FINAL REPORT

Ban Don Bay and Its Offshore Island Management Planning Project : Analysis and Diagnosis of the Coastal Production Systems

Walailak University

Coastal Habitats and Resources Management Project (CHARM)

October 2007

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Preface

Ban Don Bay is one of the most significant and productive systems of Southern Thailand. People of the Ban Don Bay rely their livelihood on resources and environment of the bay. Ban Don Bay harbors different important coastal ecosystems: mangroves, seagrass beds, coral reefs and other types of wetlands which act as spawning, nursery, and feeding grounds for various kinds of shellfish and finfish. However, the coastal habitats are facing the problems of heavy sedimentation in the bay, encroachment and reclamation of mangrove forests, water pollution from domestic and industrial sources, illegal and destructive fishing, overfishing. These causes all reduce the ecological roles of the Ban Don Bay. The offshore islands, e.g. Samui and Pha-ngan islands, which are well-known tourist destinations, are also having problems of marine environmental degradation, too rapid and overdeveloping.

Use of coastal environment and resources by the capture fisheries, aquaculture and tourism sectors significantly contributed to the rapid economic growth of the Surat Thani Province. However, the activities of these sectors have taken place in the context of largely unrestricted access to habitats and resources, frequent evasion of regulatory supervision and enforcement, and an extensive but non-integrated legislative framework that hinders effective management. Social conflicts over resource use have intensified, and Thailand's coastal resources are over-exploited with coastal habitats being rapidly degraded.

In order to maintain the integrity of coastal resources and environment in parallel to the use and economic development, we need to know the status of the ecosystems and inventory of resources and their responses to the economic growth.

The efficient economic development of all these activities needs to be framed into a coherent and workable planning system from local to provincial and national levels. Since effective and appropriate planning is based on reliable information, best available information, whatever its source, should be gathered and integrated to inform each coastal management unit along the coast. Such is the goal of the Vulnerability mapping tool that was developed between CHARM and the GEOMATIC Technology Company in the 2005. This project by the team from Walailak University, Nakhon Si Thammarat, is the updating and further improvement of the previous vulnerability mapping. This study has been in large consultation with experts from different fields, NGOs, local communities, and authorities.

The major objective of this study project is to design and construct a GIS system (geographic information system) of the Ban Don Bay based on the database of eco-socio-

economic in each Coastal Management Unit. The GIS (mapping or atlas) will be a useful tool for future coastal zone management and planning of the ban Don Bay.

The project consists of two parts: the analysis and diagnosis of coastal production systems in the Ban Don Bay and the development of database system and GIS for vulnerability mapping of the Ban Don Bay and offshore islands.

The analysis and diagnosis of coastal production systems will cover the areas of nine districts (Amphoes) in Surat Thani Province: Ampohoes Tha Chana. Chaiya, Tha Chang, Phunphin, Mueang, Kanchanadit, Don Sak, Samui, and Pha Ngan. The coastal production systems studied here include agriculture, forestry, aquaculture, fisheries, tourism, industrial development, and urban expansion. The eco-socio-economic aspects were studied in each system as well as whether the system is sustainable or not, how the system is sustained.

The information and models of environmental socioeconomic analysis will be used in designing and construction of GIS mapping in each coastal management unit. The updated mapping will be used for future coastal management and planning.

Participatory process at tambon, district and provincial levels is emphasized in the study. Several focus group discussion, in-depth interviews, local government meetings were conducted to obtain information, issues, prioritization of the problems, needs, and proposed solution options. The peer-review provincial committee was set up to guide the project, make comment and recommendations which were very helpful.

Coastal stakeholders should thus consider these maps and the information they contain as a negotiating tool for planning within the coastal management unit they share. The coastal management units are themselves to be considered as indicative and, thanks to the use of the GIS, may be adjusted to the local management needs including the acquisition of more detailed and appropriate information.

With the publication of this report and atlas and the completion of the corresponding GIS, it is the transfer of the concept and the tool that is at stake. While the CHARM Project and its partners will strive to make it happen in the two project areas during the next two years, the goal is to expand this management tool to other areas for the benefit of the sustainable development of the coast of Thailand.

Acknowledgement

The Project “Ban Don Bay and its Offshore Islands Management Planning: Analysis and Diagnosis of the Coastal Production Systems” could not be completed without assistance and cooperation from several individuals and organizations. The study team of Walailak University would like to express our sincere thanks and appreciation for the assistance and cooperation provided by the followings.

Many central and local governmental agencies to be commended including the Department of Marine and Coastal Resources and its subordinate agencies: Marine and Coastal Resources Research Center, the Central Gulf of Thailand (Chumphon Province); the Department of Fisheries and its subordinate agencies, i.e. Fisheries Resources Information Division, Surat Thani Provincial Fisheries Office, Surat Thani Coastal Fisheries Research and Development Center; private sectors; private organizations; NGOs; representatives from local communities in the Ban Don Bay. Their contribution in giving ideas, information, cooperation, support, field assistance and logistics as well as participating in workshops to provide useful opinions and supplemental data are gratefully appreciated.

In addition, the Provincial Peer Review Group who have supervised the Project and provided many constructive opinions, comments, and helpful recommendations are acknowledged. Special thanks are given to staff of the Coastal Habitats and Resources Management (CHARM) Project including the Central Offices, the Surat Thani and Krabi Project Offices. Last but not least, special thanks go to Mr. Sanchai Dhanthawanich, Co-Project Manager of the Thai side and Dr. Yves Henocque, Co-Project Manager of the European Union Side and all working team members, for their assistance, recommendations, supports, and friendship

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The Executive Summary Report

Introduction

The Project on "Ban Don Bay and Its Offshore Islands Management Planning: Analysis and Diagnosis of the Coastal Production Systems" under the CHARM (Coastal Habitats and Resources Management) Project has been conducted by the Walailak University study team. The study area is the Ban Don Bay, one of the most productive and significant bays in southern Thailand, covering 36 Tambons, in 9 districts or Amphoes in Surat Thani Province consists of Amphoe Tha Chana (Tambon Khan Thuli, T. Tha Chana, T. Wang), Amphoe Chaiya (Tambon Takrob, T. Thung, T. Talat Chaiya, T. Phum Riang, T. Lamet), Amphoe Tha Chang (T. Khao Than, T. Tha Chang, T. Tha Khoei), Amphoe Phunphin (T. Liled), Amphoe Mueang (T. Khlong Chanak, T. Talat, T. Bang Kung, T. Bang Chana, T. Bang Sai, T. Bang Bai Mai, T. T. Bang Pho), Amphoe Kanchanadit (T. Kadae, T. Takhianthong, T. Thathong, T. Thathongmai, T. Plaiwat), Amphoe Don Sak (T. Chonkhram, T. Chaikhram, T. Donsak), Amphoe Ko Samui (T. Ang Thong, T. Lipa Noi, T. Taling ngam, T, Na Mueang, T. Maret, T. Bo Phut, T. Maenam), and Amphoe Ko Pha Ngan (T. Ko Pha Ngan, T. Ban Tai). The main task is to gather all relevant data, information, and status of resources and environment of the Ban Don Bay, as well as to create the database and vulnerability mapping as a tool for decision making in coastal management and planning, environmental rehabilitation, enhancing institutional development, and increasing the capacity and collaboration of all sectors of both private and government involved with the intent of sustainable development in the Ban Don Bay.

The major objective of this study project is to design and construct a GIS system (geographic information system) of the Ban Don Bay based on the database of eco-socio-economic in each Coastal Management Unit. The GIS (mapping or atlas) will be a useful tool for future coastal zone management and planning of the Ban Don Bay.

The project consists of two parts: the analysis and diagnosis of coastal production systems in the Ban Don Bay and the development of database system and GIS for vulnerability mapping of the Ban Don Bay and offshore islands

The analysis and diagnosis of coastal production systems will cover the areas of nine districts (Amphoes) in Surat-thani Province: Ampohoes Thachana. Chaiya, Tha Chang, Phun Phin, Mueang, Kanchanadit, Don Sak, Samui, and Pha-ngan. The coastal production systems studied here include agriculture, forestry, aquaculture, fisheries, tourism, industrial development,

and urban expansion. The eco-socio-economic aspects were studied in each system as well as whether the system is sustainable or not, how the system is sustained.

The information and models of environmental socioeconomic analysis will be used in designing and development of GIS mapping in each coastal management unit. The present mapping, which has been updated and improved from the previous Vulnerability Mapping by CHARM and Geomatic Technology Co.Ltd. will be used for future coastal management and planning.

The analysis and diagnosis of coastal production systems in the Ban Don Bay

The study of Ban Don bay and its offshore island natural resources and environment has been based on collected primary and secondary data from the community focus group meetings and field surveys and published data from all related parties, respectively. Applying the concept of "Optimal Control Theory", which was developed for "Dynamic Optimization", the three main balances investigated in this study are as follows:

The first balance: Maximum Principle (MP) is the balance that mainly considers the profit/net benefit to business. The system will continue being in the equilibrium, if the producers and businesses are able to continuously achieve maximum profit/net benefit.

The second balance: Portfolio Balance (PB) is a balance that integrates resources and producers who use these resources through the growth of real resource value. Growth of these real values must be able to compete with the growth in real value of other resources in the economy. In other words, it can be said that our value of the resources growth must be equal to the value growth of other resources.

The third balance: Dynamic Constraint (DC) is a balance that is considered mainly by the amount or quantity of resources. The system of renewable resources can be balanced when the rate of restoration/recruitment of such renewable resources to the system is equal to the rate of exploitation of these resources from the system.

To sustain the system according to the Optimal Control Theory, all three balances must be maintained. If each balance has a chance to lose its balance in the future or has indicator that reveals the loss of balance, the model for management, which can help to reduce the risk of loss of balance or to bring back the balance once again, can be applied to provide an appropriate solution.

The vulnerability of these 3 balances has been connected to the linkages among Ban Don Bay and its offshore island natural resources and environment bases which are primary

production input and supportive factor bases in the area. The conditions and problems with the solution guidelines have been presented, respectively, in this study in order to develop the management planning for Ban Don bay and its offshore islands.

The Linkages of Ban Don Bay and Its Offshore Islands Natural Resource and Environment with Main Related Activities

This report has used the Ban Don Bay and its offshore islands natural resources and environment as the starting point due to their important roles of production base and of supportive environment for all main activities in the area. The main activities within the synthesis structure are tourism activities and processing activities. In part of agricultural, fishery and aquaculture activities, they have been recognized as the community-based activities due to the community's main uses and dependence. The "Institutions and Related Organizations" group has been referred to all related parties such as the Department of Fisheries (DOF), Royal Forestry Department (RFD) and Department of Marine and Coastal Resources (DMCR) from the Government that involve and being responsible for the natural resource and environment administrative and management roles. All academic institutions and Non-governmental Organizations (NGOs) can also be included in the institutions and related organizations group as well.

The main linkages of natural resource and environment in Ban Don Bay and its offshore islands with community can be further divided into 2 groups. The first group has been called "Resource Utilizations and Dependence." The resource utilizations and dependence can be referred to the benefits of resource utilizations and dependence through users' earning and occupation. For example, agricultural activities have to involve with land and freshwater resources, fishery activities have to depend on stock of fish from fishery and coastal resources and aquaculture activities have their production bases built on the mangrove and coastal resources. Furthermore, these mentioned activities have been recognized as the direct resource utilizations due to their direct uses of the resources.

Within the first group range, the indirect uses of the resources such as, being environment for supporting these activities and being resource for building occupation materials have been also classified as the "Indirect resource utilizations" group. The agricultural activities, as an example, that being relied on freshwater resource and weather condition for their targeted production can be viewed as the use of environment for supporting activities. Another example with the same type of uses is from the fishery activities and aquaculture systems that have to rely

mainly on the healthy level of coastal resources. Tourism activities from community level that have to use their natural resource and environment features to attract all tourists are fit within this type of use as well. Furthermore, the indirect resource utilizations also include the uses of resource for building occupation materials. For example, the local fishermen can build their fishing gears from the mangrove wood.

Another aspect of resource utilizations and dependence for the local community can be viewed through “environment for way of life” group. For example, the local community can use their resources and environment directly through their uses of these resources as input materials for their house construction purposes and their uses of freshwater from nearby natural water resource for their consumption and uses. Their indirect uses can be observed through the good environment for living that being blended within their ways of life.

Meanwhile, the continuously increasing in amount of resource utilizations demanded by the community may be resulted in a negative impact produced to their resources and environment. In addition to the resource utilizations and dependence group, the resource utilizations and dependence impact group has been treated as the second group. This second group can also be divided further to; “Non-sustainable Resource Utilizations” and “Pollution and Waste” groups, respectively. The non-sustainable resource utilizations can cause the decreasing trend in resource quantity and quality which unavoidably has an impact on a reduction in all activities earnings and occupation security. The over-uses of the resources and environment such as, over-fishing and deforestation problems can be used as an example for such uses. The pollution and waste discharged from the community can provide a negative impact on the resources and environment which are the fundamental bases for their community earning activities and their ways of life and eventually, lead to the problem of their earning reduction and poor ways of life.

The tourism activities have been mainly relied on the quality and quantity of natural resources and environment for attracting all tourists which can generate earnings and occupation for them. Meanwhile, from their activities themselves, they can also cause a negative impact through the system if their activities being in a way of non-sustainable resource utilizations and being discharge carelessly pollution and waste and finally, lead to the problem of their earning reduction.

The processing activities have also directly used these resources and environment as their inputs to produce their final goods. These resources and environment in the system also play a role of supportive environment for processing as their (processing activities) indirect

resource utilizations. Also, the negative impact from pollution and waste produced from these activities can reversely do harm to their resource and environment systems.

From the utilizations and impacts of the community, tourism activity and processing activity bases described above, the main utilization purposes have been provided to meet all demands of the community and operators. The resources and environment cannot only be used directly to produce the goods and services but also be used as the supportive environment for all parties to provide occupations and earnings to the community and all operators. As well as the role of occupation and earning generations, these resources and environment are also the bases for the community's way of life. Since the community expansion from the population growth together with the economic growth pressure can result in an increasing demand for resource utilizations from the limited amount of pool resources, therefore, a way of non-sustainable uses of the resource and negative impact from pollution and waste carelessly discharged have commonly been observed throughout the resource and environment systems.

In part of the institutions and related organizations, the linkage of this group with the resources and environment can be described through their administrative and management roles, monitoring and enforcement activities, promotion and extension services. Their roles, activities and services can also be linked with the community and all activity sectors.

Conditions and Problems

From the linkages of natural resources and environment with all sectors described previously, the conditions and problems can be summarized as follows (Figure 1):

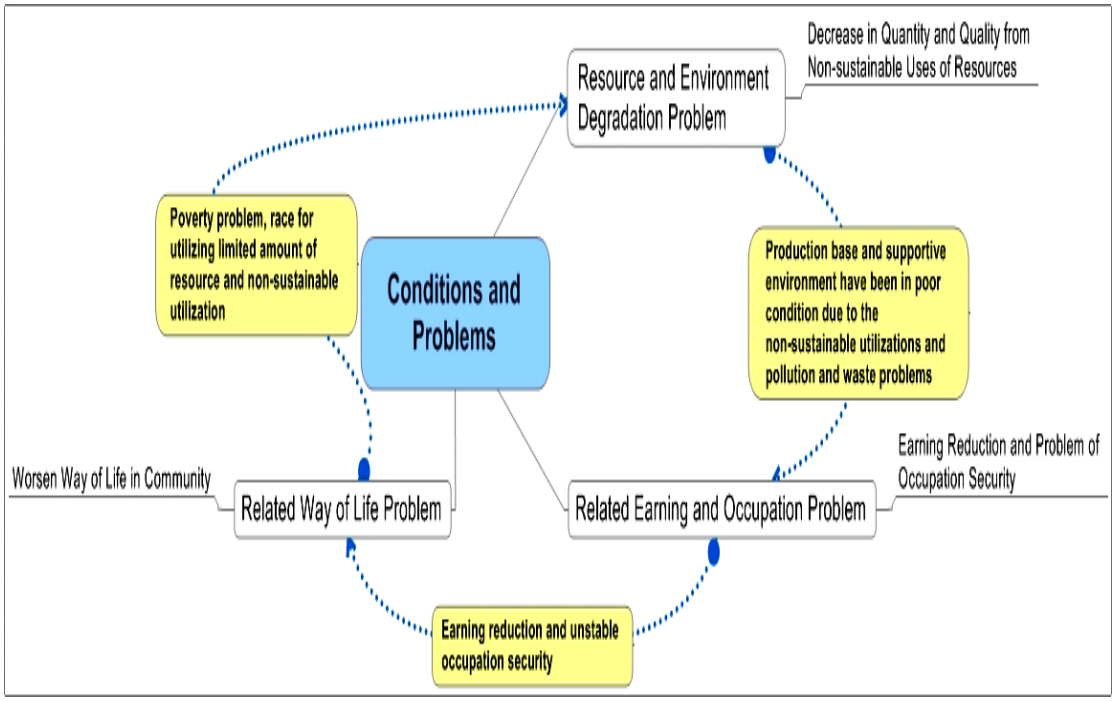


Figure 1 Conditions and Problems: Linkages among Main Three Problems

1. Resource and Environment Degradation Problems: Based on each main resource sector data and information, the general conditions for some resources can be briefly presented as;
    - Forest sector: A decrease in terrestrial forest area due to deforestation for agricultural activity purposes and community wood product has been reported. Meanwhile, an increase in mangrove area from abandoned shrimp farms has also been reported. The current condition of forest sector has been linked with the lack of freshwater resource and decreasing amount of wildlife species problems.
    - Marine coastal resources: Problems of coral reef and seagrass bed deteriorations which can have negative impact on fishery and tourism activities have been reported. The pollution and waste problems from the community and all activities have also been reported. Some natural coastal erosion has been occurred in some areas.
    - Water resource: Problems of freshwater shortage for agriculture activities and community consumption and uses have been reported. The poor quality of water resources (for both sea water and freshwater) has been reported from the

problem of pollution and waste discharged by nearby industry, community and shrimp farm.

- Fishery resource: Problems of decreasing trend of marine species quantity and quality have been reported. Lack of natural seeds problem has been report in some aquaculture activities.

2. Related Earning and Occupation Problems: As a result of the problem 1) persists, the reduction in earning and unstable occupation security can be observed. These problems can be separated into 2 main issues. The first issue involves with the reduction in earning due to the degradation of natural resources and environment as both production bases and supportive environment. Also, the low commodity price in the market due to the amount of product supplied being far exceeded the demand has been recognized as another cause. The second issue involves with the rising trend of input cost due to the shortage supply of the main inputs. These two issues can have seriously impact on their earning and occupation security from all activities.
3. Related Way of Life Problems: As results of the problem 1) and 2) persist, the poverty problem, the race for utilizing limited amount of resources, non-sustainable resource utilization without users' conscious and living environment condition deterioration can force the community and all activities to commit more on problem 1).

Guidelines for Problem Solutions

According to the conditions and problems listed above, the guideline for problem solutions can be presented as:

1. Solution for the Resource and Environment Degradation Problem: The sustainable resource utilizations must be used. The "sustainable" in this solution means the uses that being well continuously matched with the capacity of limited resources and environment and can bring about the balance of the system in the long run. The systematic planning for resource utilizations must be developed and implemented. This planning can only be obtained through the integrated planning of all resource types. The "Sufficient Economy" concept can seriously be applied as the first objective for all users. The community and all activities establishment of possessive conscious of their resources and environment must be continuously developed and maintained.

2. Solution for Related Earning and Occupation Problem: An attempt to maintain the sufficient earning and occupation security is the main target. According to the first solution provided previously, the “sustainable” in this solution can be obtained from the sustainable resource uses with the reflection of well planning in production process and produce the optimal amount of goods that conforms to the market demand and supply mechanism. The concept of “Sufficient Economy” can be used as the fundamental concept for all parties. The way to reduce the production cost and increase the production efficiency has to be developed continuously to maintain their competitive competence. The new occupation development and current occupation improvement also have an important role in this solution. The supportive roles from the Government about their basic needs and infrastructure such as, irrigation system and electricity have also been required.
3. Solution for Related Way of Life Problem: An attempt to maintain a good quality of life can be started from the establishment of the community possessive conscious of their natural resources and environment for their sustainable utilizations and their reduction on the negative impact produced back to the resources and environment systems. The concept of “Sufficient Economy” can be applied to their way of life since this fundamental concept can directly solve the problem from the beginning. The supportive roles from the Government about their basic needs and infrastructure such as, infrastructure and education have also been required.

In summary, all three solutions can only be effectively implemented through a serious cooperation and participation from the community, all related activities and institutions and related organizations. The institutions and related organizations can take their serious actions for their administrative and management role, monitoring and enforcement activities and promotion and extension services through/with the cooperation from the community and all related activities that have their roles as the users in the system. The well systematic planning for resource utilization, production and conservation can be developed through the cooperation and participation from all parties.

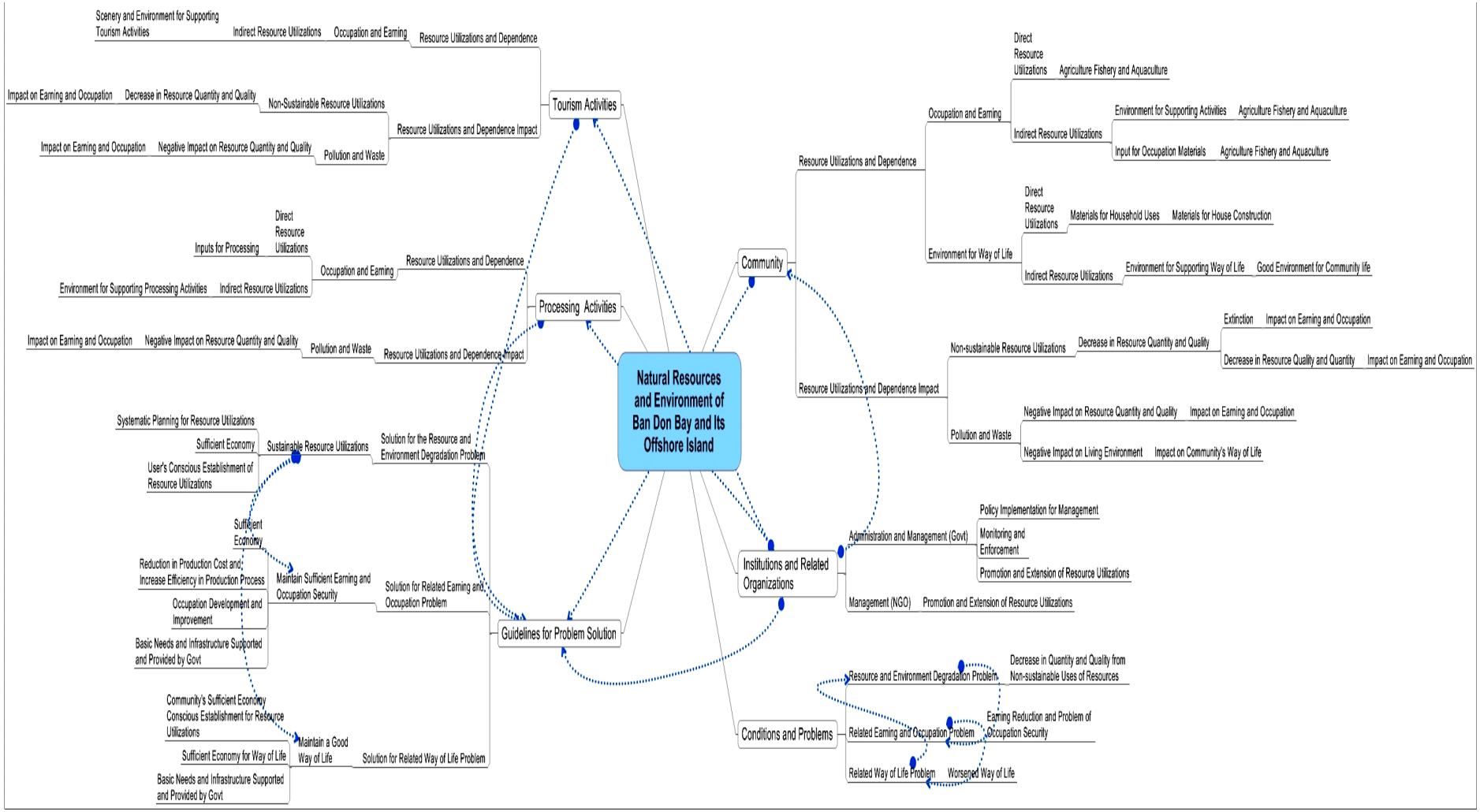


Figure 2 Result Synthesis of the Ban Don Bay and Its Offshore Islands: The Linkages among Main Activities, Conditions and Problems and Guidelines for Problem Solutions

The development of database system and GIS for vulnerability mapping of the Ban Don Bay and offshore islands

This study focuses on the application of GIS together with other database system on the analysis and diagnosis of coastal production system (CPS) and the updating and improvement of the existing vulnerability GIS mapping of the Ban Don Bay, Surat Thani Province. The coastal production systems in the Ban Don Bay were studied in each coastal management unit or CMU (at District or Amphoe and Tambon levels). Local community participatory process was employed to obtain data and information on history and evolution of coastal production systems, issues, priority of the issues, needs, and proposed solution options. Environmental and socioeconomic information of the CPS in each CMU were collected, analyzed and diagnosed. The relevant information was maintained in the database system and used in creating eco-socioeconomic models of CPS and further updating and improvement of Vulnerability Mapping and proposed recommendations for sustainable development of the Ban Don Bay.

Primary and secondary information, basically on status and inventory of the environment and resources of the Ban Don Bay and especially on ecological data of the coastal production systems, was gathered from different sources to assess the productivity and degradation impacted in each marine habitat. In case of the lack of existing information, field survey and field studies were conducted. All variables of information have been set by experts in each field to be used for modeling of each coastal production system. Two categories of information used for geographic information system and database are descriptive information and area-based information. For examples, coral reef areas, seagrass areas, mangrove areas, dugong and dolphin feeding grounds, marine threatened species from Department of Fisheries; physical information like administrative boundaries from Department of Public Administration; watershed area and water resource from Department of Irrigation and Office of Environment Policy and Planning. All information was updated, validated, and sorted out for compatibility and suitability for production of the vulnerability and resource atlases as well as the reference sources for future updating of the information.

Area-based database of the Ban Don Bay has been created in the Geographic Information System (GIS) with reference geographic range and location, attributes of cartographic objects, alphanumeric data, and information related to spatial data. Maps are produced with the GIS software. Certain area-based information can be continuously updated by local government units, TAOs and NGOs in the area, with the aid of Global Positioning System (GPS). Satellite images and aerial photographs (or Remote Sensing) were also used to

see changes with time when the images are available. Walailak University is equipped with GIS and RS facilities and will be able to offer training courses and workshop for interested people in future updating of the vulnerability and resource mapping after the project comes to an end. This GIS application for vulnerability mapping is a useful tool for decision making and planning process.

