmental standards set by Pollution Control Department and Department of Industrial Work. In long term power development plan, Thailand moved towards private participation in power supply with the emphasis on least carbon and sulfur content energy sources.

Table 13 Atmospheric concentration from 1991 – 1999 (Source: The Thai Pollution Control Department)

Unit: $mg/m^3$ of air/year

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| CO | 5.39 | 6.59 | 4.28 | 6.06 | 12.76 | n.a. | n.a. | n.a. | n.a. |
| Pb | 0.98 | 0.87 | 0.36 | 0.29 | 0.36 | n.a. | n.a. | n.a. | n.a. |
| SPM | 0.36 | 0.33 | 0.29 | 0.34 | 0.56 | n.a. | n.a. | n.a. | n.a. |

Remark:

1. CO 1991 – 1993 average for 1-Hour, 1994 – 1999 average for 8-Hour
2. Pb 1991 – 1994 average for 24-Hour, 1995 – 1999 average for 1-Month
3. SPM 1991 – 1994 average for 1-Year, 1995 – 1999 average for 24-Hour

Table 14 SPM Source Emission from 1991 - 1999 (Source: The Thai Department of Energy Development)

Unit: tons

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Transport | 15 | 15 | 17 | 19 | 23 | n.a. | n.a. | n.a. | n.a. |
| Power generation | 996 | 1,052 | 979 | 1,037 | 1,170 | n.a. | n.a. | n.a. | n.a. |

Table 14 (cont'd).

Unit: tons

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Industry | 87 | 90 | 101 | 129 | 145 | n.a. | n.a. | n.a. | n.a. |
| Commercial and residential | 79 | 82 | 87 | 90 | 89 | n.a. | n.a. | n.a. | n.a. |
| Others | 0 | 0 | 0 | 0 | 0 | n.a. | n.a. | n.a. | n.a. |
| Total | 1,177 | 1,240 | 1,185 | 1,276 | 1,427 | n.a. | n.a. | n.a. | n.a. |

Table 15 the CO Source Emission from 1991 – 1999 (Source: The Thai Department of Energy Development)

Unit: tons

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Transport | 1,074 | 1,186 | 1,257 | 1,238 | 1,378 | n.a. | n.a. | n.a. | n.a. |
| Power generation | 6 | 7 | 8 | 9 | 10 | n.a. | n.a. | n.a. | n.a. |
| Industry | 227 | 237 | 253 | 313 | 326 | n.a. | n.a. | n.a. | n.a. |
| Commercial and residential | 3,508 | 3,692 | 2,982 | 4,169 | 4,157 | n.a. | n.a. | n.a. | n.a. |
| Others | 71 | 72 | 65 | 73 | 64 | n.a. | n.a. | n.a. | n.a. |
| Total | 4,886 | 5,192 | 5,565 | 5,791 | 5,944 | n.a. | n.a. | n.a. | n.a. |

### 6.6.2 Air Pollution Indicators

Due to the information constraint of other pollutants, the indicators that proposed in this section would take into account only Carbon monoxide (CO), Lead (Pb), and Suspended Particulate Matter (SPM). These are the most important three pollutants that pollute the air quality in both urban and rural Thailand. CO is a primary air pollutant that blocks hemoglobin in the blood from carrying oxygen, is released when fossil fuels or wood are burned without sufficient air. CO can reduce visibility and cause cancer. Pb can cause Neurobehevioral development and impaired heme synthesis to the children. SPM can cause the visibility reduction and deposition of inhaled particle droplets and fibers.

To restore the air quality throughout the country, the air pollution indicators presented in this research are considered the CO, Pb, and SPM emission rates compare to the standard value and sources of emissions.