In addition to the GIS database and environmental and resource assessment, the study team has updated and improved the environmental vulnerability atlas together with environmental and natural resource atlases in the Ban Don Bay. The atlases are as follows:

- Atlas of natural resources and environment of the Ban Don Bay and each district
- Atlas of environmental vulnerability
- Atlas of environmental risk
- Atlas of environmental sensitivity
- Atlas of detailed information of each coastal management unit and the whole bay

Area-based and descriptive information are used in assessing the environmental vulnerability using the Environmental Vulnerability Index or EVI. The concept of EVI has been developed by the South Pacific Applied Geoscience Commission (SOPAC) in 1999. The Environmental Vulnerability Index is a measurement of tendency of the processes that can be negatively influence the sustainability of the environment and resources in one particular area. In this study, there are 25 indicators employed as compared to the 33 indicators used in the previous environmental vulnerability study by CHARM and the Geomatics, Co. Ltd. EVI is a composite index consisting of three subindices, i.e. Intrinsic Resilience Index or IRI, Environmental Degradation Index or EDI, and Risk Exposure Index or REI.

- Intrinsic Resilience Index (IRI) is the natural capability to resist or recover from the damage. Low IRI value means the system is more capable to be resilient to the damage. The higher value means it is more prone to the damage. IRI consists of 3 variables: vertical relief, coastal erosion, and habitat diversity

- Environmental Degradation Index (EDI) is the damage imposed on the system by human activities and natural events. The lower EDI is, the less degradation is resulted in. EDI is made up of 8 indicators which are endangered species, migratory species, sea-based farming, onshore sea farms (shrimp farms), fisheries and fishing effort, water resources, exposed land and mining, land protected area, marine protected area.

- Risk Exposure Index (REI) is the degree of risk exposure of the system by natural or man-made adversity. The lower REI is, the lower is the risk. REI comprises 14 variables: wind

speed, dry periods, rainfalls, population density, population growth rate, forest area reduction, tourist numbers, tourism areas, waste water, solid wastes, oil spills, fertilizer use, and insecticide use.

Each variable will be assigned a weight (using weighting) according to the importance in each indicator to the impact on environmental and resource vulnerability. The weight values range from 1-3. For each indicator or variable, the score will be given ranging from 1-7 according to their present status of environment and resources or the risk intensity imposed in each indicator. The scoring system follows the SOPAC EVI system. After the scores are given, they will be multiplied with the weight values assign for each indicator. The total score or EVI value is the summation of the multiplication between each score and weight value in each indicator divided by 46in each coastal management unit (each district or each Tambon).

The analysis results of EVI for the 36 districts in the Ban Don Bay are as follows:

District (Amphoe)	Sub-District (Tambon)	Intrinsic Resilience Index (IRI)	Environmental Degradation Index (EDI)	Risk Exposure Index (REI)	Environmental Degradation Index (EDI)
Tha Chana	Khan Thuli	2.67	3.86	2.81	3.11
	Tha Chana	2.33	3.14	2.50	2.67
	Wang	1.67	3.50	2.27	2.57
Chaiya	Takrob	2.17	3.36	1.69	2.26
	Thung	1.67	2.71	2.62	2.52
	Talat Chaiya	1.00	2.79	2.88	2.61
	Phum Riang	4.17	3.50	1.62	2.52
	Lamet	1.83	2.93	2.96	2.80
Tha Chang	Khao Than	1.83	2.93	2.50	2.54
	Tha Chang	1.50	3.14	2.77	2.72
	Tha Khoei	1.67	3.50	2.81	2.87
Phunphin	Liled	1.50	4.07	1.96	2.54
Mueang Surat Thani	Bang Pho	1.50	2.71	1.58	1.91
	Bang Sai	1.50	3.00	1.96	2.22
	Bang Chana	1.50	2.86	1.65	2.00
	Bang Baimai	1.00	2.71	1.58	1.91
	Khlong Chanak	2.00	2.79	1.65	2.04
	Talat	1.00	3.14	3.85	3.26
	Bang Kung	1.67	3.36	2.46	2.63

District (Amphoe)	Sub-District (Tambon)	Intrinsic Resilience Index (IRI)	Environmental Degradation Index (EDI)	Risk Exposure Index (REI)	Environmental Degradation Index (EDI)
Kanchanadit	Tha Thongmai	1.50	3.86	2.08	2.54
	Takhianthong	1.67	3.64	2.81	2.91
	Kadae	1.50	3.50	2.85	2.87
	Plaiwat	2.00	4.21	2.58	3.00
	Thathong	3.33	4.57	2.77	3.39
Don Sak	Chonkhram	1.67	3.71	2.69	2.87
	Chaikhram	2.17	3.21	2.73	2.80
	Don Sak	4.83	5.21	2.81	3.80
Ko Samui	Ang Thong	4.83	1.57	2.00	2.24
	Maenam	3.33	3.14	2.04	2.54
	Bo Phut	3.83	3.07	2.27	2.72
	Maret	3.83	3.14	2.04	2.61
	Na Mueang	4.50	3.00	1.92	2.59
	Taling Ngam	5.00	3.21	2.00	2.76
	Lipa Noi	3.00	2.86	1.92	2.35
Ko Pha Ngan	Ko Pha Ngan	5.00	2.00	1.85	2.30
	Ban Tai	6.50	1.93	1.77	2.43

The Ban Don Bay, to certain extent, is resilient to natural risks and anthropogenic activities due to the high habitat diversity. Coastal erosion and land relief are secondary factors. The damages most impacted on the system by human activities and natural events in the Ban Don Bay are on the terrestrial reserves and protected areas, areas of intensive farming, fisheries, endangered species, surface mining areas, water resources, and coastal aquaculture, respectively. The risk exposure degrees from natural and man-made adversity in the Ban Don Bay are attributed to fertilizers, insecticide, impacts of tourism, solid wastes, rainfall, wind speed, drought or dry period, population density, waste water, migrating species, human population growth, number of tourists, oil spills, and the rate of deforestation, respectively.

The Environmental Vulnerability Index is the index based on the present status and conditions of environment and resources during the study period. The status and conditions are

changing with time. Intensity of the problems and issues may arise and cannot be avoided. The information on environmental vulnerability can be used for planning, protecting the environment and mitigating the problems. Therefore, the information needs to be updated, monitored and incorporated into coastal planning, protection, and management for the future sustainable use.

Environmental Vulnerability mapping and GIS application are among important and useful tools for the coastal planning and management. To be an effective tool, the information and database need to be updated and improved. The applications can be further used to predict and monitor the changes. For example: the DIVA Program is an interactive, graphical software-tool for assessing coastal vulnerability, especially to sea-level rise. It has been designed by the European funded DINAS-COAST Project (Potsdam Institute for Climate Impact Research (Germany), Flood Hazard Research Centre (Middlesex University, UK), Delft Hydraulics (The Netherlands), Centre for Marine and Atmospheric Research (University of Hamburg, Germany), Institute for Environmental Studies (Vrije Universiteit, Amsterdam, The Netherlands).

Most importantly to attain the sustainable uses of our coastal environment and resources, planning and management need the collaboration from all involved parties of both public and private sectors, especially participation from the local communities. We hope that the study results can be of use to all user parties involved and can be extended further to help protect, conserve, even restore the coastal environment and resources of the Ban Don Bay.

CHAPTER 1 INTRODUCTION

Ban Don Bay and its Offshore Islands Management Planning Project: Analysis and Diagnosis of the Coastal Production Systems is a part of the Coastal Habitats and Resources Management (CHARM) Project.The CHARM Project Management Unit (CHARM-PMU) served in this project as the Project Executing Authority.

1.1 OBJECTIVES

To design, create and update geographic information system of Ban Don Bay and its offshore islands that base on ecological database, economic system utilization and social characteristic of each coastal management unit.

1.2 STUDY PROCESS

1. Analysis and diagnosis of the coastal production systems in Ban Don Bay and its offshore islands. The objective is to delve into evolution, history and present status of coastal production systems of Ban Don Bay and its offshore islands especially ecological, economic and social of coastal production systems such as impacts from agriculture, forest, fishery, aquaculture, tourism, industrial development and urban development.

2. Updating and further development of Ban Don Bay Vulnerability database and GIS. The objective is to update, create, design, and develop vulnerability database and GIS of Ban Don Bay and its offshore islands base on ecological database, economic system, utilizations, and social characteristic of each coastal management unit.

1.3 STUDY AREA

36 tambon and 9 amphoe of Surat Thani province was study area (Tambon Khan Thuli, Tambon Tha Chana, Tambon Wang, **Amphoe Tha Chana**, Tambon Takrob, Tambon Thung, Tambon Talatchaiya, Tambon Phum Riang, Tambon Lamet, **Amphoe Chaiya**, Tambon Tha Chang, Tambon Khao Than, Tambon Tha khoei, **Amphoe Tha Chang**, Tambon Liled, **Amphoe Phunphin**, Tambon Khlong Chanak, Tambon Talat, Tambon Bang Kung, Tambon Bang Chana, Tambon Bang Sai, Tambon Bang Baimai, Tambon Bang Pho, **Amphoe Mueang Surat Thani**, Tambon Thathong, Tambon Plaiwat, Tambon Kadae, Tambon Takhianthong, Tambon Tha Thongmai, **Amphoe Kanchanadit**, Tambon Chaikhram, Tambon Chonkhram, Tambon Don Sak

Amphoe Don Sak, Tambon Ang Thong, Tambon Lipa Noi, Tambon Taling Ngam, Tambon Na Mueang, Tambon Maret, Tambon Bo Phut, Tambon Maenam, **Amphoe Ko Samui**, Tambon Ko Pha Ngan, Tambon Ban Tai, **Amphoe Ko Pha Ngan)**.

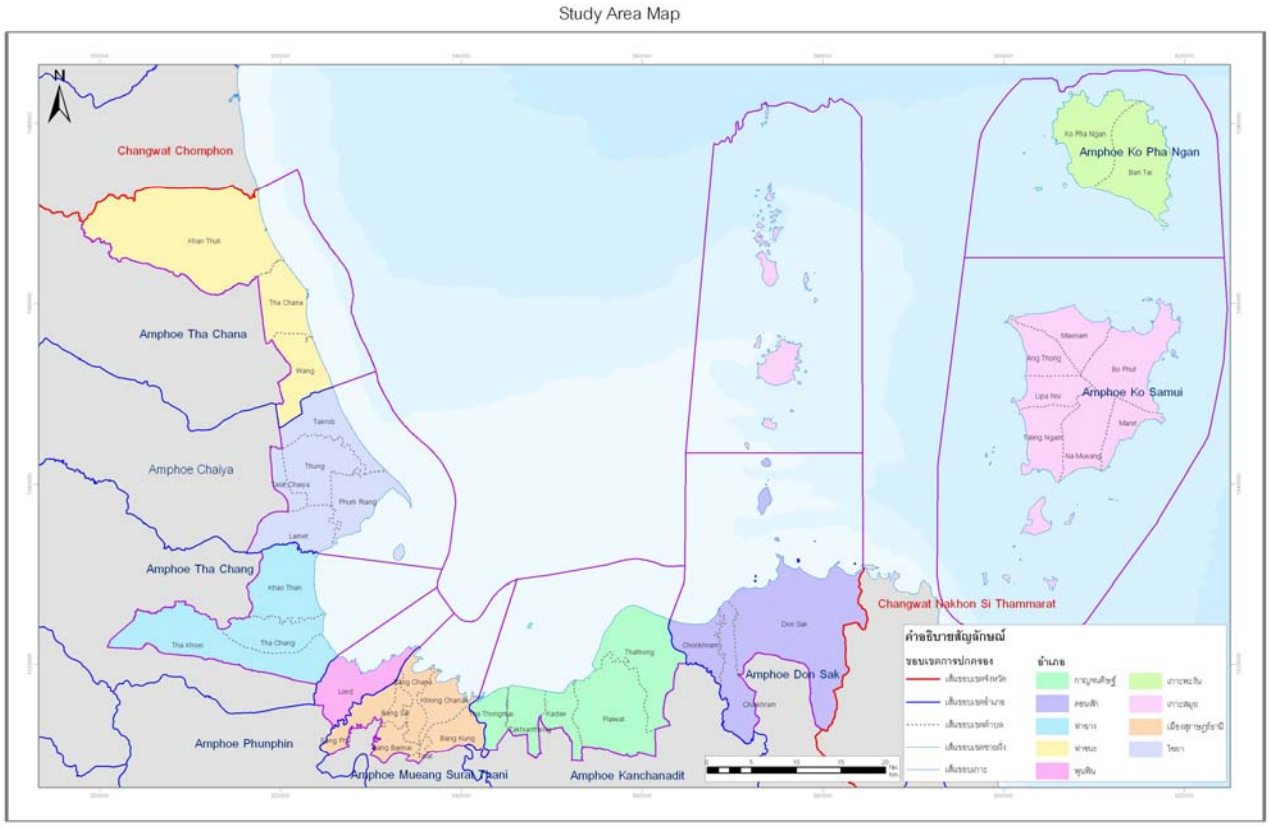


Figure 1.1.1 Study Area Map of Ban Don Bay and its offshore islands

1.4 METHODOLOGY

1) Coastal Production System : CPS
2) Coastal Management Unit : CMU
3) Participation process about attitude, point of problem, community requirement and problem solving.
4) Collect and analyse data of environment, social and economic participation.

1.5 EXPECTED RESULTS

1) Models of Coastal Eco – socioeconomic Systems
2) Vulnerability Map
3) Recommendation for sustainable development and management

1.6 STUDY TEAM

The study team of this project composed of experts in various fields. List of experts and their contribution to the project is shown in Table 1.6.1

Table 1.6.1 Study team of the Ban Don Bay and its Offshore Islands Management Planning Project: Analysis and Diagnosis of the Coastal Production Systems

No.	Name	Position
1	Assis. Prof. Dr.Pitiwong Tantichodok	Project Manager
2	Dr.Warantat Dulyapreak	Expert on Economy
3	Mr.Suthira Thongkao	Expert on GIS and Urban Development
4	Mr.Somjai Somkid	Senior Researcher on Community Participation
5	Miss.Rungrawee Jitpakdee	Senior Researcher on Tourism
6	Miss.Onanong Cheablam	Senior Researcher on Forest
7	Mr.Amonsak Sawusdee	Senior Researcher on Fishery
8	Mr.Pairot Nuannum	Senior Researcher on Economy
9	Mr.Sayan Minmun	Senior Researcher on Community Participation
10	Mr.Sarayoot Nakrod	Senior Researcher on Industry and GIS
11	Mr.Aphirat Sukkai	Senior Researcher on Aquaculture
12	Mr.Jeraphat Promchuay	Senior Researcher on Agriculture
13	Mr.Thongchai Jindaphant	Senior Researcher on Environment and GIS
14	Miss.Suwanee Sayan	Research Assistant on GIS
15	Miss.Supaporn Phasombun	Research Assistant on GIS

CHAPTER 2 METHODOLOGY

2.1 STUDY AREA AND COASTAL UNIT IDENTIFICATION

Effective coastal management leads to a compromise between natural and administrative boundaries in order to come up with manageable areas where information can be organized and scaled up using the D-P-S-I-R system (Driving forces-Pressure-State-Impact-Response). In this study, boundaries were defined in parallel to the coastline and perpendicularly from the coastline to the open sea. The marine depth limit was at an average depth of 15 to 20 meters.

In the study area of Ban Don Bay and its offshore islands, 36 coastal units were identified respectively mainly base on administrative boundary as shown in Figures 2.1.1 Table 2.1.1 show the name of districts under each coastal unit.

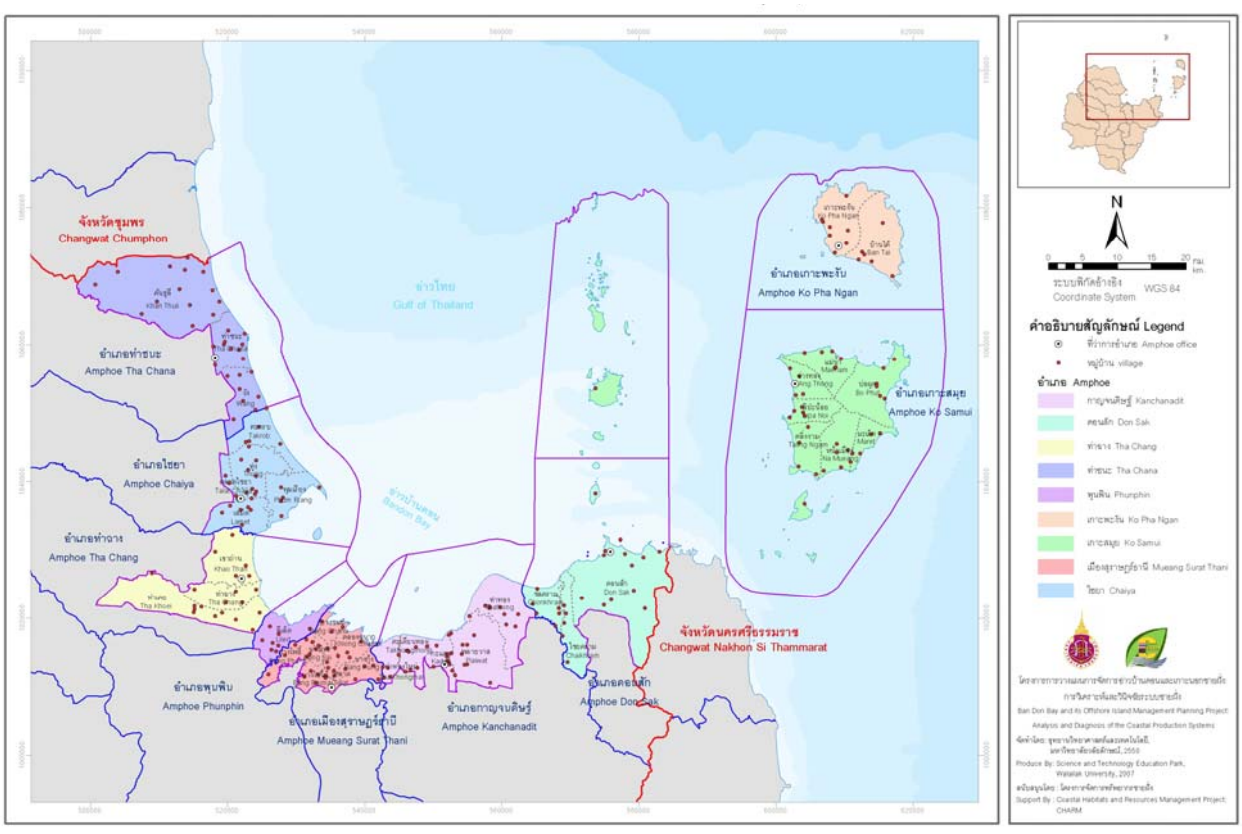


Figure 2.1.1 Administrative Map of study area: Ban Don Bay and its offshore islands

Table 2.1.1 Show the name of districts under each coastal unit.

Amphoe	Tambon
Amphoe Tha Chana	Tambon Khan Thuli
	Tambon Tha Chana
	Tambon Wang
Amphoe Chaiya	Tambon Takrob
	Tambon Thung
	Tambon Talat Chaiya
	Tambon Phum Riang
	Tambon Lamet
Amphoe Tha Chang	Tambon Tha Chang
	Tambon Khao Than
	Tambon Tha Khoei
Amphoe Phunphin	Tambon Liled
Amphoe Mueang Surat Thani	Tambon Khlong Chanak
	Tambon Talat
	Tambon Bang Kung
	Tambon Bang Chana
	Tambon Bang Sai
	Tambon Bang Baimai
	Tambon Bang Pho
Amphoe Kanchanadit	Tambon Thathong
	Tambon Plaiwat
	Tambon Kadae
	Tambon Takhianthong
	Tambon Tha Thongmai
Amphoe Don Sak	Tambon Chaikhram
	Tambon Cholkhram
	Tambon Don Sak

Table 2.1.1… (Continued)

Amphoe	Tambon
Amphoe Ko Samui	Tambon Ang Thong
	Tambon Lipa Noi
	Tambon Taling Ngam
	Tambon Na Mueang
	Tambon Maret
	Tambon Bo Phut
	Tambon Maenam
Amphoe Ko Pha Ngan	Tambon Ko Pha Ngan
	Tambon Ban Tai

2.2 QUALITY STATUS ANALYSIS

In each above coastal unit, an assessment of the physical, chemical, and biological characteristics and the extent to which they have been affected by human activities on the basis of available data were performed. The analysis of data led to summary on issues of environmental concern, attributing causes where possible, and cataloguing uncertainties and needs for more information and better understanding.

2.3 ENVIRONMENTAL VULNERABILITY INDEX (EVI) ANALYSIS

Previous database and GIS of Environmental Vulnerability (EVI), produced by Geomatic Technology Co., Ltd. and Envi Concept Co., Ltd., were updated and developed continuously.

EVI has been developed by the South Pacific Applied Geoscience Commission (SOPAC) since 1999 and agreed among international technical forum and authorities, is applied to reflect the vulnerability. EVI is an index that indicates the vulnerability of the natural resources and environment. The index is calculated from 3 sub-indices i.e. IRI, EDI and REI.

1) Intrinsic Resilience Descriptors (IRI) is the natural ability of an entity (responder) to resist or recover from damage regardless of natural adversity or human. Low IRI value means the natural resource is more able to resist to the damage. Vice versa, the higher the value, the lower the resistance or the natural resource is more sensible to the damage.

2) Environmental Degradation Descriptors (EDI) the damage occurred in the nature which designated likely to resist devastation in the future. The lower the EDI value, the lower the damage occurred.

3) Risk Exposure Descriptors (REI) rate of repetition and severely from disaster or risk despite the consequences of natural adversity or human. The lower the REI value, the lower is the risk.

Those IRI, EDI and REI indices and their indicators reflect the characteristic and intense of the natural resources, environment and stress factors of each coastal unit. The indicators represented in the EVI of SOPAC were 54, however through this study; the indicators applied to identify the EVI of each coastal unit were 33 and spread among IRI, EDI and REI, as shown in Table 2.3.1

Weight (W) used to compare important of each factor that response to natural resource and environment. Weight was 1 – 3. More important factor was 3. General factor was 2. And less important factor was 1

Table.2.3.1 Indicator used for the calculation of EVI for coastal units in Ban Don Bay and its offshore island.

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
1.	IRI	0	Land area	Round figure of land area (Inland only).	Sq. km.	Land area signals richness of habitat types, refugia, species redundancy and richness. Therefore large area is normally stable than the small area. However, certain risks might cause small area to be more vulnerable.
2.	IRI	1	Vertical relief	Altitude range (highest-lowest point of each unit).	Meter	The larger the altitude range, the greater the biodiversity of habitats and species are expected and the area is then less vulnerable.
3.	IRI	0	Lowlands	Land area less than 10 meter above sea level, interpolated by TIN.	%	Lowlands are prone to floods and tend to easily accumulate pollution, which in turns make them sensitive habitats.
4.	IRI	2	Coastal erosion	Area of erosion	Sq. km.	Coastal stability and vulnerability
5.	IRI	3	Habitats diversity	Diversity of major habitats, i.e. coral reefs, sea grass and mangrove, assessed by length and area of each habitat.	n/a	Account for both quantity and quality of different remarkable habitats, i.e. coral reefs, mangrove and sea grass beds.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
6.	EDI	0	Alien species	All introduced species.	No. of species	Biodiversity while poses threats to local species.
7.	EDI	1	Endangered species	Aquatic endangered species in the coastal unit.	No. of species	Biodiversity and keystone species.
8.	REI	1	Migrating Species	Number of known outside species which migrate the coastal unit during their life spans (including marine species)	no. of species	Lack of determination of welfare of species while they are outside the country's control. Various sites of the migrating species is conserved as tourist attraction spot.
9.	EDI	3	Area of Intensive Farming (inland)	Aquaculture farms (Shrimp farm)	Rai	The significance is on pollution, eutrophication, habitat disturbance (including disturbance of turtle and bird nesting sites) and ecosystem services. Account only aquaculture that is vulnerable to natural resource or act as receiving media (i.e. exclude that is vulnerable to human being).
		1	Area of Intensive Farming (offshore)	Coastal aquaculture farms (oyster, cockle, sea bass, and grouper)	Rai	

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
10.	EDI	2	Fisheries	Percent of coastal fishing boats (length less than 10 meters) multiple percent of coastal fishing boats with destroyed gear	%	Abundance of resources and resource depletion (fishery and endangered species).
11.	EDI	1	Water resources	Average annual water usage	$m.^3$/year	Average annual water usage of surface water and groundwater, river, canal and habitat damage.
12.	EDI	2	Open area and surface mining area	Percentage of area with open area and surface mining potential	%	Percentage of open area and mining area to land area. Major impact of mining is habitat disturbance and mine tailing or sediment contamination.
13.	EDI	0	Potential of surface mining area	Percentage of potential mining area.	%	Even though the few mining approved concession was due in 2004, the potential of mining is still foreseen. Among others, major impact of mining is habitat disturbance and mine tailing or sediment contamination.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
14.	EDI	2	Terrestrial reserves and environmental protected areas	Terrestrial zone set aside as reserves.	%	Increases resilience, pollution attenuation, limits losses of biodiversity.
15.	EDI	2	Marine reserves	Marine zone set aside as reserves (mean high tide to continental shelf).	%	Increases resilience, pollution attenuation, limits losses of biodiversity.
16.	EDI	0	Legislation/ protective measures	Environmental legislation with regulations	n/a	Controls, management of goods and services.
17.	REI	0	Sea surface temperature	Occurrence of surface sea temperature deviate more than 0.25 degree Celsius, during 1997-2004	no. of occurrence	Coral bleaching, fisheries, currents, eddy, ENSO, cyclones.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
18.	REI	1	High winds	Number of days over the last five years during which the maximum recorded wind speed is greater than 20% higher than the average maximum wind speed for the month (Data accumulated over all reference climate station and divided by the number of stations).	no. of days	Cyclones, tornadoes, storms, erosion, habitat damage, disturbance. Available data will be used for calculation.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
19.	REI	1	Dry periods	Number of months over the last five years during which rainfall is greater than 20 % lower than the 30 year average for that month (Data accumulated over all reference climate Stations/number of climate stations).	no. of months	Drought, forest fire, dries spells, water, resources, and disturbance.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
20.	REI	1	Wet periods	Number of months over the last five years during which rainfall is greater than 20 % lower than the 30 year average for that month (Data accumulated over all reference climate stations/number of climate stations).	no. of months	Floods, wet spells, coral reef, pollution and sedimentation, erosion, land slide.
21.	REI	0	Earthquakes	Potential zone of earthquake disaster occurrence.	n/a	Earthquakes, landslides and Tsunamis rarely occur. See more information about Tsunami index

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
22.	REI	0	Tsunamis	Percentage of area hit by Tsunami to total area.	%	Tsunami affects tidal waves and causes erosion, habitat disturbance, damage to and lost of life. Beach slope and total damaged area are possible indication of tsunami effect. An inland wave/water penetration is another indicator which also represents the buffer effect of the mangrove (less mangrove, more penetration). Number of occurrence is misled if used as indicator of vulnerability, since Tsunami rarely occurs (not a normal event) and therefore its significance as one of the EVI indicators is less than others. Putting less weight on this tsunami indicator will compensate this fact. It is note that the value of this indicator for Ban Don Bay since Tsunami has not yet been observed at Ban Don Bay.
23.	REI	0	Disease, pathogens and plagues	Number of reported (and verified) patients caused by diseases over the last five years in the unit.	no. of cases	Ecosystem stress, eutrophication, pollution, introduction, disturbance.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
24.	REI	3	Human population density	Total human population density.	no. per sq. km.	All incidental damage caused by human activities. It is note that higher value of this index does not always mean high vulnerability. The information obtained from the Administrative Department is recommended.
25.	REI	1	Human population growth rate	Annual human population growth rate, average over last 5 years.	%	Potential for future incidental damage by humans.
26.	REI	1	Rate of loss of natural cover/vegetation on	Net percentage of land area changed by the removal of natural vegetation, including mangrove, over last 5 years.	%	Pollution attenuation, biodiversity, soil formation, natural resource, groundwater regeneration, CO_2 fixing and habitat loss and disturbance. It is note that in some units the gain may be observed instead of loss.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
27.	REI	1	Tourists	Number of guest rooms.	no. of rooms	Major impact of tourism is an additional human loads discharged to the environment, in addition to be the cause of development. on not included in tourists visit certain attractions that charge the entrance fee, or number of hotel rooms. Number of tourists' visit each attraction is one of the best index, however, not all TAO5 record the number of tourists in their areas. The information recorded by TAT6 is not recommended since it is available only at the provincial level. Therefore, number of guest rooms is used.
28.	REI	2	Tourism Area Life Cycle.	Evolution level of Tourism site : (Butler)	Evolution level of tourism site	Level of tourism evolution, classification of tourism evolution by number of tourist who visit tourism site and dulation.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
29.	REI	3	Waste waters	Quantity of untreated industrial and domestic wastewater discharged, average over last 5 years	$m.^3/km.^3$/ year	Eutrophication and pollution.
30.	REI	3	Solid waste	Quantity of solid waste	tone/$km.^3$/year	Proportion of wastes rendered less harmful.
31.	REI	2	Waste waters	Quantity of untreated industrial and domestic wastewater discharged, average during 1973 - 2005	$m.^3/km.^3$/ year	Eutrophication and pollution.