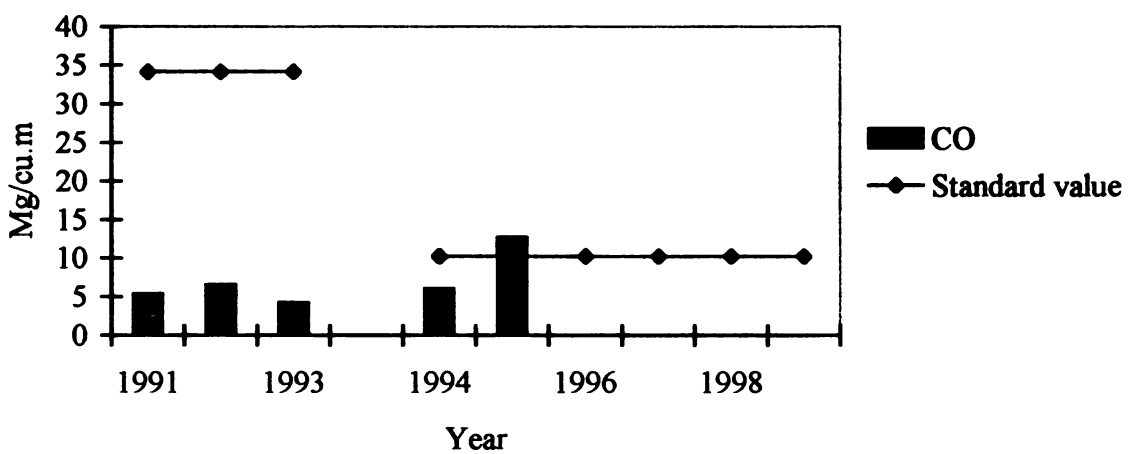


Figure 21 The CO emission from 1991 – 1999 (Source: The Thai Pollution Control Department)

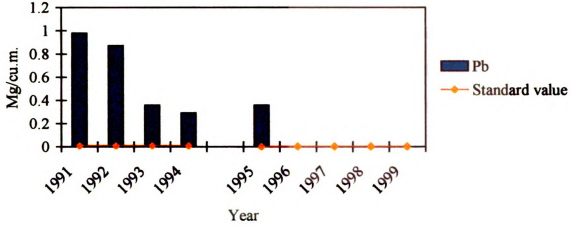


Figure 22 The Pb emission from 1991 – 1999 (Source: The Thai Pollution Control Department)

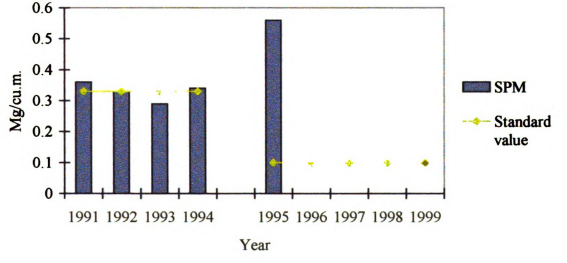


Figure 23 The SPM emission from 1991 – 1999 (Source: The Thai Pollution Control Department)

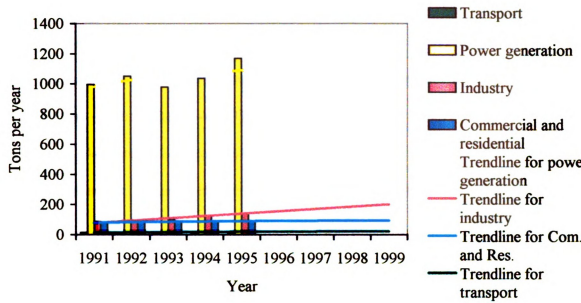


Figure 24 The SPM emission sources from 1991 – 1999 (Source: the Thai Department of Energy Development)

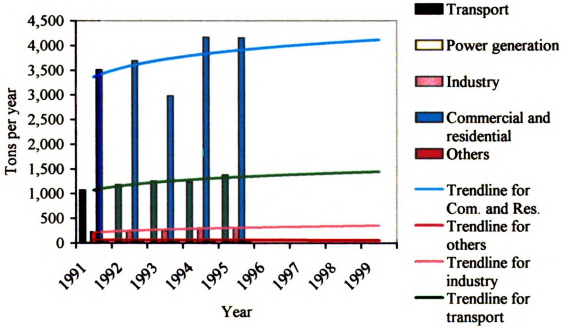


Figure 25 The CO emission sources from1991 –1999 (Source: the Thai Department of Energy Development)

The CO emissions in 1991 – 1993 was measured under the baseline of CO average for 1-Hour and in 1994 – 1999 average for 8-Hour. The CO emission values for the first four years are under average but in 1995, the CO emission value is higher above average. The major caused of CO emission is the commercial and residential consumption. Another source that caused the high amount of CO emission each year is Transportation sector. Moreover, the trendlines for CO emission of both sectors are increasing.

The Pb emissions in 1991 – 1994 was measured under the baseline of Pb average for 24-Hour and in 1995 – 1999 average for 1-Month. Either measurement, the Pb emission values are much higher than the standard value. The cause of that is the reduction of imported car tax caused the increasing amount of vehicles and lead contained fuel consumption. However the lead removal program was launched in 1996, which there is no information of Pb emission rate provided.

The SPM emission in 1991 – 1994 was measured under the baseline for average 1-Year and 1995 – 1999 averages for 24-Hour. In the first four years, the SPM emission rates are quite the same as the standard value. In 1995, based on the average for 24-Hour, the SPM emission rate is much higher than the standard value. The major source of SPM emission is power generation, which responsible around 80 percent of SPM emission a year and the trendline of SPM emission by power generation is going to increase. Meanwhile, industry trendline is also significantly increasing.

Alternative source of power generation could be considered to reduce the SPM emission. Fossil fuels are the major source of power supply for Thailand now. The use

of least carbon content sources of energy supply such as natural gas and imported electricity.

The reduction of air pollution from vehicles, industry, and transportation could be immediately performed. The government could promote and support utilization of low pollution transportation systems. The promotion and supporting of the improvement and upgrading of fuel standards to meet international standards are necessary. The government could accelerate the mass transit systems in large urban areas and between cities such as Bangkok and Samutprakarn province.

The air pollution monitoring system could be performed regularly. The collaboration concerning air pollution management among central government, local governments, and private organizations could be promoted.

# CHAPTER 7

# CONCLUSION AND RECOMMENDATION

This research was undertaken with the main objective of creating the prototypes of environmental indicators assisting the natural resources management and environmental policy and planning formulation. This is the first step to develop a national set of Thailand environmental indicators. These indicator comprise of forest resources, water resources, land use, waste water, solid waste, and air pollution.

The usefulness and accuracy of environmental indicators depends on the ability of the policy planners and/or decision-makers to create the right perspective of the community's environmental, socio-economic, and population sub-systems. The National Economic and Social Development Plan and the Enhancement and Conservation of National Environmental Quality Act 1992 should be the guideline to develop the environmental indictors along with the environmental, economic, and social information database. However the development of the environmental indicators should also rely on the concept of sustainable development of each natural resources or environmental issue to have the community move toward health and prosperity for long term resulting in a better quality of life for all Thai in habitants.

The accuracy and accountability of information should be taken into account as a crucial factor of the reliability of environmental indicators. Environmental indicator information should be standardized according to criteria, scales, units of measurement, and political administrative mandates. The lack of coordination among agencies can result in

unnecessary overlap data, incompatible formats, or inconsistent quality controls. All of these make the resulting data or information less useful.

In consideration of that the indicators proposed in this research are mostly based on the information from the Environmental Information System of the Thai Office of Environmental Policy and Planning and from other natural resources and environmental related organizations. Not only information from different agency is collected into different formats and units of measurement, depends on the needs to use, but also, the incompleteness of information effect the accuracy of the proposed environmental indicators. Natural resources and environmental database network for all Thai government agencies, public, and private sectors is needed to establish so reliable information can be effectively use.