Table.2.3.1... (Continued)

No.	Sub-index	Wt. factor	Indicator (Universal indicator)			
			Name	Description	Unit	Significance on natural resource/environment
32.	REI	3	Fertilizers	Amount of chemical fertilizers used/rai, calculated from the standard amount of chemical fertilizer used for each type of crops	Kg./rai/ year	Eutrophication, pollution, soil damage, loss arable land.
33.	REI	3	Pesticides	Amount of pesticides used/ rai, calculated from the standard amount of pesticide used for each type of crops	Kg./rai/ year	Pollution, soil damage, damage to reproductive systems of organisms.

Table 2.3.2 Old weight and new weight for EVI index

No.	Sub - index	Name of indicators	Old weight[1]	New weight[2]
1	IRI	Land area	3	0
2	IRI	Vertical relief	2	1
3	IRI	Lowlands	2	0
4	IRI	Coastal erosion	2	2
5	IRI	Habitats diversity	3	3
6	EDI	Alien species	0	0
7	EDI	Endangered species	3	1
8	REI	Migrating Species	1	1
9	EDI	Area of Intensive Farming(inland)	3	3
		Area of Intensive Farming(offshore)	3	1
10	EDI	Fisheries	3	2
11	EDI	Water resources	2	1
12	EDI	Open area ad surface mining area	1	2
13	EDI	Potential of surface mining area	1	0
14	EDI	Terrestrial reserves and environmental protected areas	3	2
15	EDI	Marine reserves	3	2
16	EDI	Legislation/protective measures	3	0
17	REI	Sea surface temperature	2	0
18	REI	High winds	2	1
19	REI	Dry periods	2	1
20	REI	Wet periods	2	1
21	REI	Earthquakes	1	0
22	REI	Tsunamis	1	0
23	REI	Disease, pathogens and plagues	0	0
24	REI	Human population density	3	3
25	REI	Human population growth rate	3	1
26	REI	Rate of loss of natural cover/vegetation	3	1

Table 2.3.2… (Continued)

No.	Sub-index	Name of indicators	Old weight[1]	New weight[2]
27	REI	Tourists	2	1
28	REI	Tourism site	3	2
29	REI	Waste waters	2	3
30	REI	Solid waste	3	3
31	REI	Oil spills	2	2
32	REI	Fertilizers	3	3
33	REI	Pesticides	3	3

Remark: 1 = Assign by Geomatic Technology Co., Ltd. and Envi Concept Co., Ltd., 2004

2 = Assign by Walailak University, 2007

With the SOPAC approach, this study set the score rate for the state of each indicator as 1 to 7 as follow.

- Level 1 Excellent score = 1
- Level 2 Good score = 2
- Level 3 Fair score = 3
- Level 4 Moderately deterioration score = 5
- Level 5 Average deterioration score = 4
- Level 6 Slightly deterioration score = 6
- Level 7 Severe deterioration score = 7

In each coastal unit, for both Ban Don Bay and its offshore, the data on each indicator were collected to understand its characteristics. The data were scored according to the criteria of each factor. Weighting factors were also given for each indicator, since the significance of each individual indicator was different. The weighting factors were scaled from 1 to 3. The combined value of the score and weighting factor for all 33 indicators was 46.

Therefore, EVI can be calculated by 1) giving score for each indicator, 2) time the score with respective weighting factor to achieve final score, 3) add up the final score of all indicators, and 4) dividing the result from 3) with 46.

Example: Calculation of IRI, EDI, REI and EVI for Tambon Khan Thuli of Ban Don Bay

$$IRI = \frac{Sc_1Wt_1 + Sc_2Wt_2 + ... + Sc_5Wt_5}{Wt_1 + Wt_2 + ... + Wt_5}$$

From above, 14 / 6 = 2.33

$$EDI = \frac{Sc_6Wt_6 + Sc_7Wt_7 + ... + Sc_{16}Wt_{16}}{Wt_6 + Wt_6 + ... + Wt_{16}}$$

From above, 44 / 14 = 3.14

$$REI = \frac{Sc_8Wt_8 + Sc_{17}Wt_{17} + Sc_{18}Wt_{18} + ... + Sc_{33}Wt_{33}}{Wt_8 + Wt_{17} + Wt_{18} + ... + Wt_{33}}$$

From above, 65 / 26 = 2.5

$$EVI = \frac{Sc_1Wt_1 + Sc_2Wt_2 + ... + Sc_{33}Wt_{33}}{Wt_1 + Wt_2 + ... + Wt_{33}}$$

From above, 123/46 = 2.67

From the above, ranges of IRI, EDI and REI are between 0-7, and can be interpret as mentioned earlier.

Table 2.3.3 Example: Calculation of IRI, EDI, REI and EVI values for Coastal Unit of Ban Don Bay

No.	Sub-index	Weight factor (W)	Name of indicators	Tambon Khan Thuli		
				Raw Data	Score (S)	S X W
1	IRI	0	Land area	N/A	N/A	N/A
2	IRI	1	Vertical relief	356	5	5
3	IRI	0	Lowlands	N/A	N/A	N/A
4	IRI	2	Coastal erosion	176.33	3	6
5	IRI	3	Habitats diversity	1.00	1	3
Total		6				14
IRI						1.67
6	EDI	0	Alien species	N/A	N/A	N/A
7	EDI	1	Endangered species	Present	4	4

Table 2.3.3… (Continued)

No.	Sub-index	Weight factor (W)	Name of indicators	Tambon Khan Thuli		
				Raw Data	Score (S)	S X W
9	EDI	3	Area of Intensive Farming (inland)	552.40	1	3
	EDI	1	Area of Intensive farming (offshore)	40.00	1	1
10	EDI	2	Fisheries	2.89	2	4
11	EDI	1	Water resources	274151.5	2	2
12	EDI	2	Open area ad surface mining area	26.33	1	2
13	EDI	0	Potential of surface mining area	N/A	N/A	N/A
14	EDI	2	Terrestrial reserves and environmental protected areas	-	7	14
15	EDI	2	Marine reserves	-	7	14
16	EDI	0	Legislation/protective measures	N/A	N/A	N/A
Total		14				44
EDI						2.50
8	REI	1	Migrating Species	43	3	3
17	REI	0	Sea surface temperature	N/A	N/A	N/A
18	REI	1	High winds	49.02	4	4
19	REI	1	Dry periods	24.57	3	3
20	REI	1	Wet periods	35.43	5	5
21	REI	0	Earthquakes	N/A	N/A	N/A
22	REI	0	Tsunamis	N/A	N/A	N/A
23	REI	0	Disease, pathogens and plagues	N/A	N/A	N/A
24	REI	3	Human population density	181.53	1	3
25	REI	1	Human population growth rate	-2.95	1	1
26	REI	1	Rate of loss of natural cover/vegetation	0	1	1
27	REI	1	Tourists	-	1	1
28	REI	2	Tourism site	level 2	3	6

Table 2.3.3… (Continued)

No.	Sub-index	Weight factor (W)	Name of indicators	Tambon Thachana		
				Raw Data	Score (S)	S X W
29	REI	3	Waste waters	17,440	1	3
30	REI	3	Solid waste	3,004.40	2	6
31	REI	2	Oil spills	-	1	2
32	REI	3	Fertilizers	169	5	15
33	REI	3	Pesticides	1.45	4	12
Total		26				65
REI						3.14

Through this study, the values of IRI, EDI, REI and EVI of each coastal units of Ban Don Bay can be graphically presented as shown in Figure 2.3. From this Figure, the values of each index value can be separated into 3 ranges, i.e., ≤ 2.00, 2.01-4.00 and > 4.00, and their intensity can be present as low, moderate and high, as shown in Table 2.3.4

The actual assessment of EVI of each coastal unit of Ban Don Bay based on the above calculation and interpretation is elaborated in details in Chapter 4.

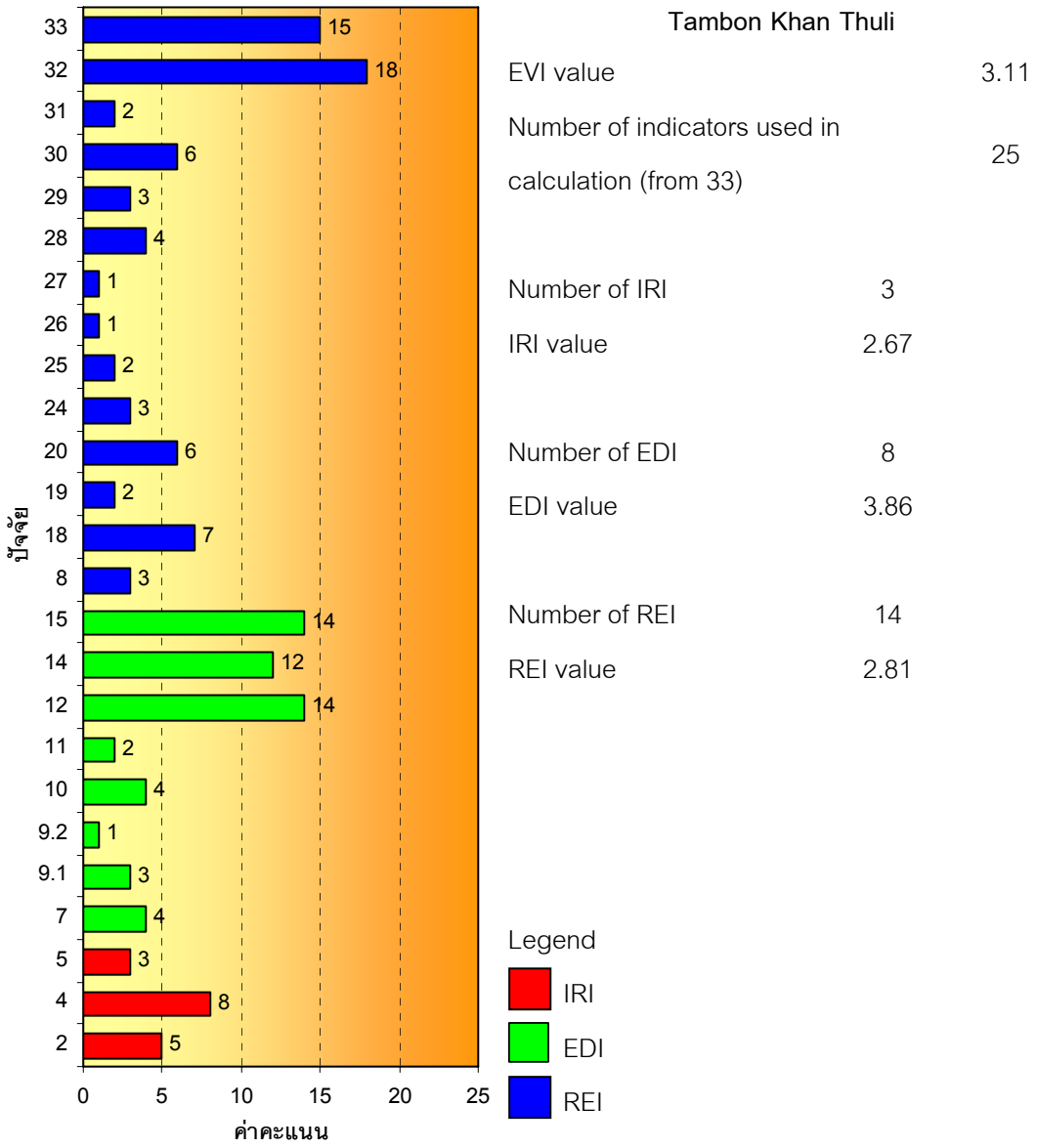


Figure 2.3.1 Example: Calculation of IRI, EDI, REI and EVI values for Tambon Khan Thuli

Table 2.3.4 Presentation of IRI, EDI, REI and EVI values

Index	Values		
	0 – 2.00	2.01 – 4.00	4.01 – 7.00
IRI	low sensibility to damages	moderate sensibility to damages	High sensibility to damages
EDI	high resistance to damages, i.e. low damages occu	moderate resistance to damages, i.e. moderate damages occur	low resistance to damages, i.e. high damages occur
REI	low risk	moderate resistance to damages, i.e. moderate damages occur	low resistance to damages, i.e. high damages occur
EVI	Low vulnerability, more stable	Moderate vulnerability	High vulnerability, least stable

2.4 ATLAS DEVELOPMENT

2.4.1 Data collection

Because of the large amount and diversity of the data characterizing the coast, a rigorous method was required to coherence between the data collected and the study's objectives. Natural riches were assessed in terms of physical of environment, biological characteristics and the inventory of uses to which the environment is subjected. Additional information regarding legal regulations could be added to describe existing protective measures or management programs.

Data collected at the beginning phase were mostly involved with intrinsic richness and degree of degradation. Richness of habitats was assessed in regard to their physical and biological characteristics, in addition to the inventory of uses to which they were submitted. Protective measures such as marine protected areas might be taken into consideration during the assessment. The degree of degradation was assessed from secondary data on the state of habitats and/or from direct observation when needed.

An indicative checklist of the various possible descriptors is given below:

1) General descriptors

Zone No., Delimitation criteria, Zone name, Administrative area, Existing urban areas, Associated small islands, Associated coral reefs, Sea-grass, Mangroves, Beaches, Estuaries, Basin unit.

2) Sensitivity-linked descriptors

2.1) Natural environment: Remarkable species, Remarkable formations (habitats intra and inter-diversity, Habitats state of health, Ecological importance of seagrass communities

2.2) Human activities: Tourism activities, Fisheries, Aquaculture, Extraction, Protection, etc.

3) Risk-linked descriptors

3.1) Zone's general vocation: Size of urban area, Cleanliness of urban zone, Urban or infrastructure development project, Classified or unclassified industries, agroindustrial structures, impact of industries, Industrial development project, type of tourist activities, tourism development project

3.2) domestic waste tips.

In data acquiring process, the required data for the analysis model were determined by the experts depending on the factors that drives the modeling. The existing data regarding significant resources in the study area could be one of two formats, attribute or spatial. Various data obtained include the following: The data from the Department of Fisheries such as coral reef, seagrass, mangrove forest, dugong habitat, dolphin habitat, and endangered sea animals. The physical data of the study area are including administration boundaries from the Department of Provincial Administration, geography data from the Department of Environmental Quality Promotion, water supplies from the Royal Irrigation Department and the Office of Natural Resources and Environmental Policy and Planning, and landuse data from the Land Development Department, etc. However, the experts noted that the correctness and accuracy of the data will be accredited only a short period of time during the year and not all of them were compatible with each other. This is due to the bio diversity of the study area and the weather cycle of Thailand. Furthermore, the different cycles of surveying by organizations also had an effect on their originally surveyed data. For example, the legislation of closing gulf during the egg-laying season of fish will affect the resource data which was surveyed during that time.

The data was collected from various sources and was the best possible quality accuracy). They were collected from different sources. The main data sources are as follows:

1. Administrative Boundary	Department of Provincial Administration
	Department of Public Works Town Planning
	The National Statistical Office
2. Meteorology	Thai Meteorological Department
3. Topography	Hydrographic Service Department

	Royal Thai Survey Department
	Department of Mineral Resources
4. Water and Water Quality	Pollution Control Department
	Office of Environmental Policy and Planning
	Royal Thai Survey Department
	The National Water Resource Committee
5. Geology and Mining	Department of Mineral Resources
6. Soil	Land Development Department
7. Forestry	Royal Forest Department
8. Transportation	Royal Thai Survey Department
9. Habitats and natural coastal resources	Department of Marine and Coastal Resources
	Scuba diving observe
10. Land use Land	Development Department
11. Tourist	Attraction Tourism Authority of Thailand
12. Places i.e. factory, hotel, landmark	Department of Industrial Works
	Tourism Authority of Thailand
13. Fishery and Aquaculture	Department of Fishery
	Department of Fishery
	National Park, Wildlife and Plant Conservation Department
14. Environment Conservation and Protected Area	Pollution Control Department
	Office of Environmental Policy and Planning

Mostly data came from government departments or scientific organizations whose specialties were in environmental monitoring or observation and some data was in the Geographic Information System (GIS) format. Direct observation was performed in the field to data obtain on terrestrial (coastal morphology, embankments, industries, tourist attraction, coastal activities etc.) or within the aquatic environment (inventory/observation of habitats through transects, observation of fishing techniques impact, etc.). The coral reef data was not up to date so the data was collected from direct observation by scuba diving observed at Ang Thong Islands (Ban Don Bay).

The data obtained generally was from diverse sources and came in various forms. So the data standardization was essential. To this purpose, data was transformed into qualitative

variables according to an exhaustive common denominator established for the whole area. The procedure consists of simplifying the data by transforming them into common denominator for the whole study area, followed by data coding.

2.4.2 GIS database

The project's spatial database was developed in GIS (Geographic information system) database which digitalized into spatial or map data and attribute data. These spatial and attribute have to be linked together and could be referenced in geographic coordinate. Because of CHARM has not the spatial database structure before so the consultant designed the GIS coastal database structure. For the other topographic base map use the same structure as the owner designed. By designing consider the data requirement, frequency use and other data conditions. In the linkage between spatial and attribute data based on unique geographic identifier and each has own attribute in theme and layer model as figure below.

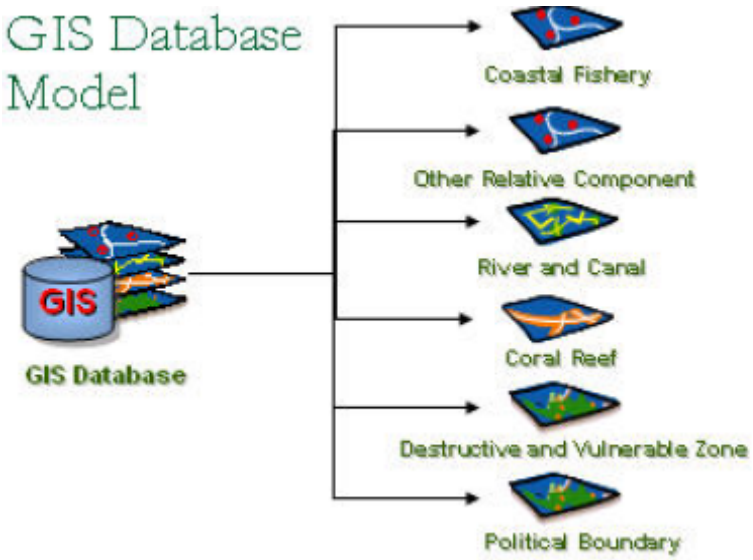


Figure 2.4.1 GIS Database model

The details of GIS database structure are in the data dictionary format. Their contents were the data group, the map layers and attribute data of each layer such as field name, field width, field type and the data code meaning. The GIS database contained 61 map layers in 14 groups as table 2.4.1.

Table 2.4.1 Geographic Information System Database Layer

Data Group		
Theme	**Map Layer**	**Shape file name**
Group 1 General description		
Theme1_Administrative Boundary	Province	Province.shp
	Amphoe	Amphoe.shp
	Tambon	Tambon.shp
	Municipality	Municipa.shp
	Village	Village.shp
	Coastal unit	Coastal_unit.shp
Theme2_Meteorology	Weather Station	Wea_sta.shp
	Rain Fall	Rain_fall.shp
Group 2 Physical characteristics		
Theme3_Topography	Bathy point	Bathy_point.shp
	Bathy line	Bathy_line.shp
	Buoys	Buoys.shp
	Coastal erotion	Coastal_ero.shp
	Various limits	Various_limit.shp
	Elevation	Elevation.TIN
	Contour	Contour.shp
	Spot high	Spot.shp
Theme4_Water and Water Quality	Water quality sampling station	Water_quality.shp
	Watershed classification	Watershed.shp
	Stream	Stream.shp
	Basin	Basin.shp
	Aquifer	Aquifer.shp
	Wetland	Wet land.shp

Table 2.4.1… (Continued)

Data Group		
Theme	**Map Layer**	**Shape file name**
	Land slide	Landslide.shp
	Submarine	Submarine.shp
Theme6_Soil	Soil	Soil.shp
Group 3 Biological characteristics		
Theme7_Forestry	Forest use	Forest_use.shp
	Forest	Forest.shp
Theme8_Transportation	Trans	Trans.shp
Group 3 Biological characteristics		
Theme9_Coastal Resource	Scaly giant clam	Giant clam.shp
	Coral	Coral.shp
	Sea turtle	Seaturtle.shp
	Dugong	Dugong.shp
	Dolphin	Dolphin.shp
	Mangrove	Mangove.shp
	Seagrass	Seagrass.shp
	Shark	Shark.shp
Group 4 Man's impact		
Theme10_Land Use	Land use	Land use.shp
Theme11_tourist Attraction	Heritage	Heritage.shp
Theme12_Places	Factory	Factory.shp
	Hotel	Hotel.shp
	DOF Office, Harbour	Office_dof.shp
	Places	Places.shp
Theme13_Fishery and Aquaculture	Fishery tool	Dof_tool.shp
	Shrimp	Shrimp.shp
	Cockle	Cockle.shp
	Fishcage	Fishcage.shp
	Permission area	Permission_area.shp

Table 2.4.1… (Continued)

Data Group		
Theme	**Map Layer**	**Shape file name**
Theme14_Environment	Control fishery zone	Control_fishery.shp
Conservation and Protected Area	Law fishery	Law fishery.shp
	National park	Nation_park.shp
	Wildlife sanctuary	Wildlife.shp
	Non-hunting area	Non_hunt_area.shp
	Plant conservation area	Plant_area.shp
	Pollution control zone	Pc_zone.shp
		Environment.shp

Finally, the consultant was already produced the database dictionary including references of the original of the data sources which will be available and benefit to related organizations that will require this data in the future those were submitted with this report.

2.4.3 Map Layout

2.4.3.1 Coastal zone

Boundaries were defined in parallel to the coastline and perpendicularly from the coastline to the open sea. Each zone was identified on a map by lines representing their longitudinal and transverse boundaries and in a table by a numeric identifier and a name under the heading of “General descriptors”

- Political boundary by tambon
- Protective area
- Resources i.e. coral reef, seagrass bed, mangrove, marine lives
- Resources exploitation i.e. fisheries, tourism
- Land Use i.e. industrial zone, resident area, agricultural zone
- Marine depth limit average to 20 meters

2.4.3.2 Map Design

Besides the database and as a communicating and negotiating tool, the main product of the study is an atlas with the following content:

• Typology presentation including type name, description, large-scale map characteristics with coastal unit

• Sensitivity map

- Risk factors map
- Vulnerability map
- Set of small-scale maps, zone-by-zone, with respective datasheets

2.5 WORKSHOP

Two workshops were organized to validate the results of the study for Ban Don Bay and its islands on 14 August 2007 at Diamond Plaza Hotel, Surat Thani Province. The participants were representatives from the users and decision-maker groups.

The objectives of the workshops were the following.

1) To introduce to the justification and objectives of the project.

2) To present approaches used to assess and factors that influence natural resources and environment of Ban Don Bay

3) To present the results of the quality status analysis of natural resources and environment of Ban Don Bay

4) To present maps and GIS database.

5) To collect ideas and recommendations through brainstorm meetings among each coastal area.

Comments made during the workshops were incorporated into the final report.

CHAPTER 3 STUDY RESULT

3.1 NATURAL RESOURCES AND ENVIRONMENT

3.1.1 Introduction

Ban Don bay and its offshore islands in Surat Thani province locate on the eastern side in the southern part of Thailand. They compose of healthy natural resources and diversity on mangrove, seagrass beds and coral reef ecosystems which are natural habitats, spawning grounds, nursery areas and food sources for a variety of marine animals including dugong, dolphin and other rare species. Related utilizations from the areas have been relied mainly on these resources (i.e. fishery, aquaculture, agriculture, industry, community settle and tourism). All activities from these utilizations, thus, have both direct and indirect impacts including pollution discharged on the natural resources and environment body.

A study of natural resources and environment has been based mainly on the secondary data and information from all related parties as well as the primary data and information which had been obtained through field surveys and group discussions in order to obtain the community opinions.

3.1.2 General Conditions of Ban Don Bay and Its Offshore Islands

3.1.2.1 Location and size

Ban Don Bay is located between the latitude of 09°07'N to 09°48N and the longitude of 98°58'E to 100°5'E. It encompasses 9 districts in Surat Thani: Amphoe Tha Chana, Amphoe Chaiya, Amphoe Tha Chang, Amphoe Phunphin, Amphoe Mueang Surat Thani, Amphoe Kanchanadit, Amphoe Don Sak, Amphoe Ko Samui and Amphoe Ko Pha Ngan. The coastal areas under the project were of 9 districts or amphoes and 36 communes or tambons[1]: Amphoe Tha Chana (Tambon Khan Thuli, Tambon Tha Chana and Tambon Wang), Amphoe Chaiya, Amphoe Tha Chang (Tambon Khao Than, Tambon Tha Chang and Tambon Tha khoei), Amphoe Phunphin (Tambon Liled), Amphoe Mueang Surat Thani (Tambon Bang Pho, Tambon Bang Chana and Tambon Bang Sai, Tambon Bang Baimai, Tambon Khlong Chanak, Tambon Bang

[1] The word 'district' is used for the translation of the Thai word "amphoe" (sometimes also amphur, Thai: อำเภอ), which is the second level administrative subdivision of Thailand. Several amphoes make up a province. Each amphoe is further subdivided into tambon, which is usually translated as "commune" or "sub-district" in English.

Kung and Tambon Talat), Amphoe Kanchanadit (Tambon Tha Thongmai, Tambon Takhianthong, Tambon Kadae, Tambon Plaiwat and Tambon Thathong), Amphoe Don Sak (Tambon Chonkhram, Tambon Chaikhram and Tambon Don Sak), Amphoe Ko Samui (Tambon Angthong, Tambon Maret, Tambon Bo Phut Tambon Maenam, Tambon Na Mueang, Tambon Taling Ngam and Tambon Lipa Noi) and Amphoe Ko Pha Ngan (Tambon Ko Pha Ngan and Tambon Bantai). The total areas are equal to 1,554.39 square kilometers or 971,492 rai.

3.1.2.2 Boundary

The adjacent sites to the north are Lamae District, Chumporn Province and the Gulf of Thailand. At the south are Phunphin, Mueang Surat Thani, and Khanchanadit District while Khanom District, Nakornsrithammarat Province are on the east, and Chaiya, Tha Chang, and Tha Chana District on the west.

3.1.2.3 Topography

The Ban Don Bay is the large bay located on the west coastal zone of the Gulf of Thailand. Their tidal system has been recognized as Semidiurnal. From Laem Sui, Chaiya district to Paknam Thathong, Kanchanadit district, the shallow water shoreline and large mud flat with mangrove forest on the edge throughout have been described. The sediments settled near the Ta Pi River estuary have created alluvial fans. The high plain can be observed in Tha Chana, Chaiya and Tha Chang districts.

Its offshore islands are groups of islands in Ko Samui, Pha Ngan and Don Sak districts producing two main lines laying north – south: Mu Ko Ang Thong, Ko Phaluai, Ko Noktaphao and groups of Ko Samui, Pha Ngan and Tan.

3.1.2.4 Climate

The influences of the south-western monsoon from the South China Sea and the northeastern monsoon from the Gulf of Thailand result in 2 seasons in the bay area:- i.e. rainy season and summer. The rainy season from May to December can be divided into 2 periods. The first period, from May to September with moderate rainfall as a consequence of the south-western monsoon while it rains heavily in the second one under the influence of the north-eastern monsoon from October to December. Summer, influenced from the south-eastern monsoon which hot weather and moisture from high atmospheric pressure in the South China Sea brings high temperature and less rainfall during January and April.

1) Rainfall

The rainfall recorded from 1993 to 2006 was in a range of 1,111.6-2,362.1 mm. The highest rainfall of 2,362.1 mm. was measured in 2003 (166 rainy days) while the lowest rainfall of 1,111.6 mm. in 2005 (153 rainy days).

2) Temperature

The average temperatures of Surat Thani Province during 1993 and 2006 were in a range of 26.47-27.36 C. The low temperature range of 17.00 to 19.5 C with the lowest temperature of 17.00 C was recorded in 2000 while the higher temperatures ranged from 35.60-38.80 C with the highest temperature of 38.80 C in 1998.

3.1.3 Natural Resources and Environment Conditions

3.1.3.1 Water Resources

1) Surface Water

1.1) Natural Freshwater Resources

The waterways that flow to Ban Don Bay are generally long or originated from conjoined waterways. The main waterway or rivers are from Ta Pi and Phum Duang rivers. The Ta Pi river has originated from the Luang mountain range, Nakhon Si Thammarat province and continuously flow to Ban Don Bay. The total length has been approximated to 200 kilometers. For the Phum Duang river, it has been originated in Phanom district from the mountain range between Phang Nga and Surat Thani provinces and eventually, conjoins with the Ta Pi river in Phunphin district. Its total length has been approximated to 120 kilometers.

The main streams flow to the coastal areas of Ban Don Bay are: Khlong Khan Thuli, Khlong Tha Chana, Khlong Tha Krachai, Khlong Bang Som, Khlong Bang Huai, Khlong Khram, Khlong Tha Chang, Khlong Ta Khoei, Khlong Phunphin, Khlong Ram, Khlong Chanak, Khlong ThongLarng, Khlong Bang Yai, Khlong Tha Thong, Khlong Bang Khuai, Khlong Tha Koop, Khlong Makamteir, Khlong Yai Phum Riang, Khlong Takhian, Khlong Rew, Khlong Kradae, Khlong Suk, Khlong Sabayoi, Khlong Bang Khung, Khlong Bang Tan and Khlong Don Sak.

The natural water sources in Ko Samui are: Khlong Khao Khwang, Khlong Khaek, Khlong Chorakhe, Khlong Chaweng, Khlong Chaweng Noi, Khlong Tha Ret, Khlong Bang Glung, Khlong Bang Thum, Khlong Bang Tha, Khlong BangnamJird, Khlong Bang Por, Khlong Bangmakharm, Khlong Bangmieng, Khlong Banthalae, Khlong Pharkbang, Khlong Pakhum, Khlong Pongpare, Khlong Phungga, Khlong Maenam, Khlong Lamai, Khlong Lipha Yai, Khlong Luek, Khlong Wattalae, Khlong Watsaked, Khlong Thurian, Khlong Hinngu, Khlong Leng, Phru Cha Weng, Phru Bang Rak and Phru Nameing.

The natural water sources in Ko Pha Ngan are: Khlong Ta Phan, Khlong Tha Chin, Khlong Tha Thon Lo, Khlong Tha Nam Cho, Khlong Tha Yai, Khlong Than Prapart, Khlong Than Sadat, Khlong Bang Chak, Khlong Bangnamkem, Khlong Mae had, Khlong Hat Kuad, Khlong Oke, Khlong Ao Wai Nam and Khlong Ao Hat Yang.

1.2) Sea Water Resources

The coastal resources within Ban Don Bay and its offshore islands are economically important for varieties of utilizations including industrialization, tourism, fishery and aquaculture. Especially, from Laem Sui, Phum Riang sub-district, Chaiya district to Thathong sub-district, Kanchanadit district, they have shallow water shoreline with mangrove forest system throughout the area. The sedimentation also provides the important base for fishery and aquaculture activities.

2) Ground Water Resource

From DMR (2001), the ground water comes from the accumulation of rainfall and surface water permeated through the soil interval and layer underneath. During its permeation, the dissolution from soil and rock layer has been occurred and mixed, thus, the quality of the groundwater has been varied depending on the soil and rock types that it has been through. The underground water utilizations from all activities have to be aware of all physical, chemical, biological characteristics and toxic content.

The capacity of Ban Don Bay and its offshore island groundwater can be further developed to a main groundwater resource. However, mixed saltwater due to saltwater intrusion, rust and hardness problems have been reported depending on their area characteristics.

3.1.3.2 Coastal Marine Resources

1) Coral Reefs

Within Ban Don Bay and its offshore islands in Surat Thani province, there are coral reef resources in Don Sak district coastal area, group of Pha Ngan islands, group of Samui islands, group of Tan islands and group of Ang Thong islands due to their proper environmental conditions for these coral reef growth. In Ban Don Bay, however, the sedimentation from Ta Pi river and other watercourses create an environment being unsuitable for the development and growth of the coral reef. The coral reef conditions within these areas can be summarized as follows:

Group of Don Sak district coastal areas has been reported the existing of coral reefs in Ko Nok Ta Pao, Ko Ga, Ko Ngiew and Ko Cherik. The Marine and Coastal Resources Research Center, the Central Gulf of Thailand (2006) report on the coral reef condition has stated that the coral reef within this area has a fringing reef type with mostly deteriorated condition. Ko Nok Ta Pao and Ko Ga have their coral reefs in the range of medium to very poor conditions. Ko Ngiew has its coral reef being in the range of poor to very poor conditions. Ko Cherik has its coral reef being in the range of medium to very poor conditions.

Group of Pha Ngan islands (8 islands are Ko Pha Ngan, Ko Ma, Ko Kong Nui, Ko Kong Krieng, Ko Tae Nok, Ko Tae Nai, Ko Kong Rin and Ko Kong Than Sadet, respectively) as reported by the Marine and Coastal Resources Research Center, the Central Gulf of Thailand (2006) have their coral reef conditions as follows; the coral reefs in the northeastern part of the islands (from Ko Ma to Hat Korm) has being in a good condition compared to a very poor condition for the southern part of the islands being reported.

From the coral reef condition survey in Ko Ang Thong groups , Ko Samui groups and Ko Tan conducted by the research team from the sciences and technology education park, Walailak university, the summaries are;

1.1) Ko Ang Thong groups: the surveyed result indicates that most of fringing reef has been in the range from very poor to healthy conditions. The main species found are *Porites lutea, Acropora spp., Goniopora sp. And P. deadalea*.

1.2) Ko Samui and Ko Mud Lhung groups: The fringing reefs in Ko Samui have their conditions within the range from poor to healthy conditions. Most of the reefs in the north are in the range from very poor to healthy conditions compared to the range of medium to healthy conditions of coral reefs in western side. The main species found are *Acropora spp., Goniopora sp., P. cactus, P. decussate, P. deadalea* and *Turbinaria sp.*.

1.3) Ko Tan groups: The fringing reefs have been found throughout the islands. The width of these reefs reported to be approximately 80 – 450 meters. Most of these reefs are in medium (healthy condition is also reported in some areas) condition. In Pha Dang and near buoyant position in Ao Oke areas, the massive, submassive and tabulate formations of coral reefs have been reported.

2) Seagrass bed

Ban Don Bay and its offshore islands has their seagrass bed in the area of Chaiya districts, Ko Samui, Ko PhaLuai, Ko Pha Ngan, Ko Tan, Ko Ang Thong groups and Don Sak district.

9 species of seagrass found are *Halophila ovalis, Halophila beccarii, Halophila decipiens, Cymococea rotundata, Halodule uninervis, Halodule pinifolia, Enhalus acroides, Thalassia hemprichii, Syringodium isoetifolium*. The total area of seagrass bed has been approximated to 3,663 rai which has been scattered throughout areas in Ao Chaiya, Chaiya district, Ko Pha Ngan, Ko Tha Rai, Ao Nang Gum and Ko Nok Ta pao, Don sak district.

Nattawadee (2005) reported the species of seagrass found in Chai Ya district are *Halophila ovalis, Halophila beccarii* and *Halodule uninervis* in the total area equal to 992 rai. Ko

Pha Ngan has been reported with 5 species of seagrass; *Enhalus acroides, Halodule uninervis, Halophila ovalis, Thalassia hemprichii* and *Cymococea rotu*ndata with the total area equal to 1,942 rai. Don Sak district has been reported a seagrass species *Enhalus acroides*, in the ferry pier with the total area of 12 rai and Ko Nok Ta Pao area with 4 seagrass species (*Halodule pinifolia, Halodule uninervis, Halophila ovalis* and *Syringodium isoetifolium*) within 80 rai area.

Ko Tan reported by UNEP (2004) indicated 2 seagrass species: *Enhalus acroides* and *Halophila ovalis* with no report on the total area data.

From the seagrass surveyed in Ko Samui, Ko Phaluai and Ko Ang Thong groups by the research team from the sciences and technology education park, Walailak university, the result shows that the dispersion of seagrass bed has been reported in Ko Samui bays and capes with 3 main species: *Enhalus acoroides, Halodule uninervis* and *Halopjila ovalis* with the total area of 636 rai.

Ko Ang Thong groups have only been reported with one species (*Enhalus acoroides*) in Ko MaeKo area with the total area of 0.56 rai.

3) Endangered Species

3.1) Dugong

The Marine and Coastal Resources Research Center, the Central Gulf of Thailand (2006) reported the 5 -6 dugongs found in Phum Riang bay area, Chai Ya district and 1 -2 dugongs in Ko Nok Ta Pao and Ko Thum areas, Don Sak district. The dead dugong had also been found and reported on 4th February 2005 by small-scaled fishermen in Phum Riang sub-district. The dead dugong (2.06 meters length with 85 -90 kilograms weight) was found in Ko Sed area located in the coastal area of Phum Riang sub-district, Chai Ya.

Kanchana (Unpublished data, 2003) claimed that total of 8 dead dugongs were recovered in Mueang district (1), Chai Ya district (4) and Ko Samui district (3) by fishing gears.

3.2) Dolphin

A dolphin has been recognized as the endangered species that can be commonly found compared to sea turtle and dugong. A group of dolphin can be found in the coastal areas in Tha Chana district, Don Sak district, Ko Ang Thong groups, Ko Samui and Pha Ngan. Three common species commonly found *are Sousa chinensis, Orcaella brevirostris and Neophocaena phocaenoides*.

10th December 2003: a dead body of *Neophocaena phocaenoides* (Male with 1.37 meters length and 29 kilograms weight) was recovered in Ban Lam Sai Hat, Phum Riang sub-district, Chai Ya district.

19th January 2004: a dead body of *Neophocaena phocaenoides* was recovered in Pal Khlong Gew, Wang sub-district, Tha Chana district.

2nd March 2004: a dead body of *Neophocaena phocaenoides* (0.83 meters length and 9 kilograms) was recovered Takrob sub-district, Chai Ya district. A cause of death has claimed to be from the fishing net.

3rd June 2004: a dead body of *Neophocaena phocaenoides* was recovered in Lam Hat area, Don Sak sub-district, Don Sak district.

12th December 2004: a dead body of *Sousa chinensis*(Male with more than 70 Kilograms) was recovered in Lam Sai, Phum Riang sub-district, Chai Ya district.

3.3) Sea Turtle

The 2 species of sea turtle that have commonly found in the areas are *Chelonia mydas* and *Eretmochelys imbricsata*. The dead body of Hawksbill turtle was recovered in the fishing net near the coral reef in Ban Thong Grude, Ko Samui on 1st February 2007. The dead body of green turtle was recovered on 17th November 2003 in Takrob sub-district, Chai Ya district with the approximated weight of 40 Kilograms.

3.4) Coastal

The coastal resources have been complicated by their physical aspects and coastal configurations (i.e. rocky shore, sandy beach and mud flat). The change in coastal conditions can be continuously occurred due to impacts from wave, current, tide and sedimentation resulting in the coastal erosion, land growth accumulation and coastal maintaining condition. Human activities such as, dam construction and ferry pier construction, can also have an impact on changes in coastal conditions.

Based on report by Sin and others (2002), changes in Surat Thani coastal areas of the total length of 135 kilometers shoreline are as follows; 102.3 kilometers (71 % of the total shoreline length) are still being in coastal maintaining condition, 9.2 kilometers (6.8%) are in land growth accumulation condition and the heavy and medium coastal erosion conditions occur for 8 kilometers (6%) and 15.5 kilometers (16.2%), respectively.

3.4.1) Land Growth Accumulation Condition in Coastal Resources

The coastal area in Pak Khlong Khan Thuli, Tha Chana district has an annual growth accumulation rate of 1 – 2 meters for both sides with the total length of 1 kilometer.

The coastal area in Ban Don Bay, Tha Chana district has sandy beach with the growth accumulation rate on both sides with the total length of 1 kilometer caused by the sedimentation from Khlong Taling Num and Khlong Taling Tao.

The coastal area of north side of Lam Sui, Lam Thong Larng area, Chai Ya district has an annual growth accumulation rate of 2 meters with the total length of 1 kilometer.

The coastal area of Lam Po, Chai Ya district has an annual growth accumulation (sand bar) rate of 2 – 3 meters with the total length of 1.2 kilometers.

The coastal area of Ban Lang, Chai Ya district has an annual growth accumulation rate of 1 - 2 meters with the total length of 1 kilometer.

The coastal area of Ko Kee Nok, Tha Chang district has an annual growth accumulation rate of 2 meters with the total length of 1.5 kilometers.

The coastal area of Ban Na Kai, the northeastern part of Ko Samui, Ko Samui district has an annual growth accumulation rate of 1 meter with the total length of 3 kilometers.

3.4.2) Coastal Erosion Condition in Coastal Resources

- **Heavy Coastal Erosion Condition**

The heavy coastal erosion has an average annual rate of erosion higher than 5 meters. It has been occurred in Ban Pod – Ban Pak Khlong Kram, Don Sak district with the total erosion length of 8 kilometers with an average annual rate of erosion of 16 meters.

- **Medium Coastal Erosion Condition**

The medium coastal erosion has an average annual rate of erosion from 1 – 5 meters.

The coastal area of the north Ban Pak Nam Tha Krajai, Tha Chana has the total length of erosion equal to 700 meters with the annual rate of erosion equal to 3 meters.

The coastal area of Ban Tha Krajai – Ban Thung Nom Maew, Tha Chana district has the total length of erosion equal to 4 kilometers with the annual rate of erosion equal to 1 – 2 meters.

The coastal area of south Ban Tha Mueang, Tha Chana district has the total length of erosion equal to 500 meters.

The coastal area of up north of Ban Gew, Tha Chana district has the total length of erosion equal to 1.5 kilometers with the annual rate of erosion equal to 2 meters.

The coastal area of Ban Bang Pakkrad and hat Jintara, Chai Ya district has the annual rate of coastal erosion of 1 -2 meters with the total length equal to 1 kilometers and 0.8 kilometer for Ban Pakkrad and hat Jintara, respectively.

The coastal area of Ban Wanghin – Lam Kula, Don Sak district has the total length of coastal erosion occurred in the front of sandy beach portion of 7 kilometers starting from Lam Kula to Don Sak community with the annual rate of 2 -3 meters.

During the end of 2006, there was a high wind and wave in the Gulf of Thailand. DMR (2006) reported the damage from high tidal wave and flood from 18th-22nd December 2006 had been occurred due to the northeast monsoon wind.

3.1.3.3 Environmental Pollution

1) Air and Noise Pollutions

The Ban Don Bay and its offshore islands has only one air quality monitoring station , which has been operated by Department of Air Quality and Noise Management, Pollution Control Department (PCD), located in the Mueang district office, Surat Thani province. During 1997 – 2006, all air quality parameters (SO_2, NO_2, CO, O_3 and PM_{10}) have been met with the standard requirement.

2) Water Quality

2.1) Freshwater Resource Quality

PCD (2007) reports the water quality of Ta Pi and Phum Duang rivers during 1997 – 2006 as; most of the parameters (pH, DO, BOD, nutrients, bacteria and heavy metals) have well met the standard requirement. However, the water quality in Khlong Prasang Thai Keun Ratchprapa, Prasang sub-district, Ban Takhun district has been reported the low value of DO for the surface water 3rd type. Also, Tha Thong ferry pier, Talad sub-district, Muang district together with Ban Don ferry pier, Muang district and Phum Duang bridge, Ban Ta Khun, Pra Sang sub-district, Ban Ta Khun district have been reported a low value of DO and high values of both coli form bacteria and fecal coli form bacteria.

2.2) Coastal Water Quality

PCD (2006) reported that all parameters (Temperature, pH, Salinity, DO, suspended solid, nutrients, bacteria and heavy metals) have mostly met the standard requirement. Only in the areas of mouth of the canals and rivers, crowded community and dense Industry areas have a poor water quality problem. The areas mentioned here are Pak Khlong Phum Rieng, Chai Ya district, Pak Khlong Tha Khoei, Tha Chang district, a mouth of Ta Pi river, Ban Don Bay, Khlong Ka Dae, Kanchanadit and Ko Samui ferry pier, Ban Hua Thanon, Ko Samui District.

3) Waste Water Treatment Condition

The expansions of the community, industrial sector, aquaculture farms, tourism activities, ferry piers and fish houses have caused problems of waste water and deteriorated water quality in pool watercourses. The four wastewater treatment sites have been established as follows;

1) Ban Tai TAO waste water treatment, Pha Ngan district located at Moo 6, Ban Tai sub-district, Pha Ngan district with the total area of 1.5 rai. It has the capacity of 22

square meters per day for waste water treatment. Currently, the Wastewater Management Department has operated and managed the system.

2) Ko Samui district waste water treatment (Lamai community), Ko Samui district located at Moo 4, Ko Red sub-district, Ko Samui district with the total area of 5 rai. It has the capacity of 8,650 square meters per day for waste water treatment. Currently this waste water treatment has not been operated and still looked for the contractor to operate the system.
3) Ko Samui district waste water treatment (Natorn Community), Ko Samui district located at Moo 3, Angthong district, Ko Samui district with the total area of 3 rai. It has the capacity of 2,400 square meters per day for waste treatment. Currently this waste water treatment has not been operated and still looked for the contractor to operate the system.
4) Ko Samui district waste water treatment (Chaweng Community), Ko Samui district located at Moo 2, Borphud sub-district, Ko Samui district with the total area of 5 rai. It has the capacity of 6,000 square meters per day for waste treatment. Currently this waste water treatment has not been operated and still looked for the contractor to operate the system.

3.1.3.4 Solid Waste Management

During 1999 to 2005, an amount of solid waste within Ban Don Bay and its offshore islands has been increase continuously. In 1999, the amount of solid waste per day was equal to 150.86 tons and being increased to 241.5 tons in 2005. The highest amount of solid waste volume has been reported from the Mueang district and followed by Ko Samui district. The Tha Chana district has been reported with the lowest amount of solid waste.

All solid waste ollected and managed by solid waste trucks from each district. Each district has different way of solid waste treatment. Most of technique used for managing solid waste open air burning with solid waste burying, solid waste dumping and burying site and solid waste incineration stove in Ko Samui district.

The highest capacity for solid waste treatment has found in Muang district. The least capacity for solid waste treatment has found in both Kanchanadit district and Pha Ngan district. PCD (2004) reported that all districts were not able to collect all the solid waste. Mostly the solid waste collected has been recycled through the solid waste buyers. The solid waste or leftover product bank and solid waste for egg or commodity exchanging have been established in Muang district.

3.1.3.5 Natural Resource and Environment Conservation

The Ban Don Bay and its offshore islands have been conserved through the protection areas for natural resource announcement by the Government office and community. The natural resource protection areas are the National Park at Ko Ang Thong groups and National Park at Than Sadet- Ko Pha Ngan, respectively.

Ko Ang Thong groups have been announced to be the national marine park. The office of Ko Ang Thong group Marine National Park has been located at Ko Woetalub, Ang Thong sub-district, Ko Samui district, Surat Thani province or 20 kilometers west of Ko Samui with the total area of 63,750 rai or 102 square kilometers.

Than Sadet-Ko Pha Ngan National Park has their office located at 108 Moo 3, Ban Madierwan, Ko Pha Ngan district, Surat Thani province which is about 80 kilometers away from Surat Thani province. Their total area are equal to 28,500 rai or 45.6 square kilometers.

In additional to these natural resource protection announcements, the area of Ban Don bay and its offshore island has been announced to be a fishing control area under the Fishery Act 1947 issued by the Department of Fisheries, Ministry of Agriculture and Cooperatives.

The community activities for resource conservation have been through the establishment of local conservation groups by each community and environmental networks. For examples, the Sea for Life project, Dugong Lover's group of Phum Riang, Liled ecotourism group, Volunteer for conserving aquatic animal group, Ban Khlong Rang group of Trammel net, Ban Chang Nger group of mangrove conservation and Nang-ngiek Ko Samui group.

The environmental protection volunteer network of Surat Thani has been established by the Office of Environment 14th division, Surat Thani province through a cooperation of environmental protection volunteer network boards from all areas within Surat Thani province.

3.1.4 Result of the Study

The impacts on natural resources and environment caused by all activities including community, industry sectors, aquaculture activities, agricultural activities, fisheries and tourisms can be expected. These impacts can be further categorized into 2 main groups as:

1) The problem that incurred by the nature mechanisms. This problem can hardly be prevented. For examples, thunderstorm, monsoon wind, tidal wave, strong wind, tides, etc.
2) The problem that incurred by Human activities. This problem can be monitored and investigated. This problem type can be solved through a well-planned management.

For examples, waste water discharge problem, coastal area development, illegal fishing problem and solid waste etc.

Within Ban Don Bay and its offshore islands, there were three main problems of natural resource and environment deterioration (Forest sector not included) as:

3.1.4.1 Water Resources

The important sources of surface water from Ta Pi river, Phum Duang river and all waterways and ground water have been used for all activities including community, industry sectors, aquaculture activities, agricultural activities, hotels, resorts and fish houses. The amounts of waste and sludge from these activities being discharged to the waterways without any treatment have deteriorated the water quality.

Water Resource Problems

1) Problems from Natural causes: A lack of water for consumption and use can be divided further into 1) poor water quality (slightly salt water and rust problems) and a shortage of water during the dry season (especially, the community that stay on the offshore islands)
2) Problem from Human Activities

2.1) Water Quality in Natural Water Resource. The areas that have been reported such problems are Khlong Phum Riang, Chai Ya district, Khlong Tha Kueoi, Tha Chang district, Ta Pi river, Muang district, Khlong Kadae, Kanchanadit district, Khlong Don Sak, Don Sak district, Nathorn ferry pier, Ban Hua Thanon, Ko Samui district and central fish market, Ko Pha Ngan district.

2.2) Problem of Waste Water Treatment and Management: Only 1 (Ko Pha Ngan district Waste Water Treatment) out of 4 waste water treatment sites has been operated.

3.1.4.2 Coastal Marine Resources

1) Coral Reefs

The coral reefs has been scattered around offshore islands. Most of coral reefs in Ko Samui groups and island group in Don Sak district have been in very poor condition. Meanwhile, most of coral reefs in Ko Ang Thong groups have been in healthy condition. The medium conditions of coral reefs have been reported in Ko Pha Luai and Ko Tan. Ko Pha Ngan has their coral reefs in good condition.