Development and choosing the appropriate environmental indicator framework need to be an interactive process, requiring collaboration among numerous stakeholders of the information system, including central and local government; private and public sectors; state enterprises; and local people that share environmental management responsibilities with the central government. By doing so, implementation of the indicators will require that the central government takes a leading role in providing and disseminating information on the development of indicators; advocates the consistent use of the framework to develop indicators; financially assists with the implementation of indicators where this is appropriate; and establishes formal measures to secure the ongoing collection and provision of indicators data.

An environmental indicator is a tool evolves as our understanding of human-environment interactions and as society's environmental values evolve. Following this concept, along with the research outcome, an environmental indicator should consist of hierarchical sets of environmental values, goals, and priorities for natural resources management and environmental policy formulation defined at various scales, with sustainability of human activities as an explicit goal or constraint. Such an environmental indicator should seek to be anticipatory, by focusing on long-term and emerging natural resources, environmental, economical and social issues as well as immediately regulatory concerns, in keeping with the intergenerational focus of the concept of sustainability.

# APPENDIX

## THE QUESTIONNAIRES FOR THE ENVIRONMENTAL INFORMATION SYSTEM OF THE OFFICE OF ENVIRONMENTAL POLICY AND PLANNING, MINISTRY OF SCIENCE, TECHNOLOGY AND ENVIRONMENT, THAILAND

*Questionnaire 1*

**Forest Resources Information**

Date ____ Month _____ Year_____

Area of Forests _____ rai

Area of Mangrove Forests_____ rai

Area of Reserved Forests_____ rai

Area of Botanical Garden_____ rai

Area of National Park _____ rai

Area of Wildlife Sanctuary _____ rai

Area of Headwaters_____ rai

Others ( specify ) _____ rai

**Land Use Information**

Date ____ Month _____ Year_____

Area of Paddy field _____ rai

Area of Agriculture _____ rai

Area of Para Rubber Plantation _____ rai

Area of Oil Palm Plantation _____ rai

Area of Grazing _____ rai

Area of Shrimp Ponds _____ rai

Area of Fish Ponds _____ rai

Others (Specify) _____ rai

*Questionnaire 3*

**Waste Water/ Solid Waste/ Air Pollution Information**

Date ____ Month _____ Year_____

| Manufacturer | Average Amount of Waste Water ( cu.m/day) | Number of Manufacturer, which has an Air Pollution Treatment System | | | | |
|---|---|---|---|---|---|---|
| | | Dust | Smell | Acid | Chemical Substances | Others |
| 1. Food | | | | | | |
| 2. Beverage | | | | | | |
| 3. Tobacco | | | | | | |
| 4. Clothing | | | | | | |
| 5. Leather | | | | | | |
| 6. Construction | | | | | | |
| 7. Service | | | | | | |
| 8. Textile | | | | | | |
| 9. Wood | | | | | | |
| 10. Paper | | | | | | |
| 11. Petroleum | | | | | | |
| 12. Rubber | | | | | | |
| 13. Ceramic | | | | | | |
| 14. Non-metal | | | | | | |

| Manufacturer | Average Amount of Waste Water ( cu.m/day) | Number of Manufacturer which has an Air Pollution Treatment System | | | | |
|---|---|---|---|---|---|---|
| | | Dust | Smell | Acid | Chemical Substances | Others |
| 15. Chemical Substances/Plastic | | | | | | |
| 16. Metal | | | | | | |
| 17. Machine | | | | | | |
| 18. Electrical Parts | | | | | | |
| 19. Transportation | | | | | | |
| 20. Medical | | | | | | |
| 21.Others (Specify)_____ | | | | | | |

**Commumnity Waste Water Treatment**

| Source of Waste Water Drainage | Please Mark |
|---|---|
| Sea | |
| Natural River/Pond | |
| Man-made Pond | |
| Bare Land or Paddy Field | |
| Other (Specify) _____ | |

Do your community have a Waste Water Treatment Plant ? ◯ yes ◯ no

In case of YES

Name of the Waste Water Treatment System _____

Constuction Cost _____ Baht

Start in (Year)_____

Maximum Amount of Discharged Waste Water _____ cu.m./day

Average Amount of Discharged Waste Water _____ cu.m./day

BOD at the enter point of the Treatment Plant_____ mg./l.