Coral Reef Deterioration Problems

- Natural Caused Problems (monsoon wind, thunderstorm, Starfish and white breach coral problem)
- Human Caused Problems

- Problems from Tourism activities (Anchoring, Swimming and Diving Activities)
- Problems from coastal area development (Road construction, ferry pier construction, landfills and waterway constructions)

2) Seagrass

9 species of seagrass have been identified with the total area of 3,673 rai scattered throughout Chai Ya coastal areas, Ko Samui, Kor Pha Leoui, Ko Pha Ngan, Ko Tan, Ko Ang Thong groups, Ao Nanggum and Ko Nok Ta Pao.

Seagrass Deterioration Problems

- Natural Caused Problems (monsoon wind, thunderstorm, temperature and light)
- Human Caused Problems
  - Fishing Activities Problems (Destructive fishing gears such as, trawler and pushnet, fishing activities in seagrass bed)
  - Sedimentation and Wastewater Caused by Coastal Area Development (Road construction, ferry pier construction, waterway construction, industrial activities, community and aquaculture farms)

3) Endangered Species

3.1) The only species of Dugong that has been found in the area is *Dugong dugong*. Chai Ya district has reported with the amount of 5 -6 dugongs found. Ko Nok Ta Pao, Don Sak district has reported with the amount of 1 – 2 dugongs found. The total death count of dugong in Surat Thani province has been reported at 8 animals (1 at Muang district, 4 at Chai Ya district and 3 at Samui district, respectively)

3.2) Three species of dolphin have been found (*Sousa chinensis, Orcaellla brevirostris* and *Neophocaena phocaenoides*) in the coastal areas of Tha Chana district, Chai Ya district, Don Sak district and Ko Ang Thong groups.

3.3) Two species of sea turtle have been reported (*Chelonia mydas and Eretmochelys imbricate*) in the area of Ko Ang Thong groups and Ko Samui.

Reduction in Number of Endangered Species Problems

- Natural Caused Problems (Strong wind and tide)
- Human Caused Problems
  - Fishing Activities Problems (Deaths caused by fishing gear, ghost fishing and destructive fishing gears)
  - Pollution and waste (Deaths caused by contaminated and toxic foods)
  - Non-digestible foods (Deaths caused by plastic bag)

3.4) Coastal Erosion

The coastal erosion is the change in the area caused by wave, tide and tidal mechanisms. Not only can the nature features (Strom wind and monsoon wind) but also human made construction (coastal area developments such as ferry pier and seawall) also have the impact for the coastal erosions.

The coastal shoreline of Surat Thani has the total length equal to 135 kilometers (not included its offshore islands). The coastal erosion area has the total length equal to 23.5 kilometers. Two levels of coastal erosions have been recognized. The high level of coastal erosion (more than 5 meters for an annual rate of erosion) has been report at the coastal area in Ban Pod, Don Sak district with the total length of 8 kilometers. The medium level of coastal erosion (1 – 5 meters for an annual of erosion) has been reported in the coastal area of Tha Chana district and Don Sak district. The level of coastal erosion has depended on the weather condition. In 2006, a strong wave and tide had been observed in the Gulf of Thailand and caused more impact on coastal erosion.

3.1.4.3 Solid waste

The continuous increase in amount of solid waste has been reported in the Surat Thani municipality (1999 with 150.86 tons of solid waste per day compared to 2005 with 241.5 tons of solid waste per day). The Surat Thani municipality has the highest volume of solid waste discarded daily (approximately 120 tons). The solid waste trucks have been to collect the solid waste from each area and then, either solid waste burying technique, solid waste dumping site, open-air burning technique or solid waste incineration stove can be further processed.

For the outside of Surat Thani municipality, TAO's have their roles for solid waste management. Some community residence themselves may manage solid waste by burning, burying and carelessly discarding to the canal.

Solid waste Management Problems

1) Solid waste Collecting Problems (Unable to collect all the solid waste and order and leaking problems from solid waste trucks)
2) Solid waste Management Site Problems (Lack of area and non-sanitation solid waste management technique)
3) No Solid waste Sorting from the Community Problems (Lack of community cooperation for sorting solid waste, reduction for solid waste discard and recycle activities)

3.1.5 Recommendations and Solution Guidelines

3.1.5.1 Water Resources PCD (2004) proposed the recommendations and solution guideline as:

1) Developing a water quality control plan by enforcing wastewater treatment in Surat Thani municipality.
2) Enforcing an industrial wastewater standard for industry sector.
3) Improve the Mueang Surat Thani district sanitation system by increasing effectiveness and capacity of drainage ditch and wastewater treatment system.
4) Monitoring water quality twice a year for water quality management planning benefit.
5) Establishment of community awareness of pollution problem impacts on their ways of life.

3.1.5.2 Coastal Resources

- **Coral reefs**: Thammasak (2004) provided a guideline for conserving coral reefs as follows:

1) Do not buy or collect any coral reef resource (i.e. coral reef, sea shell, sea cucumber and ornamental fish etc.)

2) Seriously obey the laws and rules that related enforced for coral reefs

3) Tide boat with prepared buoy instead of dropping anchor

4) Recommend tourist activities such as, swimming and diving, in the coral reefs not to touch or step on the coral reefs

5) Do not discard any solid waste or waste to the sea

6) Do not use illegal or destructive fishing gears

7) Enforce all coastal activities by the laws

8) Disseminate an information and understanding of coral reefs and establish conservative conscious to all related parties

9) Support the community and local organization participatory roles on coral reef management

10) Support related research and monitor activities continuously for coral reef recovery.

- **Seagrass**: Sombat (2006) provided a guideline for conserving seagrass as follows:

1) Prohibit all destructive fishing gears in seagrass bed

2) Provide enforcement for controlling and protecting an impact from coastal area

3) Disseminate an information and understanding of seagrass resource and establish conservative conscious to all related parties

4) Support the community and local organization participatory roles on seagrass management

5) Support related research and monitor activities continuously for seagrass recovery.

- **Endangered Species**

1) Do not destroy and try to conserve the natural habitat for these endangered species (e.g. seagrass bed)

2) Support the community and local organization participatory roles on endangered species management

3) Disseminate an information and understanding of endangered species and establish conservative conscious to all related parties

4) Support related research and monitor activities continuously for endangered species.

- **Coastal Erosion**

Sin and Others (2002) provided a guideline for protecting and solving the problems of coastal erosion as follows

1) **Preventive measures and constructions**: The engineering constructions can be developed for protecting the coastal erosion. Two main categories of the constructions are rigid and soft construction types (offshore rock breakwater, rock groins and rock seawall for rigid type and beach nourishment, dune restoration and afforestation for soft types). The well selected type of preventive measures and constructions has to be under the supervision of expert due to their sensitive characteristics. DMR (2006) recommended rock groins and beach nourishment for 20 meters to protect the coastal area of Ban Pod, Don Sak district to solve the high coastal erosion problem in the area.
2) **Accommodations**: Maintaining the ecosystem original condition without any construction development that changes community's way of life and Community's acceptance and way of life adaptation afterward for the change that has been occurred have been recommended.
3) **Relocation**: Community in a high coastal erosion area can be relocated to the new area.
4) **Coastal management**: The problem solution in a way of administrative and management can be applied. A use of laws and regulations as a tool may also be an alternative measure. The data and information for all aspects of the resources have

to be concerned for developing integrated short-term and long-term coastal management plan.

3.1.5.2 Solid waste PCD (2004) provided a guideline for community solid waste management as follows:

1) **Reduction in Solid waste Discarded Volume**: Community participatory campaign to reduce solid waste discarded volume can be developed. These activities include a reduction on packaging material discarded, select or buy the goods that have less packaging material, use or buy goods that have a long lifetime, use or buy nontoxic or non-polluted goods and reduce a use of hard-to-decomposed materials (plastic and foam).
2) **Recycle Management**: Or reuse of the material by the ways of:
   2.1) Community "solid waste sorting" campaign for reusing and re-selling the solid waste (e.g. paper, plastic and metal sheet) has to be developed.
   2.2) Recycle management system establishment
   - Arrange and prepare the proper solid waste container by sorted types.
   - Arrange the suitable time for picking up the sorted solid waste (daily pick up for common solid waste, weekly pick up for recycled or hazard waste solid waste)
   - Arrange the community group of re-selling old product and solid waste for supporting the recycle activities in the area.
   - Establish a network of recycle-related business in the area.
   - Establish a solid waste management system for a large solid waste produced area (e.g. market, school, governmental office and department store)

   2.3) Volunteer Group, Organization or Project for Recycle Activities Establishment (e.g. recycled for commodity exchanging project, Solid waste market, Solid waste bank etc.)
   2.4) Recycle Center Establishment for handling a high volume of solid waste through solid waste sorting and solid waste buyback.
3) **Transportation** Arrange the proper solid waste trucks that met standard and do not have a leaking problem.
4) **Solid waste Elimination Technique**: Due to a re-use feature of the recycled solid waste, the solid waste elimination technique has to be performed wisely and

effectively. The proper mixed techniques may have to be applied due to a lack of area problem. Also, the improvement of the current solid waste elimination sites to solid waste centre by including solid waste sorting procedure and applying integrated techniques to eliminate solid waste, respectively.

3.2 FISHERY PRODUCTION BASE

3.2.1 Introduction

Fishing has been the main occupation of Thai people for many years. Fishing collects aquatic resources which are an important source of protein for Thai people. It is recognized that, at the present time, the aquatic resources have become depleted. The fishermen have exploited larger amounts of aquatic resources than previously to support the demand from people in Thailand. The population of Thailand has been increasing. The catches are also used as raw materials to support the industrial sector and to export to foreign markets to bring income into the country. The fishermen are usually highly dependent on fishery resources, so they are the first group that will be impacted from a decrease in catch amounts and income. The financial status of the fishermen will get worse. However, to increase the amount of catch the fishermen have developed new types of fishing gear, which are more efficient than previously, e.g. many new types of destructive fishing gear. Currently, there is a variety of types of fishing gear in use by fishermen. Each type of fishing gear can collect various types of aquatic fauna of different sizes. Aquatic fauna that are small are being caught more frequently than before. Apart from the depletion of aquatic fauna, fishermen face the problem of a decrease in the price of catch because the protein needs that came from aquatic fauna are being supported by other types of meat available in the market. The products that come from aquaculture are another cause of the low price of fishermen's catch. Fishing costs, in particular the cost of gasoline is higher than in previous years. In conclusion, it can be said that people who have fishing as their main occupation are currently facing many constraints.

In the Surat Thani Province, most people who are living on the coast have fishing as their main occupation. The length of the coast in this province is 156 kilometres. It is one of the important fishing areas of the upper part of southern Thailand. There are a variety of types of fishing gear which are operated by fishermen in the Ban Don Bay of Surat Thani Province, such as squid light luring cast net, clam dredges, push net, trawl net, trap, crab gill net, shrimp gill net, fish gil net, handline and others (Figure 3.2.5 At the present time, the fishing area is smaller than previous years because many parts of the fishing area are now used for clam culture. The study has selected the Ban Don Bay as the study area (Figure 3.2.1). The 4 objectives of the study has been as follow..

1) To study the history changes of the inputs to the fishing activities by sub-district and type of fishing gear

2) To study future trends of the inputs to the fishing activities by sub-district and type of fishing gear
3) To study the rankings of problems and the preferences in the sub-district, and use of the results as primary data for managing fisheries in the Ban Don Bay based on the needs of the community.
4) To analyse the fishery status of fishery resources, benefit and costs, and biological and social problems of fisheries by using the Optimal Control Theory.

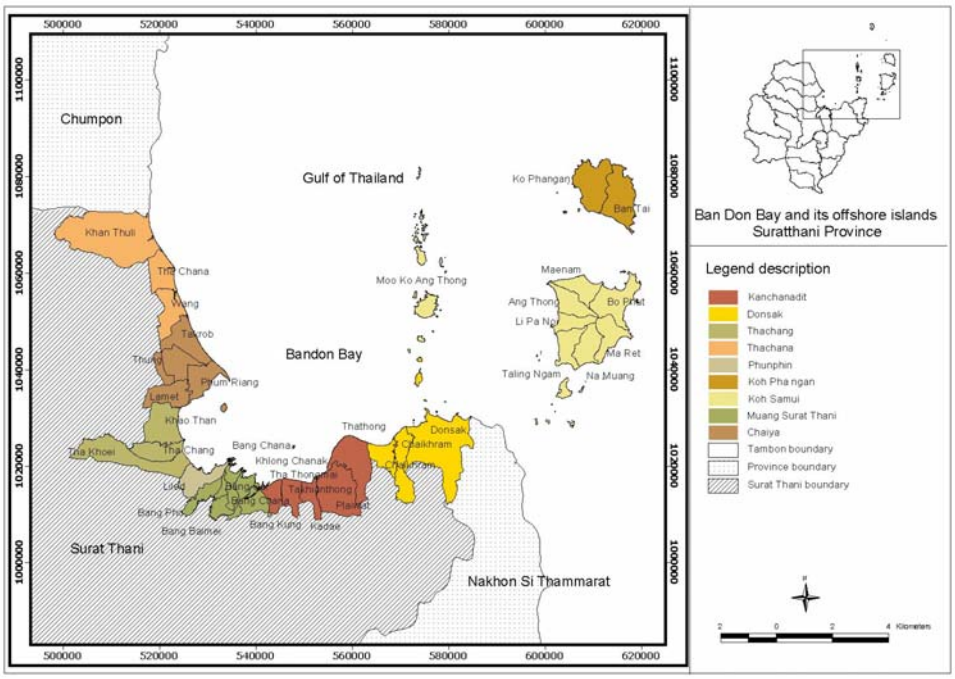


Figure 3.2.1 Study area in Ban Don Bay, Surat Thani Province

The study of the fishery economic sector, which is under the project known as management of the Ban Don Bay and its offshore islands, has study duration 6 months (December, 2006 – May, 2007), is a survey research project. The secondary data from existing research and primary data from field survey have been collected. Focus group meetings and the in-depth questionnaire surveys have been undertaken. The total number of the focus group meetings is 19 (Table 1 and Appendix (D), See in full report). In order to use the results from focus group meetings as being representative of the area, the meetings were designed to be held in all sub-districts in which there are fishing activities. The questionnaire was designed using a multi-stage sampling method. Sampling selection was done using cluster sampling methodology to cover all fishing areas in the study area and by stratified sampling methodology to include all types of fishing gear in the Ban Don Bay. As reported by the Surat Thani Fishery

Office, the total number of fishing boats in the Surat Thani Province is 3,632. Total number of questionnaires completed by respondents is 336. Using the Taro Yamane (1970) equation, the level of confidence of the samplings is 94.8%. The number of fishermen by the locations and types of fishing gear is shown in Table 2 in full report.

3.2.2 Literature review

Most people in the Surat Thani Province who live on the coastal area of Ban Don Bay have fishing activities and aquaculture as their main occupation. The total number of fishing boats in the Surat Thani Province is 3,632. The total number of fishing boat that are registered is 697, which consists of 362 boats that are less than 14 metres in length, 210 boats that are between 14-18 metres in length, and 125 boats that are between 19-25 metres in length. Most of the boats are registered with crab gill net, push net, crab trap, fish gill net, crab gill net, trawl net, and squid light luring net (Surat Thani Fisheries Provincial Office). There are still many boats that are not yet registered and most of them are the cause of fishing conflicts, e.g. push net, beam trawl net, traditional net (Uan Rang in Thai), set bag net, set bag net with wing and clam seeds dredges.

Taweesak (1988) studied the catch of push net boat in the Tha Chang District, Ban Don Bay in 1987. He found that the push net boats had an average catch of about 108.72 Kilograms, which consists of economic species (50.9%) and trash fish (49.1%). When comparing the results with Surat Thani Fisheries Provincial Office (2005) found that the average amount of catch from push net boat in 2005 is higher than in 1987 (Taweesak, 1988) about 65.5% while the proportions of economic catch species in 2005 (31.8%) is lower than in 1987 (50.9%).The Chumphon Marine Fisheries Research and Development Centre for the Middle Gulf of Thailand also surveyed the status of aquatic fauna. The results from 2001 to 2005 from the survey station of the centre in the Ban Don Bay were selected for this study (Appendix (B) 1, See in full report). The largest proportion of the catch is from the trash fish group (>70% of the total catch in some years). The proportions of the catch in the groups of demersal fish, shrimp and prawn, and crab are decreasing year on year. When considering the size of catch, almost all of the types of catch had groups of small aquatic fauna as the largest proportions (Figure 3.2.2 and Appendix (B) 1, See in full report).

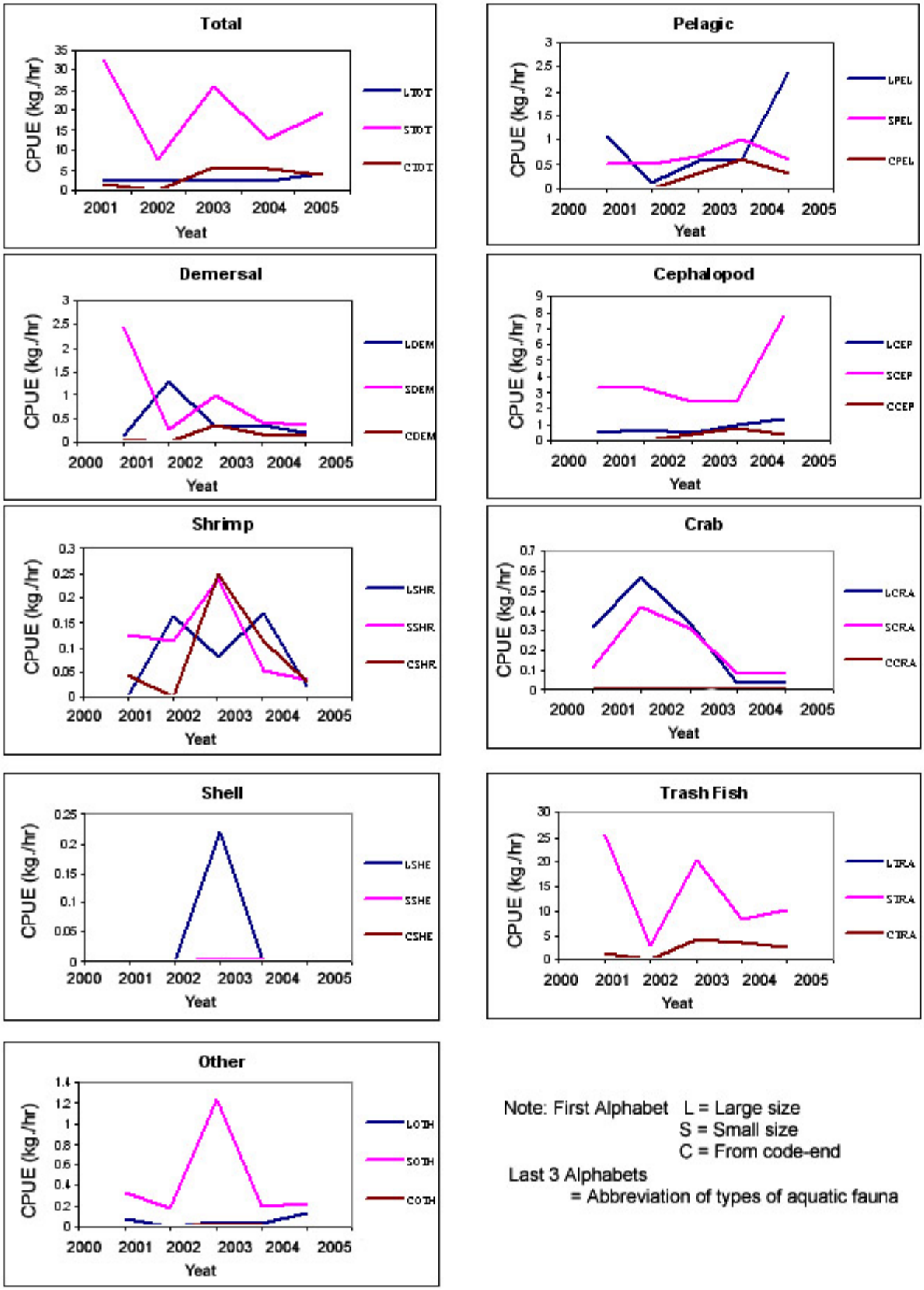


Figure 3.2.2 Capture per Unit Effort (CPUE)(Kilogram/ Hour) by Survey Boat No.1 using Otter board trawl net

For the total catch between 2001 and 2005, more than 63% of the total catch amount each year is small aquatic fauna while there is only a small proportion of large aquatic fauna caught.

Amonsak (2005) reported that gasoline is the main cost of movable fishing activities, e.g. push net and trawl net boats - approximately, 68.5% of the total cost is for gasoline. Phongphat (2003) stated that gasoline is the main input to fishing activities in particular for marine fisheries, accounting for about 24 to 64% of the total cost. Based on the records of the PTT Public Company Limited about retail prices that has been used in Bangkok for the last 10 years the price of gasoline, both benzyl 91 and diesel, which are used in fishing have been increasing particularly in 2004 (Figure 3.2.3). These prices were adjusted with a baseline using consumer price index from the Bank of Thailand 2002

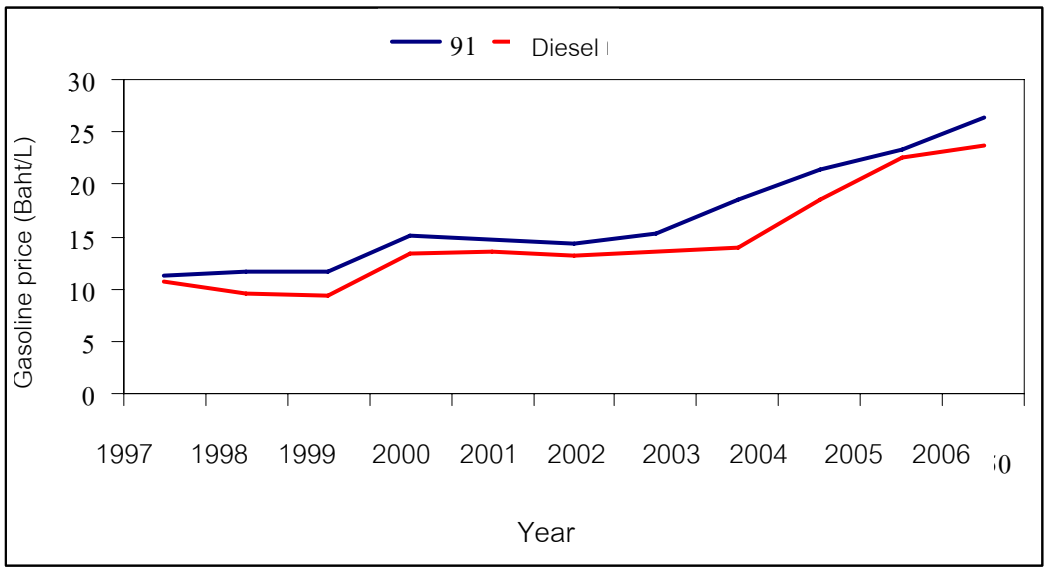


Figure 3.2.3 Changes in price of gasoline (Benzyl 91 and Diesel) 1997-2007

The result of the study on fishery resource status in the Ban Don Bay indicates that the fishery resources are being depleted. This result can be supported by the perception of the fishermen about the poor status of fishery resources and a decrease in catch. The study and survey from government agencies also show that the fishery resources are getting worse than previously observed. Most of the catch is from the trash fish group and small aquatic fauna compose the largest group in the catch. Therefore, the price of catch is an important variable that can indicate the benefit available to fishermen at the present time. The data collected by the Fish Market Office (2002-2006), adjusted with a baseline using the fish price index from the Bank of Thailand 2002, shows that the prices of almost all type of catch have decreased noticeably.

However, the prices of some type of catch are increasing gradually, e.g. Indo-Pacific mackerel, Frigate Mackerel, Silver pomfret, Giant tiger prawn, Short necked clam, Cockle, Octopus, and Lobster (Figure 3.2.5 and Appendix (B) 4, See in full report). Only the price of fish meal, that is made using trash fish, has been increasing since 2005. The significant increase in price of fish meal is one of the reasons that the fishermen to exploit the aquatic fauna catch that are small (Figure 3.2.5 and Appendix (B) 5, See in full report). This situation for the fishery resource status will not be good in the future as the small fish has no chance to spawn. However, when comparing the catch price index and gasoline price index, it was found that the growth of gasoline price index is higher than the growth of the catch price index. After 2002, the trend of the gasoline price appears to be increasing when compared to the catch price index that is increasing slower (Figure 4).

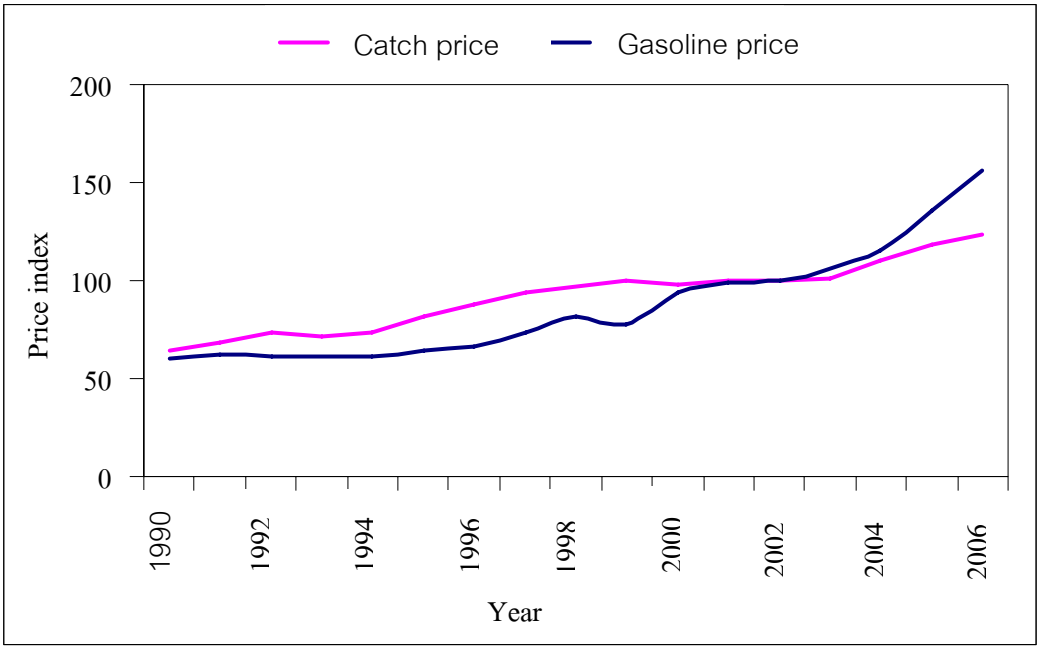


Figure 3.2.4 Comparison of growth of catch price index and gasoline price index

3.2.3. Result

To study the management of Ban Don Bay and its offshore islands with respect to fishery economic sector, we had arranged 19 focus group meetings and had 336 respondents who answered the questionnaire specifically designed to discuss fishery issues. We only conducted the study in areas where there were people doing fishing activities as mentioned in the scope of study. In addition, secondary data and research result of the government sector were also reviewed.

We tested the questionnaire to find out the level of confidence, which is 74.08% (Alpha=0.7408). Most respondents (73.8%) are male and the remaining 26.2 % are female. Respondents' ages range between 17-78 years old. Most respondents are Buddhists (81.5%) and the other 18.5% are Muslims. Almost half of the respondents (49.4%) finished grade 4 and 33 % finished grade 6. Remaining 80.7 % of the respondents support their children to have education. This indicates that the fishermen have recognized the importance of education. This is an observed change because in the past when the children grew up, they will work as fishermen and had no chance to study. We found that education levels of their children are between kindergartens to bachelor degree. More than half (54.8%) of the respondents have fishing experience from 15-30 years. In Ko Samui District, 71.9% of the respondents have immigrated to the area while in other areas, most respondents (71.4%) are born in the area itself. Many residents in Ko Samui District changed their jobs from being fishermen to being involved in the tourism industry where they can gain more benefit. As a result, fishermen from other areas had opportunity to come to Ko Samui.

At the present, fishing areas in Ban Don Bay have been used as clam culture areas, which lead to overlapping uses of the said areas particularly between fishermen and clam farmers. This resulted to conflicts within the area. However, in some places this conflict does not occur because the clam farmers used to be fishermen before. In many places in Ban Don Bay, the credit system between fishermen and fish house owner still occurs. Fish house owner will provide money or gasoline/oil or fishing gear to the fishermen and the fishermen are obliged to sell their catches at a lower price compared to the market price to them as they are the ones who provided fishing inputs to the fishermen.

In general, major problems of fishery activities are low price of aquatic fauna/catch, spatial conflicts (clam culture and fishing gear, push net and stationary gear, e.g. trap, traditional crab trap (Raeo in Thai), gill net, handline, etc.), conflicts between local fishermen and fishermen from outside who use push net and trawl net, decrease in number of aquatic fauna and high cost (gasoline/oil and fishing gear). These problems are commonly found in any area in Surat Thani Province. Generally, the preference of fishermen in Ban Don Bay is that they would like to have clear delineation between fishing zones and the prohibited zone. The current prohibited zone, which is 3,000 metres from the shoreline, is too far from the shore. Small scale fishing boat cannot go to fish that far. Thus, the fishermen have an idea to define a new prohibited zone based on the specific characteristics of each coastal area. For example, slope of the coast can be used to identify the prohibited zone. Moreover, the fishermen prefer to have

additional occupations, to release aquatic fauna to natural water body and to develop a fishery group. At present, they lack financial support to initiate the fishery group.

The results from the sampling survey show that fishermen in Ban Don Bay owned on average 1-2 boats per person that is between 6 and 28 metres in length. More than a half (67.3%) of total number boat reported in the survey are shorter than 10 metres in length and are mostly used with gill net and other stationary gears. 5.4% of all boats are longer than 14 metres and they are mostly used with squid light luring cast net, clam dredges, and push net. Each fisherman owns between 1 and 7 different types of fishing gear. Most respondents (79.8%) own 3 or 4 types of fishing gear. Fishermen use different types of fishing gear based on their experience and also select suitable gear for different seasons and different levels of tide. Some of fishermen respondents perceived that in the future they will reduce the number of fishing boats because of low catch and the high cost of fishing. There is 76.5% of the respondents (most of them use stationary gears, trap, traditional crab trap, handline, and gill net) that indicated that they have not changed the size of boats they use. About 10% indicated that they reduced the size of their boats with the aim of reducing fishing cost, in particular for gasoline and oil. A decrease in size of boat resulted in a decrease in the size of boat engine in particular for boats with push net, trawl net, squid light luring cast net. However, in the future, most respondents answered that they will not change size of boat and engine.

Most respondents (85.5%) responded that they own more types of fishing gear than in the past. This is because they had a low catch when using only one or few types of fishing gear. Therefore, to increase their catch they need to use more types of fishing gear so that they can fish for longer and in different seasons during the year. In the future, most respondents (85.5%) expect that they will increase the number of types of fishing gear because of current low levels of catch. Most fishermen stated that the number of some types of fishing gear (gill net and trap) that they used has been increasing. Nearly half of the respondents (49.7%) have reduced numbers of their fishing days. They went for fishing when they had confident for gaining benefit such as on the day with suitable climate (weak wind and wave). Half of the respondents perceived that the trend of number of fishing days will decrease. About 79.8 % of the respondents claimed that at present they can get lower amounts of catch than in previous years. Only 5.7% feel that the catch amount has been getting higher, in particular the fishermen in Li Let Sub-district because of an increase in mangrove areas (from mangrove conservation promotion) and decrease in the number of push net boat in the area. This is in accordance with the perception about the benefits from fishing. The most of the respondents who mentioned that

their benefits from fishing have been decreasing over time. Remaining 75.0% of the respondents never changed their fishing areas. Only 25.0% changed the fishing areas mainly because the previous fishing areas have deteriorated or have been allocated for clam culture. 80% of the respondents stated that the amount of their catch of target species decreased. The main catch is composed of trash fish. Approximately 92.5% of the respondents answered that they caught smaller sizes of aquatic fauna. Some endangered species are caught less or have become almost extinct, e.g. Pla Mok, Pla Meng, Pla Krathing, and Pla Khop Mun (in Thai local name). The most of the respondents perceived that high dependence on the fishery and 89.9% of the respondents will continue fishing activities because they enjoy and have the skills for their jobs and have no capacity to work on other jobs. 10.1% would like to change from fishing to other occupations because there is a decrease in number of aquatic amount available so there is greater competition between fishermen. (Please see more detail in full report)

3.2.4 Analysis and Discussion

The Maximum Principle (MP)

Maximum Principle is the balance that considers the results of fishing activities. The system will continue to stay in balance if the fishermen can continuously gain the maximum benefit from their fishing activities. The study on the perception of the fishermen gave the results that the almost all of the fishermen gained less benefit from fishing activities than previously. This was because of a decrease in the amount and price of catch available and an increase in fishing costs, in particular with gasoline. For example, as illustrated in Figure 3.2.3, the prices of diesel and benzyl 91, which are commonly used in fishing activities, have tended to increase. The prices have been increasing continuously, in particular from 2003 until the present time. An increase in the price of the fishing equipment is another reason for the increase in fishing costs, as the price of equipment is much higher than previously. Income from fishing depends on the amount, size of fish, and the overall value of the catch. The aquatic fauna survey results from 2001-2005, collected by the Marine Fisheries Research and Development for the Middle Gulf of Thailand, show that the largest proportion (70%) of the total catch is a group of trash fish. The survey also found that the proportion of the groups of benthic fish, shrimp and prawn, and crab have been getting smaller year on year. Considering the size composition of the catch, the largest proportion of almost all types of catch are the groups of small fish. Based on the survey, it can be seen that fishermen collect smaller amounts of economic aquatic fauna and the size of their catch is smaller than in previous years. As a consequence the fishermen can sell their

catch at lower prices, based on the prices of different sizes of catch shown in Appendix (B) 4 in full report. Considering the changes in the catch prices from the past to the present time, that are adjusted with a baseline using fish price index from the Bank of Thailand 2002, the trend of these prices of many target species are a decrease, in particular for shrimp and prawn (e.g. Triple grooved shrimp, Banana shrimp, King prawn, and Pink shrimp), Mud crab, Red snapper, Giant seaperch, Black pomfret, and Green mussel. However, the trends of some types of catch are a gradual increase, e.g. Indo-Pacific mackerel, Frigate Mackerel, Silver pomfret, Giant tiger prawn, Short necked clam, cockle, Octopus, and Lobster. When comparing the gasoline price index and the aquatic fauna price index, the growth rate is greater than the latter. The trend of the gasoline price index has been increasing rapidly since 2002 while the trend of the aquatic fauna price index has only been increasing gradually.

In conclusion, considering the Maximum Principle, the fishery status of the fishermen at the present time cannot continuously provide the maximum benefit. Almost all of the fishermen who use different types of fishing gear have initially faced the risk of loss of profit because of a decrease in the amount and price of catch and an increase in fishing cost. Phongphat (2003) reported that at present the gasoline price is much higher than the break-even gasoline price. Therefore, fishermen have changed their behaviour to reduce the risk of loss of profit caused by high gasoline prices. For example, they have reduced the number of fishing days. The fishermen have started to operate only on the days with good climate and they have selected the type of fishing gear that is suitable for the climate, e.g. wind and wave conditions. They have also increased the types of fishing gear and switched the types of gear used in different seasons. The number of each type of fishing gear they own has also been increasing, such as the number of fishing nets and other fishing equipment. However, most fishermen think that they will continue their current fishing activities, which are the main careers of the fishermen and the subsequent generations. However, we have observed the distinct change of fishing activities in the Ko Samui District. In the past, most of the people in the district worked as fishermen while at present most of them have changed their occupations to be engaged in the tourism sector from which they can gain more income. Another observation is that other communities have no options like the community in Ko Samui District to change to other jobs. That is why they think that they will continue fishing. We also found that fishermen in many areas prefer to have additional occupations to support their income. This is one of the variables that indicate that the fishermen have faced problems with household income because the income from fishing activities is less than household expenses.

Portfolio Balance (PB)

Portfolio Balance is the balance that considers both the resources and the producer or the owner who extracts value from the resources. In general, the growth of the real value of the resource (or the growth of the benefit from using the resource) must be equal to the growth in value of other resources (or the growth of the benefit from using other resources). The system will continue if the resource is able to compete with other resources in terms of value. From the questionnaire survey, the fishermen perceived that the catch price is a little bit higher than previously but the living expense is also higher. Although there is an increase in price of some types of catch, the size of the catch is small. The consequence of this is low income for the fishermen. We used the catch prices of the aquatic fauna surveyed by the Fish Marketing Organization and we adjusted the prices with a baseline using fish price index from the Bank of Thailand 2002. It was found that the trend of the prices of the target species of many types of fishing gear is decreasing while the trend of the price of the gasoline that is the main input to the fishing is increasing rapidly. The trend of the growth of the gasoline price index is obviously greater than the corresponding growth in the fish price index. The result of a decrease in price of aquatic fauna is that fishermen have changed the pattern of their marketing channel by selling their catch by themselves at the market, because this is where they can gain a higher price. Some fishermen have added value to their catch by processing fishery products (e.g. dried squid, Mullet, and Bream), before selling the products by themselves at the market.

In conclusion, the growth of the aquatic fauna price cannot compete with the growth of gasoline price, which is the main input to fishing activities. As a consequence, the status of fishing activities at the present time is not providing a balance of the Portfolio Balance (PB). The PB considers that the system will be able to continue if the price of the resource can compete with the prices of other resources or the costs of the inputs. This can be supported by the fact that the size of the catch tends to be decreasing, which brings a decrease in price of such small catch. The future trends of the prices of two types of gasoline are rapid increases. Therefore, we can conclude that there is no balance between the catch price and the input costs.

The Dynamic Constraint (DC)

Dynamic Constraint is the balance that mainly considers the amount or quantity of the resources. The system of renewable resources will balance when the rate of substitution of such renewable resources to the system is equal to the rate of exploitation of these resources from the system. Taweesak (1988) reported the catch composition surveyed in 1987, and the composition of the catch is 50.9% of economic species and another 49.1% of trash fish. When we compared this study with the catch composition recorded in 2005 by Surat Thani Fishery

Office (2005), we found that in the Tha Chang District, the catch amount collected by push net is higher in 2005 than in 1987 (about 65.5%). However, the amount of economic species in 2005 was lower than in 1987 (decrease from 50.9% to 31.8%). This is in accordance with the result of the survey in Ban Don Bay by the Chumphon Marine Fisheries Research and Development Centre for the Middle Gulf of Thailand. The result from the centre shows that the largest proportion of the catch is the group of trash fish (>70% of the total catch in some years). Moreover, the proportions of the groups of benthic fauna, shrimp and prawn, and crab are decreasing. Considering the size composition, the largest proportions of almost all types of catch are the groups of small catch. From 2001-2005 the total proportion of small aquatic fauna is greater than 63% while the proportion of big aquatic fauna is small. The results of the centre's work can be used to indicate the fishery status which is depleted. The Capture Per Unit Effort (CPUE), which is an indicator used to measure the abundance of aquatic resources, tends to be decreasing in almost all types of economic species and the largest proportion of the catch composition is in a group of catch with small size. Therefore, it is important to consider that, if the fishermen can catch huge amount of small fish, which have no chance to spawn, the fishery status in Ban Don Bay will be affected by the over fishing. As consequence, the recruitment rate of the aquatic fauna in the system will be decreasing year on year.

We can conclude that the fishery resource status at the present time is not in balance and this situation has an impact on the fishermen. As almost all of the fishermen perceived that the fishery resources are getting worse, which leads to a decrease in benefit from fishing. This is made worse by the problem of a decrease in fishing area after some parts of the area were converted to clam culture. Thus, we can conclude that the fishery resource status in Ban Don Bay is clearly worse than previously. A consequence of a decrease in amount of aquatic resources and a decrease in fishing area is that the fishermen have to compete for fishing area and this leads to the conflicts among the fishermen who use different types of fishing gear and who come from different regions. It can be noted that the depletion of fishery resources is the root cause of other problems in the area.

From the analysis, we found that the three balance systems are not currently in the balance. We can conclude that the fishing status and fishery resource status in the Ban Don Bay are vulnerable and will be depleted in future. If the fishermen have options that provide greater benefits than fishing (e.g. the fishermen in Ko Samui District) more fishermen will probably leave the fishery sector. At present, most fishermen spend all the money they earn from fishing on their living expenses. Not many fishermen are able to have savings. Therefore, it is an urgent need to prepare the plan for managing the resources in the Ban Don Bay and its offshore islands for sustainable use.

3.2.5 Recommendations for managing fisheries in the Ban Don Bay

The results of the study on perceptions, problems, and the preferences of the fishermen as well as the secondary data on fishery resources and catch price show that the fishing status and the fishery resource status of the Ban Don Bay and its offshore islands are in a vulnerable state. The resources now have a higher risk of destruction than in previous years. The fishery production system probably will not be able to continue in its current state because fishermen cannot make a profit. Therefore, to manage the fishery resources and fishing activities in the Ban Don Bay, we developed a management plan, which consists of two elements - an intermediate plan and a long-term plan.

Intermediate plan

1) Release more aquatic fauna seeds into the Ban Don Bay and involve local participation when the seeds are released to improve the relationship between the government and fishermen.
2) Provide support for additional occupations for the fishermen during the monsoon season and in the closed season. The fishermen recommended that the additional occupations should be relevant to fishing activities that they are familiar with. They believe that they should use raw materials that are available in the area to reduce input costs and the market should be prepared for selling these products.
3) Provide basic knowledge to the fishermen about fishery processing to add the value to their fishery resource.
4) Develop agreement and friendship, and reduce the spatial conflicts between the fishermen and the clam culture owners.

Long-term plan

Socio-economic aspect

1) Develop an accurate and up to date database of the fishery census including information of fishermen and aquaculture farmers in the Ban Don Bay.
2) Develop the central market for distribution of aquatic catch and fishery products and promote the market to increase the marketing opportunity to the fishermen in the Ban Don Bay.
3) Promote and support the development of fishery cooperatives in each sub-district so that the fishermen will be able to negotiate the catch price and buy cheaper fishing

equipment as well as support the fishermen to save the money through the fishery cooperatives.

4) Promote the eco-tourism to motivate people to increase their awareness about conservation, and this will increase income to the local fishermen.
5) Develop the mechanism for monitoring and controlling the discharged water from different sources, e.g. factories and shrimp farms, to reduce water pollution in the Ban Don Bay. This should be done with the participation of government and local communities.
6) Campaign to raise awareness of environment and fishery resource conservation in the Ban Don Bay and support the fishery conservation group in each district (the fishermen would like to have groups but they lack of understanding about the process and lack of funds makes this difficult).
7) Campaign for the treatment of discharged water from households and the reduction of solid waste from households into the canal to reduce pollution in the Ban Don Bay.

Environmental and fishery resource aspects

1) Change the types of fishing gear that are considered as destructive gear, e.g. push net, trawl net, traditional net, and trap to other types of gear or other activities by training the fishermen to make other types of fishing gear or to do culture activities, e.g. cockle farm and cage culture. The destructive gear usually catches small size of fish, which will have no chance to spawn.
2) Support the study on life history of aquatic fauna, evolution of aquatic fauna, and structure of the aquatic fauna community that will help in understanding the food chain and ecosystem of the Ban Don Bay. The data can be used for Ecological Base Fisheries Management.
3) Develop the database of environmental and fishery resources, which can be used and extended by other studies and will be useful for administration and management of the environment and fishery resource in the Ban Don Bay.
4) Rehabilitate the aquatic fauna that have potential to increase, such as swimming crab, Sesarmid crab, and cockle.
5) Promote the extension of mangrove plantation, in particular for the vulnerable areas to increase the nursery ground for aquatic juveniles.

6) Evaluate the economic loss from use of small aquatic fauna and disseminate the information to the fishermen to increase their awareness of the problem.
7) Promote the use of appropriate mesh size of each fishing gear so that the small fish will have chance to spawn.
8) Study the possibility of setting up artificial reef in the Ban Don Bay to increase the habitat for the aquatic fauna.

Policy aspect

1) Cleary define the clam culture zone, fishing zone, and conservation zone to reduce the conflicts between the fishermen and clam culture farmers. The conservation zone should be defined by considering the opinions of the fishermen to ensure that the policy developed will be practical to implement and not unpopular.
2) Review the measures that ban fishing activities within the 3,000 metres from the shoreline by considering the possibility of operating the fishing activities and characteristics of the coast in each area. This should be done to ensure that the policy developed will be accepted by the local community and in the long-term the government can reduce the cost for monitoring and enforcement.
3) Ban fishing activities using destructive fishing gear, e.g. push net, trawl net, destructive traditional fishing gears, such as Uan Rang, and trap in the conservation zone that is accepted by the community to reduce the destruction of small aquatic fauna.

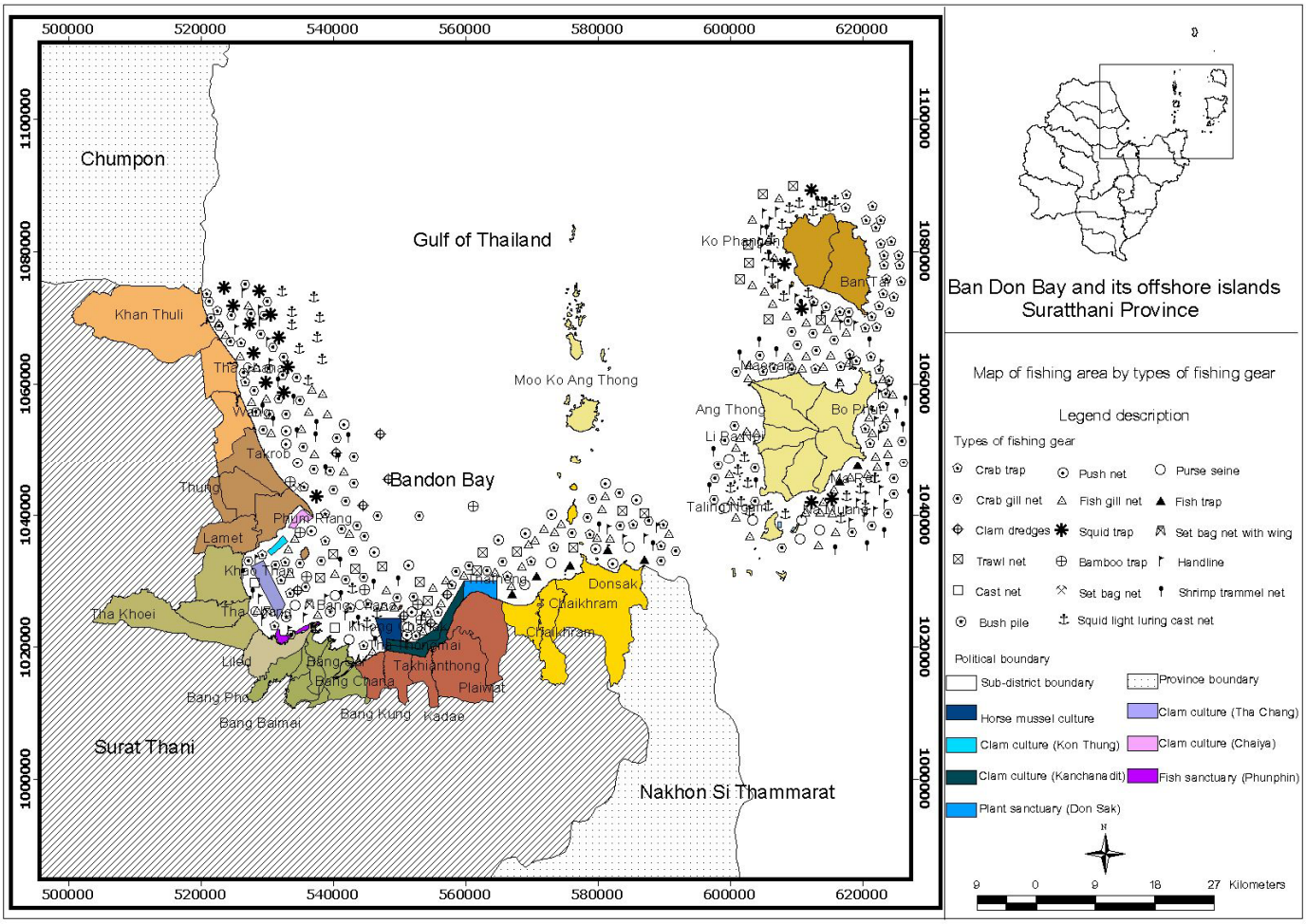


Figure 3.2.5 Map of fishing area in the Ban Don Bay, Surat Thani Province

3.3 AQUACULTURE PRODUCTION BASE

3.3.1 Introduction

Coastal Aquaculture in Surat Thani province composes marine shrimp culture, whiteleg shrimp culture (*Litopenaeus vannamai*), and black tiger shrimp culture (*Penaeus monodon*), blood cockle culture, oyster culture, green mussel culture, giant perch culture, brown spotted grouper culture, and serrated mud crab culture. In 1999-2004 the culture area, the production quantity, and the cost of black tiger shrimps production in Surat Thani province turned to be down continuously. While year 2004-2005, the production quantity of whiteleg shrimps has increased instead of black tiger shrimps production.

There are 3 culture areas of the blood cockle in Surat Thani province: Chaiya district, Tha Chang district, and Kanchanadit district while there are 2 culture areas of the oysters: Chaiya district and Kanchanadit district. The culture area of the green mussel in Kanchanadit district has been expanded.

The giant perch culture and the brown spotted grouper culture in Surat Thani province are located in Mueang district, Chaiya district, and Don Sak district. Besides, there are an increasing number of marine fish culturists, especially in 2005, the culturists in Kanchanadit district, Phunphin district, Tha Chana district and Tha Chang district cultured the giant perches in the earth pond increasingly. Furthermore, there is the increasing number of culturists culturing the giant perches in the floating basket in Kanchanadit district.

3.3.1.1 The marine shrimp culture

The prominent geography of Surat Thani is Ban Don Bay which is one of large-sized bays in the South. Moreover, there is a plain coastline encircles Ban Don Bay totals up 7 districts, longer than 100 km., that appropriate for coastal aquaculture, both of shallow water area and ground level area through Ban Don Bay. Consequently, all these aspects can support aquaculture business in Surat Thani which can maintain income to Surat Thani not lower than 10,000 million baht a year.

Actually, shrimp culture is an important business that have been running for a long time, and respectively developing. Generally, the growth process can be divided into 4 periods as follows:

Period 1 Extensive Shrimp Culturing (1967-1983)

Extensive shrimp culturing in Surat Thani started in the salt farm areas at Ban Naklia (Prasong sub district), and Tha Chana district since 1967. It was found that natural aquatic

animals came to rest and grew up in the salt farm areas. Hence, the development process had been done slowly to enhance the aquatic animal quantity, especially the shrimps which had the high value among the aquatic animals.

Period 2 Opened System Intensive Shrimp Culturing (1983-1992)

Since 1982, the shrimp culture in natural ponds had been developed from large-sized ponds into small-sized ponds. Also, the development needed to have water filtration toward the ponds and eradicate other kind of aquatic animals, releasing the black tiger shrimp fry only. Basically, feeding, oxygen enhancing, and periodically circulating water to and from the ponds were necessary during the culture period. It was normally called "opened system shrimp culture". In year 1983-1989, the shrimp culture with opened system rapidly expanded in the extensive shrimp farming at the old coastline, the coconut garden area, the paddy area, and the area behind the natural shrimp farm line. In 1992, the total area of shrimp culture was about 48,000 rais, separated into development style about 32,000 rais (8,000 ponds). The average product is 1,500 kg. per rai (800-2,500) or 7,500 tons per year, and the value is about 12,000 million baht per year.

Period 3 Closed System Intensive Shrimp Culturing and Recycling System (1996-2002)

In 1993 Yellowhead Virus Disease (YHV) was dispersed to the culture farms in Surat Thani province although many activities were organized to cooperate the environment conservation and to prevent yellowhead virus disease which happened in other provinces since 1993. Therefore, the culturists in Surat Thani had to solve the problem and adjust the culture method to the closed system. At the same time, the farms where have the readiness began to change the old culture into the recycle system, this was to respectively use the closed circulating water system in the farm. During this period, White Spot Syndrome Virus (WSSV) dispersed in China, Taiwan, and Japan in 1992 and dispersed to Thai shrimp culture area in 1994 including Surat Thani in 1995. These factors caused the shrimp culture in Surat Thani decelerated from 1996 to 2002; moreover, the shrimp product was down at the average level 800 kg. per rai , the total product averaged at the level 5,500 tons per year, and the average cost was 7,500 million baht per year. In 1999, the occurrence of shrimp problems affected the average product which declined at 600 kg. per rai, the product totaled up 4,500 tons, the average cost was 7,000 million baht per year (because of currency exchange rate, the value was similar to year 1996-1998).

Period 4 Closed System Bio-intensive Method and Recycling System (2003 - The present time)

Since the shrimp culture has been started in Surat Thani long time ago by using the traditional area continuously, the culturists needed to improving the soil quality and the environment both inside and outside the farm system. As well, the biological technology of the shrimp culture was developed and used since 1997. Generally, the culturists still used the biotechnology until 2003 and also there was a species of whiteleg shrimp called *Vannamai* which was an alternative species. Nonetheless, Thailand faced many problems of the shrimp export business that influenced the reduction of the culture quantity. The remaining culture area was not more than 20,000 rais, the average product was 2,500 kg. per rai , the total product was about 5,000 tons per year, the value was 6,000 million baht per year. The main product was Vannamai in the ratio 80% of the total quantity products (the shrimp culturist club of Surat Thani).