BOD at the exit point of the Treatment Plant _____ mg./l.

Total Area under the service of Treatment Plant _____percent of total area

Location of Treatment Plant ( Specify the address and include map, if possible )

_____

_____

Do your community reserve any additional area for the second phase of The Waste Water Treatment Plant in the next 10 years?

◯ No ◯ Yes, How many rai do you have? _____ rai

**Garbage**

| Number of Garbage Truck | Large Size Truck | Small Size Truck |
|---|---|---|
| Number of usable Garbage Trucks | | |
| Number of unusable Garbage Trucks | | |
| Amount of Garbage per day ( Tons) | | |
| Number or round trips per truck per day | | |

Total amount of garbage _____ ton per day

Total amount of garbag left from gethering _____ ton per day

Total amount of disposed garbage _____ ton per day

Total amount of garbage left from dispose _____ ton per day

Average cost of garbage gathering _____ baht/ ton/ day

Average cost of garbage disposal _____ baht/ ton/ day

Average revenue from garbage gathering_____ baht per year

What is your garbage disposal system?

- ○ left on the ground
- ○ burning
- ○ sanitary landfill
- ○ recycled for fertilizer
- ○ Incineration
- ○ Other (Specify) _____

Do your community have your own garbage disposal area? ◯ No ◯ Yes

_____ rai

What year will this garbage disposal area fill up ? _____

Please specify the location ( including Map )

_____

Do your community reserve any additional area for garbage disposal in the next 10 years ?

◯ No ◯ Yes _____rai

Location_____

**Air Pollution**

Name of the Air Quality Measurement Station

1. _____

2. _____

3. _____

4. _____

| Date | Unit | Result of Station 1 | | | Station 2 | | | Station 3 | | | Station 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Summer | Rainy | Winter | S | R | W | S | R | W | S | R | W |
| Carbonmonoxide | | | | | | | | | | | | | |
| Methane | | | | | | | | | | | | | |
| Dust | | | | | | | | | | | | | |
| Lead | | | | | | | | | | | | | |
| Nitrus-oxide | | | | | | | | | | | | | |
| Ozone | | | | | | | | | | | | | |
| Sulpherdioxide | | | | | | | | | | | | | |

*Questionnaire 4*

**Water Resource**

Date ____ Month _____ Year_____

Name of the river _____

Name of Water Quality Measurement Station

1._____

2. _____

3. _____

4.

_____

| Data | Result of Station 1 | | Result of Station 2 | | Result of Station 3 | | Result of Station 4 | |
|---|---|---|---|---|---|---|---|---|
| | Rainy Season | Dry Season | R | D | R | D | R | D |
| pH | | | | | | | | |
| Temperature ( °C) | | | | | | | | |
| Conductivity | | | | | | | | |
| Turbidity | | | | | | | | |
| Acidity | | | | | | | | |
| Iron | | | | | | | | |
| Manganese | | | | | | | | |
| Copper | | | | | | | | |
| Sediment | | | | | | | | |
| Zinc | | | | | | | | |
| Lead | | | | | | | | |
| Cromium | | | | | | | | |
| Cadmium | | | | | | | | |
| Mercury | | | | | | | | |
| Arsenic | | | | | | | | |
| Chloride | | | | | | | | |

| Data | Result of Station 1 | | Result of Station 2 | | Result of Station 3 | | Result of Station 4 | |
|---|---|---|---|---|---|---|---|---|
| | Rainy Season | Dry Season | R | D | R | D | R | D |
| Nitrogen | | | | | | | | |
| Ammonia | | | | | | | | |
| Nitrate | | | | | | | | |
| DO | | | | | | | | |
| BOD | | | | | | | | |
| Phosphate | | | | | | | | |
| Coliform | | | | | | | | |

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