3.3.1.2 The shell culture

1) The blood cockle culture

In Surat Thani, the blood cockle culture has been done more than 30 years. The first culture area was in Tha Chang district, and then expanded to Chaiya district and Kanchanadit district (Yount Musik et al., 2006). In Ban Don Bay, the blood cockle fry stocking area are located in Kungmor cape, Kradaejae, liled, pakrongBan Don (close to Naibang). Thus, they might have a total culture area about 20,000 rais. The important stocking area of blood cockle fry of Ban Don Bay is in Kungmor cape where the area totals up 8,750 rais. The blood cockle fry exactly propagate during November to December (Teeraya et al., 2004).

The results from the questionnaires showed that the blood cockle culturists increased during 10 years (1997-2007). The blood cockle fry was imported from Malaysia where is the main stocking source, then from natural stocking area, satoon, and Burma. After harvesting, there were the brokers in the province purchased, a direct selling sold to the markets or minor retailer ordered.

2) The oyster culture

The oysters which are cultured in Ban Don Bay is Pacific oyster (*Crassostrea Gigas*). The pacific oyster fry are from the natural stocking area in Ban Don Bay. From the result of the study of Teeraya et al. (2006) have noted that the pacific oysters were able to generate their own genetics cell all the year; however, the most suitable period to generate and breed was in April to November (Teeraya et al., 2004).

3) The green mussel culture

The culture area is in Ban Don Bay where located in Chaiya district, Kanchanadit district, and Tha Chang district. The culture style is pole culture. Culture period lasts for 6–8 months. From questionnaire data, in Plaiwat sub district, Kadae sub district, and Phum Riang sub district use the green mussel fry from the natural stocking area.

3.3.1.3 The marine fish culture

1) Giant perch culture

There are 2 culture methods: Floating Basket Culture and Earth Pond Culture. From the questionnaires, 10 year retrospection found that the giant perch culture was increased. However, there were many stocking areas of the giant perch fry, the largest one is from Satoon province. The most wanted size is 1 inch. The large market is the brokers in Surat Thani province.

2) The brown spotted grouper culture

The brown spotted grouper culture is located in Don Sak district (Don Sak sub district), Chaiya district (Phum Riang sub district), and Tha Chana district (Wang sub district). After 1999, there has been the increasing number of the brown spotted grouper culture. There is a self-cultured of the brown spotted grouper fry in Tha Chana district (Wang sub district) both for self-culture and for sale whereas other districts use the brown spotted grouper fry from Nakhon Si Thammarat province or Ranong province.

3.3.1.4 The serrated mud crab culture

The largest culture area is in Kanchanadit district (Thathong sub district, Tha Thongmai sub district), and Chaiya district (Lamet sub-district). Normally, the serrated mud crabs are cultured in aBan Doned shrimp ponds. After 2003, there has been the increasing number of the serrated mud crab culture. There are various stocking areas and different prices of the serrated mud crab fry. Respectively, the large markets are the brokers, restaurants, and Ranong province.

3.3.2 The study method

There are 2 information resources of the analysis study information and the diagnosis of aquaculture production system: primary data and secondary data.

- Primary data are from Department of Fisheries in Surat Thani and Fishmarket of Bangkok.
- Secondary data are from

1) The groupwork conferences of aquaculture entrepreneurs in 27 sub districts of Ban Don area and the islands outside the coastline. In each conference and every production base, there were interviews to reach the resource and environment information, the effects, problems, and suggestion.

2) The interview and questionnaire were distributed to the culturists. The 235 culturists were randomly selected; those were 62 shrimp culturists, 84 shell culturists, 79 giant perch and brown spotted grouper culturists, and 10 serrated mud crab culturists. The field data survey in the aquaculture study area that covered Tha Chana district (Wang sub district, Tha Chana sub district, Khan Thuli sub district,), Chaiya district (Takrob sub district, Phum Riang sub district, Lamed sub district), Tha Chang district (Khao Than sub district, Tha Chang sub district, Takei sub district), Phunphin district (Liled sub district), Mueang district (Bang Sai sub district, Bang Pho sub district, Bang Baimai sub district, Bang Chana sub district, Khlong Chanak sub district, Bang Kung sub district), Kanchanadit district (Takhianthong sub district, Tha Thongmai sub district, Kadae sub district, Thathong sub district, Plaiwat sub district), Don Sak district (Chaikhram sub district, Chonkhram sub district, Don Sak sub district)

3.3.3 The analysis method

To analyze the delicacy and the permanency of aquaculture at the Ban Don Bay and islands outside the coastline referred to Optimal Control Theory which was an administration management with Dynamic style. There are 3 important principles for balance consideration as follows:

1) **Maximum Principle (MP)** It was importantly considered from the turnover of the producers or the entrepreneurs meaning that the system will be steady if the producers or the entrepreneurs can continuously get the highest profit.

2) **Portfolio Balance (PB)** It was combined with the resources and the producers or the entrepreneurs using the resources through an actual value[2] of those resources. A general consider way was the growth of the resource actual value (or the value return rate from using the resources) had to equal with the growth of other resource value (or the value return rate from

[2] The resource actual value might not be equal with the resource value in the market price. The evaluation of the actual resource value would be calculated by using an economic method. However, the project has a limited time so, it needed to use the resource value that was instead evaluated from the market. It was believed that the resource actual value will happen when the value of those resources happens in the market system simultaneously.

using the other resources). To keep the steady state, the resources would be able to compete with other resources in the value aspect. However, the aquaculture will be considered from the tendency of aquatic animal price, product quantity, and significant cost.

3) **Dynamic Constraint (DC)** It was significantly considered from the amount and the quantity of the resources. This meant the turnover of the resource equilibrium and the rate of using resources had to be equivalent. In the aquaculture case will consider from the tendency of aquaculture area use, problems and causes.

3.3.4 Costal aquaculture base research and analysis results

The research and analysis results of costal aquaculture base by Optimal Control theory were as follows:

3.3.4.1 Shrimp Culture

Maximum Principle: MP of shrimp culturists from shrimp culture was changed from extensive system to Whiteleg shrimp culture. The changing occurred during the black tiger shrimp culture by intensive system and the culturists encountered lost. The lost caused by declining of shrimp price, shrimp disease, higher costs, water quality, shrimp strain. Many small culturists ran off business, some changed to culture whiteleg shrimp instead of black tiger prawn. Now whiteleg shrimp culturists are big culturists and big companies. Lately, decline in shrimp price brought the same problems of black tiger prawn culture.

Portfolio Balance: PB of shrimp culturist, the Whiteleg shrimp price was declining and costs were increasing caused small culturists lost. The big culturists and big companies could buy cheaper food or use their own food. Moreover, they had bargaining power in selling, so they gained positive results.

Dynamic Constraint: DC of Ban Don Bay aquaculture from the existent resources observed from shrimp culture problems; in the past, there were young shrimps in nature, then the system was destroyed after increasing of shrimp farms, mangrove forest were changed to shrimp farms, culturist had to culture young shrimp themselves and face many problems such as shrimp stain, slow growth and different sizes of shrimp. The important system of shrimp farming was water quality, release of clay and sewage water into natural water sources and decreasing of mangrove forest directly affected aquaculture system.

Under Optimal Control theory, it was said that if there were problems in one of MP, PB or DC, the system would be fail. In this case, both PB and DC got problems, it showed that shrimp cultures were delicate.

3.3.4.2 Shell Culture

Maximum Principle: MP - Data from the questionnaires stated that most of turnover of blood cockle, green mussel and oyster cultures were positive, but obtained more problems in the future about higher production costs, higher petrol costs, and young shell illegal import from Malaysia. The increasing of labor costs caused the higher production costs. By theory, business would be alive if the culturists gained the maximum profit continuously. In this case, main costs were rising, the culturist could not gain the maximum profit turnover.

Portfolio Balance: PB – Considering the shell price trend, the declining of shell prices brought negative and sensitive result to the system.

Dynamic Constraint: DC – the resource which affected directly to blood cockle, green mussel and oyster culture was water quality. Freshwater flowed into the ponds caused shell death. Freshwater flowed into the bay in monsoon season, sewage from the city, communities, factories, marine shrimp culture, salty water, and higher temperature of sea water impacted on shell culture. Ban Don Bay was crowded with shell farms, some of them were outside permitted area. Shell culture area affected other production bases such as fishery.

According to Optimal Control theory, it was said that if one of MP, PB or DC was in trouble, the system would be fail. In this case, all MP, PB and DC had trouble. That means shell cultures were delicate.

3.3.4.3 Giant Perch and Grouper Culture

Maximum Principle: MP - Most results of Giant perch and grouper cultures were positive. But the increasing of production costs such as, food, fries and equipments caused the impossibility of continuous maximum profit turnover.

Portfolio Balance: PB - A decline in price trend of giant perch and grouper year by year made the system was in trouble and sensitive.

Dynamic Constraint: DC - resource which affected directly to the system was water. Quality of water in canals depended on water pollutions from communities, shrimp farms, factories, salty water, and too much freshwater in rainy season. Moreover, expansion of canals directly impacted on giant perch and grouper cultures.

According to Optimal Control theory, it was said that if one of MP, PB or DC was in trouble, the system would be fail. In this case, all MP, PB and DC had trouble. That means fish cultures were delicate.

3.3.4.4 Serrated Mud Crab Culture

There were a few crab farms in Ban Don bay area, mostly run as an additional job over fishery, shell and shrimp culture. If culturists follow sufficiency culture, it could be a stable additional job.

3.3.5 Problems and Solutions

3.3.5.1 Shrimp Culture

According from the questionnaires about the problems of shrimp culturist, we can conclude that:

1) Shrimp disease problem in black tiger prawn and whiteleg shrimp

Suggestions: Set up a qualified shrimp project by control the forbidden chemical in culture, support personnel development in culture knowledge by setting academic seminars, evaluate the materials and chemicals using in shrimp culture and provide information to culturist, and continuously provide public relation about disease situation to culturist.

2) Shrimp price fluctuation and decline

Suggestions: Promote consumption of shrimp to public and encourage culturist to follow the GAP and COC standard in order to get qualified shrimp.

3) Water quality – most of water pollutions came from chemical and waste water of shrimp farms. Moreover, some culturists supplied clay into natural water resources.

Suggestions: There should be a checking of soil and water at the canal or river mouths and continuously report water quality conditions to culturist such as changing of salt level or troubles in water quality,control farming management because some culturist still release clay into water punish illegal clay injection suppliers campaign fishery boats do not throw engine oil into water realize environment impact that affect shrimp and shell farms because of expansion of canal and river mouths do research about the impact of shell raking on water quality.

4) Higher production costs – according to the questionnaires, we ranked the main costs of black tiger prawn culture by intensive system as food, petrol, labor, chemicals and equipments, young shrimp, and electricity. Main costs of whiteleg shrimp culture were food, petrol, labor, electricity, chemicals and equipments, and young shrimp.

Suggestions: Expand electricity limit for small culturists in order to replace petrol utilization, cost cutting by promote using of LPG gas together with petrol for water pump, support petrol and food price in order to reduce costs, provide interest-free loan, provide loan from both public and private banks for the farms with GAP and COC, 6) support money for co-operative operation, and develop biodiesel in order to reduce costs.

5) Problems of young shrimp were slowed growth, poor growth, different sizes, and young shrimp death.

Suggestions: Government section should control shrimp nurseries to get good quality shrimp, and government should be a young shrimp producer.

6) Trade boundaries - difficulties of export impacts on the declining of shrimp price.

Suggestions: use government negotiation about trade boundaries.

7) Labor problem – most of labors came from Myanmar and Laos, the registration and labor insurance fees are high caused higher production costs.

Suggestion: Reduce registration and labor insurance fees.

8) Thieve – there were thieves stole shrimp, electric wire and equipments.

Suggestion: Support police and local police expense.

3.3.5.2 Shell culture

The problems of shrimp culture concluded from the questionnaires and survey were as follows:

1) In rainy season, freshwater flowed into the sea changed salty level of sea water caused shells died and slowly grew.
2) In Kanchanadit district, there were problems of sewage from factories and clay release from shrimp farms.
3) Water quality such as high temperature of sea water and too salty water.
   Suggestion: usually evaluate water quality
4) Lacking of young shell, the culturists have to import young shell from Malaysia.
   Suggestion: conserve young shell in the nature
5) Shell stealing by neighbors

Suggestion: Set up a security group to watch out shell stealing.

Other Suggestions

1) Product value-added, such as cleaned shell
2) Surat thani shell brand creation
3) Check water treatment of factories
4) Tidily manage the shell stall in the sea (Ban Don Bay)
5) Set up a central market. Get rid of middle men.

3.3.5.3 Marine Fish Culture

The problems of giant perch culture concluded from the questionnaires and survey were as follows:

1) Fish disease

2) Sewage water from factories and shrimp farms

3) Fish slowed growth

Suggestions: Fish culture in floating baskets at river mouths around Ban Don bay should be managed to prevent ground dirt accumulation by switching culture areas or cleaning sewage under water ground and control release of waste water into water resources without treatment.

3.3.5.4 Serrated Mud Crab

Culture problems were:

1) Slow growth of crab

2) Sewage water from shrimp farms

3) Disease and crab stealing

Suggestions: Let government sectors improve young crab quality, always evaluate water quality, and watch out the crab stealing.

3.4 AGRICULTURE PRODUCTION BASE

3.4.1 Introduction

The value of agricultural product changes based on the market price that is uncertain. In a year where there is a high quantity of agricultural product on the market, the price will decrease as there is too much supply in the market. On the other extreme in a year where there is a low quantity of agricultural product on the market, the price will increase because there is a high demand from the consumer and insufficient supply. Factors such as changes in investment or production activities in the agricultural sector will cause the trends of the prices of goods and the expected prices to change in the future. Support from the government and suitability of the area for farming are also factors that will make farmers feel confident in investing in their agricultural activities or change in plant species.

The limitations in growth ability of different plant species are determined by the characteristic of the different geography where they grow. The important factors for consideration by the farmers are price and suitability of the land. The price will indicate whether the farmer will make a profit or loss after harvest. The land characteristics will influence and possibly limit the growth and production abilities of plants. For example, if the farmer plants Para rubber in an area that is submerged or an area that has low levels of nutrients in the soil, the Para rubber trees will grow slowly and will be shorter. The consequence is that the period during which the farmer can harvest the Para liquid from the tree will be delayed.

In the study area, in 1977, the main occupation of the people the Kanchanadit District was rice farming and some people also had fishing activities as additional occupations. Some areas were used for coconut plantations. The land had been used without maintenance and the farmers could not gain any profit so the farmers decided to change their main occupations from ricer farming to fishing activity. When shrimp farming was introduced to the area, people decided to change their rice farm and coconut plantation areas to be used for shrimp farm areas. People who still had rice farms located near shrimp farms were affected from shrimp culture activities so they had to stop rice farming and leave the land unused. Some farmers sold their land to businessmen. At present, only the businessmen are involved with farming shrimp culture in the area. People who did not sell their land have invested in oil palm plantation on their land. The trend of the oil palm plantation area is increasing because the land is suitable for oil

palm plantation and the price is a major motivation for the farmers to switch the use of their land to oil palm plantation (Chumwara, 2007).

In the study area, peat swamp forest is the main characteristic of the land in the Tha Chana District. The *Melaleuca cajuputi* (Samet Khao in Thai) and the *Resak Tembaga* (Mai Khiam in Thai) were grown in the land in the past. The growth abilities of different plant species vary in the three sub-districts in the Tha Chana District. For example, the sub-district or areas that are close to the sea will be suitable for coconut plantations while the land that is far from the sea is suitable for rice plantations. Currently, rice farmers cannot make a profit from rice plantations. Thus, in the land that is suitable for oil palm and Para rubber, the farmers decided to change from the growing rice to producing these species. Most farmers would like to plant Para rubber and if the area is submerged, the farmers will decide to plant oil palm (Phongphankasem et al., 2007).

The accumulation of sediment is usually found in the areas that are near the estuaries. The soil composition in these areas is usually clay. The areas are submerged in some seasons. The characteristics of these areas are found in the Liled, Bang Sai, Khlong Chanak, Bang Pho, Bang Baimai, and Bang Chana Sub-districts. These sub-districts are suitable for coconut, betel palm, and fruit plantation. Farmers have considered the transportation system as a factor for slow changes of the area near the estuaries. People need to use boats for transporting the technologies into the area. This is one of the limitations caused by the slow changes in the areas.

Analysis and diagnosis of the coastal production system is the study of dynamic changes in the agricultural activities. The study considered whether the plant species that are planted by the farmers are sustainable or not using the concept of Optimal Control Theory in the analysis. The concept has 3 main components, which are:

1) The Maximum Principle (MP) is the balance that considers the results of the fishing activities. The system will continue if the fishermen can continuously get the maximum benefit from the fishing activities.

2) The Portfolio Balance (PB) is the balance that considers both the resource and the producer or the owner who extract the real value from the resource. In general, the growth of the real value of the resources (or the growth of the benefit from using the resources) must be equal to the growth in value of other resources or the growth of the benefit from using other resources. The system will continue if these resources are able to compete with other resources in terms of value.

3) The Dynamic Constraint (DC) is the balance that mainly considers the quantity of the resources. The system of renewable resources will balance when the rate of substitution of such renewable resources is equal to the rate of exploitation of these resources in the system.

The characteristic of coastal areas is one of the factors that influence coastal production. The areas were classified based on the similarity of the characteristics of the areas and type of land use. Brainstorm meetings were held with people's participation to identify the plant species that are used in the area and to find out the factors that influence changes of agricultural activities. The results from the meetings were also used for area classification. The secondary data was gathered at the sub-district level. The primary data was gathered by political boundaries. The approach used random sampling in the sub-districts of the study area. The data were analysed by using the concept of Optimal Control Theory.

3.4.2 Literature review

In the study area, the agricultural products that have been considered as the important products from the past to the present are rice, coconut, Para rubber, oil palm, Swiftlet bird, and duck. The details of these agricultural products are described below.

1) Rice

Currently, plantation areas with local rice species that are tolerant to conditions of water shortage are replaced by developed rice species that require sufficient water to grow. As a consequence, at present the paddy field area is decreasing because of shortage of water as well as low profits from growing rice. Another consequence is a change in agricultural activities because of the price and suitability of other alternative plant species; these alternatives provide greater profits. Most paddy fields were converted into oil palm plantation and the paddy fields that are not submerged were changed to be Para rubber plantations. In the past, fruit plantations were promoted by the government. After the harvest season, there were a lot of fruit products in the market but there was no market prepared for this large amount of products and the prices of fruit were low as a consequence. This is one of the reasons that farmers lost of confidence in the government and they have selected plant species to grow according to the market's demand (Chaiwong and Nakhonko, 2007).

In the Chaiya District, the average quantities of rice yield of the farmers in the Chaiya, Lamet, Takrop, and Thung Sub-districts are higher than other areas because the farmers have a good water system. The Tha Khoei Sub-district has the largest planted area (2,580 Rai), the

second largest area is in the Lamet Sub-district (2,220 Rai) and the third largest area is in the Tha Chang Sub-district (1,528 Rai)

2) Coconut

The quantity of coconut yield is reducing over time. The farmers may have limited profits from coconut plantation and they may find alternative plant species or products that may provide more profit than coconut in the future. The price of coconut is uncertain. Prices of coconut were adjusted with a baseline using consumer price index 2002(Figure 3.4.1). The trend of coconut price is decreasing. The prices vary between 2,000 and 3,000 Baht per ton.

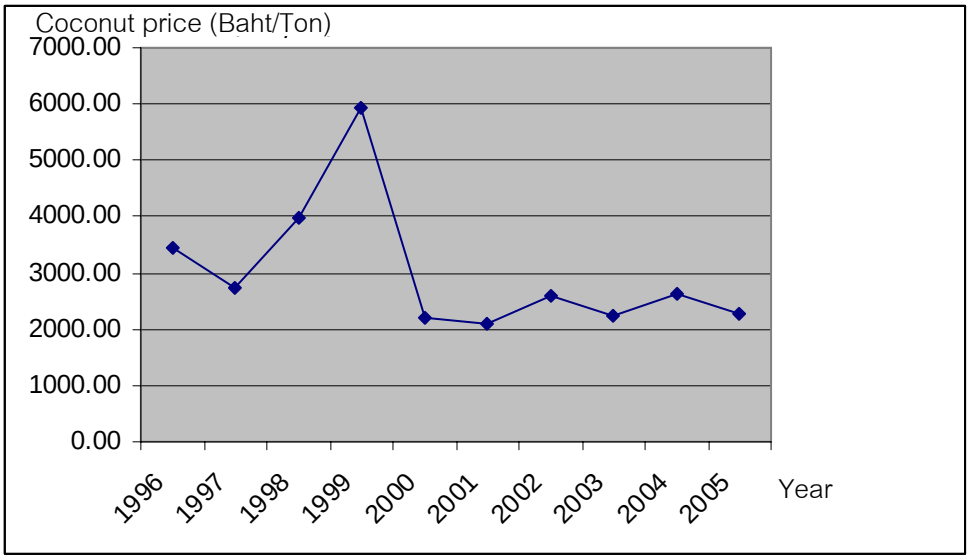


Figure 3.4.1 Prices of coconut adjusted with a baseline using consumer price index from 2002

Most coconut plantation areas are found in the Ko Pha Ngan Sub-district (30,746 Rai). There are other coconut plantation areas, e.g. Ban Tai Sub-district (26,445 Rai), Maenam Sub-district (17,722 Rai), Bo Phut Sub-district (15,089 Rai), Ma Ret Sub-district (13,810 Rai), Na Mueang Sub-district (12,326 Rai), Lipa Noi Sub-district (11,521 Rai), and Taling Ngam Sub-district (10,941 Rai). The total quantity of coconut yield on the island is still low because there is a limitation on availability of water sources. The price set by the middlemen on the island is lower than on the mainland because the middlemen have to pay for transportation cost. However, coconut is considered as a suitable plant for the area. The highest amount of average yield was found in Ban Baimai Sub-district (1,328 Kilograms per Rai per year) because the soil in the sub-district has high levels of nutrient and the sub-district is near the water.

3) Para rubber

The trend of Para rubber planting is increasing because the farmers can get higher profit than from planting other plants, e.g. fruit plants. The soil in the south is suitable for growing Para rubber, which can give high yield in the tropical areas. After the period of harvesting Para rubber liquid is finished, the farmer can also sell Para rubber wood and the money from selling the wood can be used as an investment for new crop. The farmers will get higher price if the diameter of the Para rubber tree is large. At present, the area of Para rubber plantation is extended every year. The price of the Para rubber is the most important factor for the farmers when making a decision to extend the Para rubber plantation area.

The trend of the prices of Para rubber, adjusted with a baseline using consumer price index from 2002, has been an increase since 2001 (Figure 3.4.2).

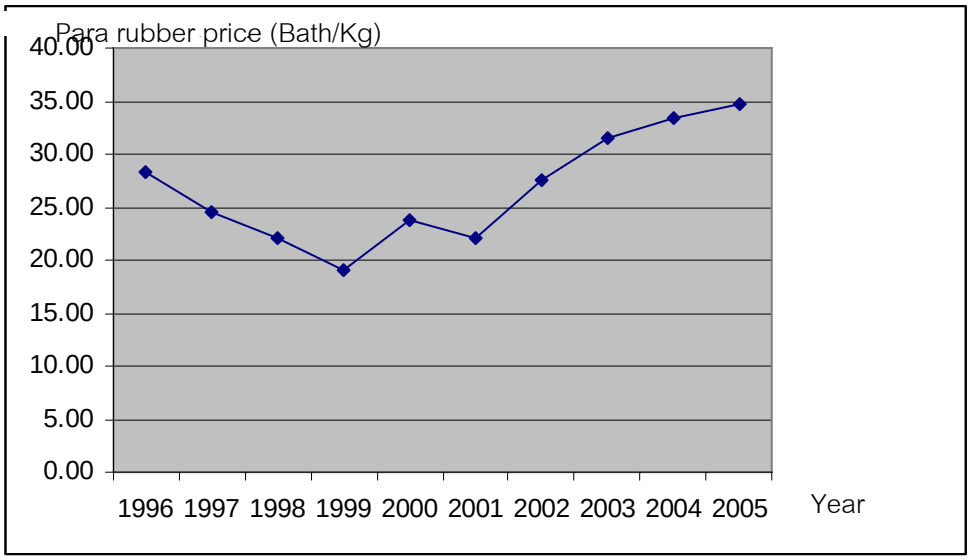


Figure 3.4.2 Prices of Para rubber adjusted with a baseline using consumer price index 2002

Para rubber plantation area is extended into the areas that are not submerged. The Don Sak District has the largest area of Para rubber plantation (53,255 Rai) and its average yield is about 250 Kilogram per Rai each year. The Khan Thuli, Khao Than, and Tha Khoei Sub-districts have also large areas of Para Rubber plantation. In the study area, the Phunphin District and the Mueang Surat Thani District have no areas with Para rubber plantation.

4) Oil palm

The trend of oil palm plantation area is increasing because there is a high demand for the oil palm products and the area has limitations for planting other plants or doing other activities. For example, in the past, the paddy field area was converted into shrimp farm area but

after this change the shrimp farmers faced problems of disease of shrimp and low price of shrimp products. As a consequence, the shrimp farmers stopped the shrimp culture and the farms were aBan Doned. In 2004, the promotion of the government on oil palm planting was the motivation for the farmers to change their land to use for oil palm plantation (Bunnam, 2007).

The trend of oil palm plantation area is increasing. However, the trend of oil palm yield is variable probably because of the suitability of the land in different seasons having a direct influence on the yield. The price of oil palm fluctuates and sometimes the price can be low. The oil palm prices that are adjusted with a baseline using consumer price indices from 2002 have been increasing for the last 5 years (Figure 3.4.3). The price has varied between 1.00-2.50 Baht per Kilogram.

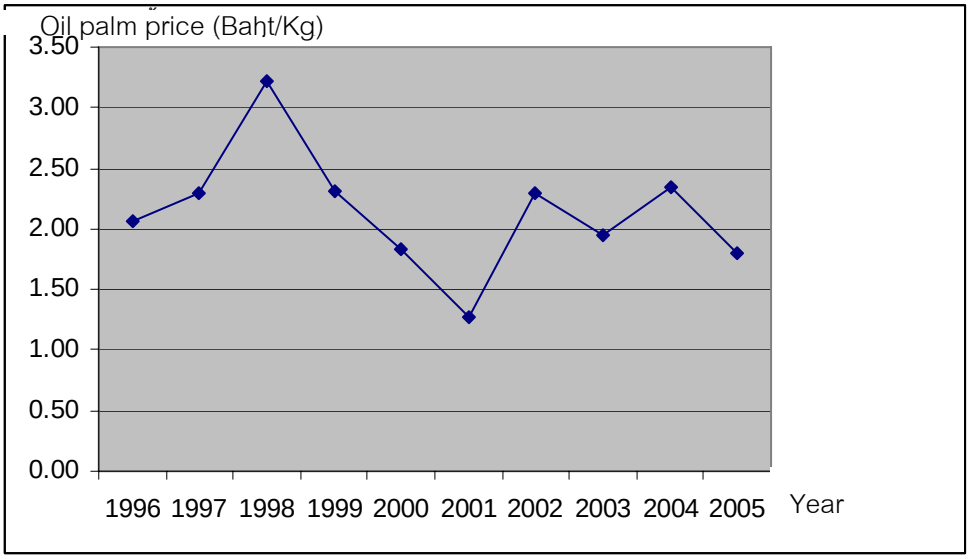


Figure 3.4.3 Prices of oil palm adjusted with a baseline using consumer price index 2002

The plantation area of oil palm in the Surat Thani Province has been extended because of the policy of the province. Table 3.4.1 shows that in the Surat Thani Province, the plantation areas in which the oil palm yield was harvested has been increasing from 2003 to 2005.

The Khan Thuli Sub-district has the largest oil palm plantation areas (73,300 Rai). The areas of the Khan Thuli sub-district that can produce oil palm are 11,665 Rai with an average yield of 2,500 Kilograms per Rai. Since the oil palm plantation activities have recently started the area where the yield is harvested is much smaller than the plantation area. In the study area, the areas that have no oil palm plantation areas are Ko Samui District and Ko Pha Ngan District because the areas are not suitable for oil palm plantation.

Table 3.4.1 Oil palm: Area production and yield by Surat Thani Province (2003-2005)

Year	Harvested area (Rai)	Yield (Tons)	Yield per rai (Kgs.)
2003	502,966	1,310,503	2,606
2004	545,365	1,409,223	2,584
2005	554,478	1,347,382	2,430

Source: Office of Agricultural Economics

5) Swiftlet bird

Collecting the Swiftlet's nest from the natural habitat in Surat Thani is undertaken by the businessmen who got concessions from the government. There is no available information about this activity. In the past, the owners will hire the villagers who are living in the island to clean the cave, which is the living place of the Swiftlets. Currently, the owners do not allow the villagers to go inside the cave. There are eight islands that have Swiftlets and Swiftlet's nest business; Ko Wua Te, Ko Wua Chio, Ko Si, Ko Ha, Ko Wua Ta Lap, Ko Tae Nok, Ko Tae Nai, and Ko Phaluai (in the Bay) Islands. The Swiftlets also live in the Ko Wua Kantang Islad, which is in the boundary of Marine National Park therefore there is no concession there.

The area of "Swiftlet bird condo" or "Swiftlet house" is currently being extended. Recently, five Swiftlet houses were built in Don Sak District (2 houses designed for the Swiftlets and 3 houses extended from the human living places). In the Tha Thong Sub-district in Kanchanadit District there is one Swiftlet house. In Mueang Surat Thani District, there are 7 Swiftlet houses that are newly built particularly for Swiftlets and many Swiftlet houses that are extended from the human living places. In the Phunphin District, there is only one Swiftlet house.

In Thailand, the price of the nests of the Edible-nest Swiftllets and the German's Swiftlet are between 70,000-100,000 Baht per Kilogram. The market price of the nest of these two species in Hong Kong is about 2,620-4,060 US$ per Kilogram. The price of the nest of the Black-nest Swiftlet in Thailand is about 6,000-20,000 Baht per Kilogram (Prices in 1998) (Chandum, 2004).

6) Duck

The farmers who keep ducks need to have proper understanding and spend time running their farms. Study of the behaviour of ducks is also important for ensuring the quality of duck eggs. The average lifespan of a duck is 2.5 years. However, ducks that can produce few

eggs will be sent to the slaughter house or the duck will be sent to the slaughter house after 2.5 years anyway.

Duck feed formula is one of an important components for the success of the duck farms. Shrimp head is also very important. In the Chaiya District, the duck eggs produced from the area has distinct characteristics, which is red yolk. The farmers in Chaiya District put the shrimp head in the instant duck feed. The main components of the duck feed are rice bran, soybeen fish meal, grinded shell, and shrimp head. The main source of shrimp head is from Chumphon and Ranong Provinces (Thueanthep, 2007).

Considering the total number of duck in the farm is another important thing to control the total amount of duck eggs sent to the market. In case that other farm ordered high number of ducks the farmers in other farms will try to reduce the number of duck in their farms. The expansion rate of this duck culture is not so high. The farmers will send their products to the salted egg group in the Chaiya District. The selling price of the best quality of the egg is 4 Baht per egg.

3.4.3 Results

General information was collected from the respondents and used as primary data. The results are presented by district (only in the sub-districts covered by the study area). The summary of the results are as follows:

1) Tha Chana District

The study was done in the Khan Thuli, Tha Chana, and Wang Sub-districts. The 32 respondents were selected as representative samples of the district. The education level of most respondents is grade 4 of Elementary School. About 59.4% of the respondents have agriculture as their main occupation. Most of the respondents reported a high level of the satisfaction with their lifestyle (40.6%). Most of the respondents work on oil palm plantations as their main occupation (65.6%) while the rest have Para rubber plantation as their main occupation (34.4%). The respondents selected the plant species according to the sale price and the demand from the market. The oil palm plantation has been in operation since 2001. About 52.4% of the respondents do not get oil palm yield yet from the plantation. About 90% of the respondents who harvested the oil palm said that they received higher oil palm yield than previously. Half of the respondents (50%) who have oil palm plantation as the main occupation can get higher price than before. All of the respondents (100%) who have Para rubber plantation as their main occupation mentioned that the prices of Para rubber are higher than in the past. 38.10% of the

oil palm farmers selected to plant oil palm based on the demand in the market place. About 51.8% of the oil palm farmers changed their lands from paddy field to be used for oil palm (14 out of 27). There are 5 farmers who changed the vacant land to be oil palm plantation (18.52%).

2) Chaiya District

The study was done in the Takrop, Talat Chaiya, Thung, Phum Riang, and Lamet Sub-districts. There were 33 respondents in the district. The education level of the respondents is Grade 4 of the Elementary School (66.7%). About 66.7% of the respondents have agriculture as their main occupation. Most of the respondents have a high level of the satisfaction with their lifestyle (36.4%). The respondents were working in Para rubber plantations (33.3%), rice plantations (30.3%), and oil palm plantations (12.1%). The respondents selected the plant species to cultivate according to the price and the demand from the market. The respondents have been growing these plants for many years. The Para rubber and rice plantation were started prior to 1996. Oil palm has been planted since 2002. Most of the oil palm and Para rubber farmers have not harvest yet in this year. The prices of oil palm, Para rubber, rice, and coconut is currently increasing. All of the oil palm farmers changed rice fields to be used as oil palm plantation (4 out of 4). About 55.56% of the Para rubber farmers changed rice fields to be Para rubber plantation (5 out of 9).

3) Tha Chang District

The study was done in the Khao Than, Tha Khoei, and Tha Chang Sub-districts. The total number of the respondents in the district is 34. The education level of the respondents is Grade 4 of the Elementary School. About 73.5% of the respondents have agriculture as their main occupation. Half of the respondents have a high level of the satisfaction with their lifestyle (50.0 %). The respondents are engaged in Para rubber plantations (47.1%), oil palm plantations (26.5%), and rice plantations (20.6%) as their main occupation. The respondents selected their plant species according to the suitability of land and plant species. The Para rubber tree was planted prior to 1996. Oil palm started to be planted in 2001. An increase in paddy fields has been observed since 1997 in the low land area, and the production is good in the major rice plantations. About 55.6% of the farmers who planted oil palm have not got their oil palm yield yet. The trend of the price of Para rubber is increasing (93.3% of the Para rubber farmers). The prices of oil palm and rice are constant. Rice yield is mostly used for household consumption and the remainder is sold. There are 56.25% of the oil palm farmers who changed their land from paddy field to oil palm plantation (9 out of 16). There are 12.50% of the oil palm farmers who changed their land from Para rubber plantation to be oil palm plantation (2 out of 16).

4) Phunphin District

The study is undertaken in the Liled Sub-district. The number of respondents in the sample is 32. The education level of the respondents is Grade 4 of the Elementary School. About 78.1% of the respondents have agriculture as their main occupation. Most of the respondents have medium level of the satisfaction with their lifestyle (43.8 %). The respondents have been engaged in coconut plantations (78.1%) and oil palm plantations (12.5%) as their primary occupations. The respondents selected the plant species according to the suitability of land and plant species. The coconut plantations were started prior to 1996. Extension of the oil palm plantation has taken place since 2002. The oil palm farmers have not got the oil palm yield yet. The coconut yield was distributed to the market prior to 1996. The price of coconut had been increasing since 2003 and recently started to decrease in early 2007. All of the respondents who have oil palm plantation have changed their coconut plantation areas to be oil palm plantation areas (4 out of 4).

5) Mueang Suratthani District

We studied the Khlong Chanak, Bang Chana, Bang Sai, Bang Baimai, and Bang Pho Sub-districts. The total number of the respondents was 33. The education level of the respondents is Grade 4 of the Elementary School. About 78.8% of the respondents have agriculture as their main occupation. Most of the respondents have medium level of the satisfaction with their lifestyle (39.4%) and about 27.3% of the respondents have a high level of satisfaction. The respondents have been engaged in coconut plantations (75.8%) and oil palm plantations (18.2%) as their main occupation. The respondents selected the plant species according to the suitability of land and plant species. The coconut plantation was started prior to 1996. Extension of the oil palm plantation has been taking place since 2004. The oil palm farmers have not got the oil palm yield yet. The coconut yield was distributed to the market prior to 1996. The price of coconut has increased since 2004, but started to decrease at the end of 2006. All of the respondents who have oil palm plantation changed their coconut plantation areas to be oil palm plantation areas (8 out of 8).

6) Kanchanadit District

The study was undertaken in the Kadae, Takhianthong, Thathong, Tha Thongmai, and Plaiwat Sub-districts. There were 33 respondents in the district. The education levels of the respondents are at the Diploma level and Grade 4 of the Elementary School. About 66.7% of the respondents have agriculture as their main occupation. Most of the respondents have high levels of satisfaction with their lifestyle (45.5%) and about 36.4% of the respondents have

medium level of satisfaction. The respondents have engaged in oil palm plantations (48.5%), Para rubber plantations (12.5%), and coconut plantations (12.1%) as their main occupation. The respondents selected the plant species according to prices and market demand. The coconut plantation and the Para rubber were started before 1996. Extension of the oil palm plantations has taken place since 2002. Some of the oil palm farmers have been receiving oil palm yield since 2006 but others are still waiting to receive their yield. The Para rubber farmers started work on Para rubber plantations before 1996 and the farmers can get higher profit than previously because of an increase in the price of Para rubber. The farmers produced coconut yield before 1996 and there has been no extension of the coconut plantation area in this district. The price of coconut had been increasing since 2003 and started to be decrease in 2006. The trend of coconut yield in the district is decreasing. About 53.33% of the oil palm farmers changed their rice plantation area to be oil palm plantation area (8 out of 15).

7) Don Sak District

Three sub-districts were covered by the study area; Chonkhram, Chaikhram, and Don Sak Sub-districts. The total number of the respondents was 35. The education level of the respondents is at Grade 4 of the Elementary School. About 82.9% of the respondents have agriculture as their main occupation. Most of the respondents have high level of satisfaction with their lifestyle (42.9%) and about 37.1% of the respondents have medium level of satisfaction. The respondents are engaged in Para rubber plantations (71.4%), coconut plantations (17.1%), and oil palm plantations (11.4%) as their main occupation. The respondents selected the plant species according to prices, market demand, and land suitability. The coconut plantation and the Para rubber plantation were started prior to 1996. The Para rubber trees were planted in the same area that used to be Para rubber plantation - the previous Para rubber trees were cleared because the trees are too old. Extension of the oil palm plantation has taken place since 2003. Some of the oil palm farmers have received their oil palm yield since 2006, but some have not received the yield yet. Some of the Para rubber farmers got the yield before 1996 and some yield was produced from the new plantation that replaced the old trees. The price of Para rubber has been increasing since 2003 until the present time. The coconut farmers got their products before 1996. The price of coconut had been increasing since 2004 and started to decrease in 2006.

8) Ko Samui District

The results from the focus group meetings in the Ang Thong, Lipa Noi, Taling Ngam, Na Mueang, Ma Ret, Bo Phut, and Maenam Sub-districts are summarized. The agricultural area in

the Ko Samui District is mainly covered by coconut trees, which have been planted in the area for many years. Some fruit gardens are also found in the area. Some of the coconut plantation areas were changed to be Para rubber plantation areas particularly in the central part of Ko Samui Island because of an increase in price of Para rubber. The trend of coconut yield is decreasing because some coconut trees are too tall and there are difficulties in harvesting. The price of coconut is constant. Some farmers changed their main occupation from the agricultural sector to tourism. Some farmers sold their land to the businessmen. As a consequence, agriculture can be considered as the second occupation of some people in the district. On the Ko Phaluai Island in Ang Thong Sub-district, people changed from coconut plantation to Para rubber plantation because the coconut trees were damaged from insects called (Maeng Dam Nam (in Thai) and Duang Huakhaeng (in Thai)).

9) Ko Pha Ngan District

Results from the focus group meetings in the Ko Pha Ngan and Ban Tai Sub-districts are summarized. The results show that coconut trees and other fruit trees have been planted in the district. The coconut yield is constant. The price of coconut bought on the island is cheaper than the coconut bought from the mainland because the collectors need to pay for transportation from the island to the mainland. The resorts are operated in the coconut plantation area, therefore in the high season of tourism the tourism is the main occupation of the farmers.

3.4.4 Conclusion

Primary and secondary data for the coastal area of the Ban Don Bay were collected. The secondary data was gathered at the sub-district level covered by the study area. The prices of agricultural products were adjusted inline with inflation to analyse the change in prices. Data about farmers was gathered using random sampling to collect primary data at the district level. The data were analysed using the concept of Optimal Control Theory and the results are summarized below.

3.4.4.1 Analysis of the production system by district

1) Tha Chana District:

There is a decrease in rice plantation area because of water shortages for the secondary rice farming; therefore the farmers decided to change to plant oil palm. A decrease in coconut plantation area was also found, because farmers can get a higher price and greater profits from growing other plants, in particular for oil palm compared to coconut. The plantation areas of Para rubber and oil palm have also increased because the farmers can get higher profits than by producing other types of plant. The price of Para rubber liquid and Para rubber

wood are the main reasons cited by farmers when selecting the type of plant to use. Promotion of oil palm plantation by the government, price and quantity of the oil palm yield are the main motivations that encourage farmers to select oil palm for their plantations.

2) Chaiya District:

The current rice plantations in the district are sustainable. The farmers choose to plant rice because of the suitability for this type of land use, and irrigation systems can be used to provide water for the rice plantations throughout the whole year. However there has been no expansion of the rice plantation area in the district. Aromatic coconut plantations are an additional occupation for the farmers. The areas that have old coconut trees have been replaced by oil palm trees. Oil palm has been selected to be planted in low land area that is submerged as well as in areas that were previously used for rice plantation. Para rubber plantations have been expanded, particularly in the higher land. Planting Para rubber has been successful because of an increase in the price of Para rubber liquid and the availability of markets and demand for Para rubber wood. In the Chaiya District, duck egg farming is another occupation for the local people. Salted egg is the product from duck eggs. The duck egg farms are sustainable because there is sufficient demand and no problems about transportation of goods.

3) Tha Chang District:

Rice plantation in the district is not sustainable because of decreasing profits for farmers engaged in this activity. Shortage of water for secondary rice farming is another constraint for rice plantations. The price of rice yield has remained constant. These are the main reasons that farmers have been replacing rice with oil palm and Para rubber, which provide them with higher profit than rice plantation.

4) Phunphin District:

Coconut plantation has been in operation for many years. The land is suitable for planting coconuts, which has led to the sustainability of the coconut plantations in the district. However, there has been no expansion of the coconut plantation area. Some farmers decided to plant oil palm because there has been no change in the price of coconut and there are other economic plants that can be sold to achieve higher profits. Some farmers were motivated to plant oil palm by promotion from the government in the province.

5) Mueang Surat Thani District:

Most of the land areas have accumulated sediment particles from the Ta Pi River. Coconut and betel palm are commonly planted in the district. Coconut plantation has been in operation for many years. The land is suitable for planting coconut, which leads to the

sustainability of the coconut plantation in the district. However, some areas of coconut plantation have been replaced by oil palm.

6) Kanchanadit District:

Coconut plantation in the district is not sustainable because there has been a decrease in profit, which is the consequence of an increase in the cost of harvesting. Planting oil palm in low land and Para rubber in high land are the alternative options that have been selected by the farmers in the district. In the aBan Doned areas and aBan Doned shrimp farm, the farmers selected to plant oil palm because of land suitability.

7) Don Sak District:

Coconut plantation in the district is not sustainable. Oil palm and Para rubber have been selected to replace coconut. Para rubber plantation is sustainable because of an increase in price of Para rubber liquid and there is demand in the market for Para rubber wood. Expansion rate of the Para rubber is low because Para rubber plantations have already been planted by the farmers in the area. In addition, the farmers in low land selected oil palm instead of Para rubber. The oil palm is planted in aBan Doned areas and aBan Doned shrimp farm as well as in areas that are used for coconut plantation.

8) Ko Samui District:

Coconut and fruit plantations are the main agricultural activities in the district. Para rubber trees were planted mainly around the mountain area. Ko Samui is a famous tourist destination. In Ko Phaluai in Ang Thong Sub-district, coconut trees were replaced by Para rubber trees because the coconut tree was damaged by plant pests.

9) Ko Pha Ngan District:

Coconut plantation in the district is sustainable because the coconut is the main economic plant in the island.

Swiftlet bird business is currently expanding. To build a “Swiftlet bird condo” or “Swiftlet house” there needs to be a large financial investment, so this business is mainly for rich businessmen. The districts that have “Swiftlet bird condo” are Don Sak, Kanchanadit, Mueang Surat Thani, amd Phunphin Districts.

3.4.4.2 Analysis of production system by type of plant

1) Rice

Dynamic Constraint: There is a decrease in rice plantation area. Rice plantation area was replaced by other alternative plants that provide higher yield and price than the rice plantation. Water shortage is another limitation for rice plantation. As a consequence, the farmers are able to culture only the major rice crop. Except in the Chaiya District, the farmers

culture both the major rice crop and the secondary rice crop because there is an irrigation system. However, there is no expansion of the rice plantation area in the Chaiya District.

Maximum Principle: Most of the rice yield that is produced in the study area is mainly used for household consumption. The remaining yield is sold to the rice mills. The rice plantation has taken place in the study area for many years. However, the rice farmers have not received profit because of uncertainty of the yield. There is an exception for the farmers in the Chaiya District because the farmers have produced a regular yield so the farmers can maintain the annual profit and they will increase their profits when the price increases.

Portfolio Balance: The trend of the price of rice is decreasing when compared to prices that are adjusted for inflation.

The rice plantation can be promoted and maintained in the Chiya District because the land is suitable for rice plantation and there is also an irrigation system. Other areas should be encouraged to change rice plantation areas to other suitable types of plant, e.g. planting of Para rubber trees in high land and planting of the oil palm in low land.

2) Coconut

Dynamic Constraint: The area of coconut plantation is less than in previous years. The coconut tree was replaced by oil palm tree which provides higher yield and price than coconut trees. One distinct characteristic of coconut is that it can be grown well in coastal areas, where there is sandy soil. The Ko Samui and Ko Pha-Ngan Districts have sandy soil that is suitable for growing coconut trees, which are the favourite areas for tourists. In Mueang Surat Thani and Phunphin Districts, the areas that are near the estuaries are also suitable for growing coconut trees. However, in recent times oil palm was introduced to the areas that are near the estuaries.

Maximum Principle: Cost of harvesting the coconuts is higher than previously. As a consequence, the farmers get lower profits than previously.

Portfolio Balance: The trend of the price of coconut is constant when compared to prices that are adjusted for inflation.

The conclusion for the coconut plantation is that the trend of the land use for coconut is not sustainable. However, there is a need to promote planting coconut trees in areas that are near the sea, on islands to support the tourism sector because this land is suitable for planting coconut trees. In the areas that are near the estuary, the coconut tree can grow well and can produce good yield but there is a problem of harvesting costs that is higher than previously while the coconut price is constant. These problems lead to lower profits for the farmers. In other areas, the farmers can consider the oil palm as an alternative plant to replace coconut.

3) Para rubber

Dynamic Constraint: There is an increase in Para rubber plantation area. Para rubber plantation is cultured in the same area as the previous crop, which has finished its lifespan. Some extended areas are found in the areas that used to be paddy field and in area that has no land title.

Maximum Principle: Farmers gained higher profit from planting Para rubber than previously. Apart from selling the Para rubber liquid, the farmers can also sell the Para rubber wood to the Para rubber wood factories.

Portfolio Balance: The trend of the price of the Para rubber yield is increasing when compared to prices that are adjusted for inflation.

Therefore, the Para rubber plantation tends to be sustainable. There is a need to promote the planting the Para rubber tree in the suitable area to reduce input cost problem.

4) Oil palm

Dynamic Constraint: There is an increase in oil palm plantation area in the study area. The aBan Doned area, rice plantation area, and coconut plantation area with old coconut trees are replaced by oil palm plantation. Oil palm can grow well in low land.

Maximum Principle: Farmers who changed their lands to plant oil palm can earn higher profit than previously because they can get a greater yield from oil palm than the previous plant.

Portfolio Balance: During the promotion period for oil palm planting, the trend of the price of the oil palm yield was increasing when compared to the prices that are adjusted for inflation.

Using the land for oil palm plantation tends to be sustainable. However, there is a need to promote planting oil palm in suitable areas to reduce the problem of yield because to receive high yield, water and fertilizer are required.

3.4.4.3 Problems in the production system

From the data collection about the production system of rice, coconut, Para rubber, and oil palm, which are the important products in the study area, the problems and resolutions of each production system were presented in the Table 3.4.2

Table 3.4.2 Problems in the production system and resolutions based on the farmer's demand

Type of plant	Problem	Resolution
Rice	1. Water shortage for the secondary rice farming 2. Decrease in price of rice yield	-Develop an irrigation system -Construct water reservoirs -Change the type of plant -Plant rice species that require less water -Guarantee price of rice -Promote consumption of rice from the community
Coconut	1. High cost of harvesting 2. Change of land use to other type of plants 3. Price of dried coconut is cheap	-Promote the school for monkey -Define the zones for controlling the plantations -Promote coconut processing
Para rubber	1. Money for investment in Para rubber plantation	-Develop funds for providing loans
Oil palm	1. Price of fertilizer 2. Price of oil palm 3. Long distance for transportation 4. Quantity of water 5. Suitability of land	-Promote the use of bio fertilizer -Set up fertilizer producer group -Develop central market to control the price of oil palm -Promote small and medium scales factories for extracting palm oil -Promote the oil palm plantation near areas that have water -Provide the knowledge about land use to the farmers

Source: The results from the survey

3.4.5. Recommendations

From the analysis of the production system, the problems, and the needs of the farmers, the following recommendations about the guidelines and policies for management and extension the agriculture that will be useful for the administration and management of the Ban Don Bay are presented below.

3.4.5.1 Guidelines for administration and management

1) Rice

- Develop water reservoirs and set up irrigation systems in land that is suitable for rice plantation.
- Restore the existing water reservoirs or storage and natural water habitat.

2) Coconut

- Develop the agricultural map and define measures for collaboration about coconut plantation.

3) Para rubber

- Support the Para rubber Aid Fund at the district level to administer funds for Para rubber planting.
- Develop a map of Para rubber plantation area and its extended area. Para rubber plantations should be promoted only in the area that is suitable. In the areas that are unsuitable other types of plant that are suitable for each area should be promoted.

4) Oil palm

- Train and promote the production of bio fertilizer to the farmers.
- Develop a map of oil palm plantation area and its extended area. The oil palm plantation should be promoted only in the area that are suitable. In the areas that are vulnerable to the ecosystem and the scenery, a plan and study on the impact of planting oil palm should be done.
- Provide money for loans to the community or the farmers to develop factories for extraction of palm oil from oil palm in the community.

3.4.5.2 Policy for managing agricultural extension

1) Develop a map of land suitability for agriculture.

2) Promote suitable plants to be grown in the suitable areas that are identified.

3) Prepare market and promote agricultural business.

4) Promote and provide the proper knowledge for agriculture to the farmers.

5) Provide budget and financial sources to the farmers.

3.5 FOREST PRODUCTION BASE

The study of forest production base in Ban Don Bay and offshore islands have been conducted by collecting secondary data from departments and relevant documents, which yielded preliminary results. The primary data have been collected from people resided in 36 sub-districts and 9 districts. The findings provided data for forest resources in the areas, problems and opinions on forest management. The in-depth interviews were also carried out by dividing target respondents into 3 groups: government agencies, NGOs and conservationists, and local people. For local people, this study chose people who lived in or surrounding the forests areas. The researcher employed the concept of Dynamic Constrain (DC) by focusing on how forest resources were exploited, which should have been balanced with forest resource regeneration in order to maintain sustainability of the resources.

The results were then analyzed in order to find the core problems of the communities, which will lead to solutions on sustainable forest resource management in Ban Don Bay and offshore islands.

3.5.1 Data Collection

3.5.1.1 Forest Data

In 9 districts of Ban Don Bay consists of terrestrial and mangrove forests. The mangrove forests are found adjacent to the sea or canals, but terrestrial forests are found in the inner land areas.

1) Terrestrials Forest Terrestrials forests found in Ban Don Bay areas are currently preserved in different forms. They are mostly in national reserved forests, or preserved in public lands such as temples or schools.

2) Mangrove Forest Since Ban Don Bay and offshore islands are adjacent to the sea, the majority of the forests in these areas are mangrove forests along the coastline. Few of beach forests can also be found in the coastal area. The mangrove forests in the areas are both nationally and locally reserved.

3.5.1.2 Forest Resource Status

Since Ban Don Bay and offshore islands are geographically basin areas that are adjacent to the sea, the principle forest resources are mangrove forests and wetlands. Terrestrial forests are scattered in high lands and in the mountains. Since terrestrials forests are divided because of human activities, such as concession-based logging and encroachment for

agricultural plantation, the forests have become less fertile. Mangrove forests from the initial survey in 1961 to 2004, there had been two major changes in mangrove forests in this area, as shown in Figure 3.5.1

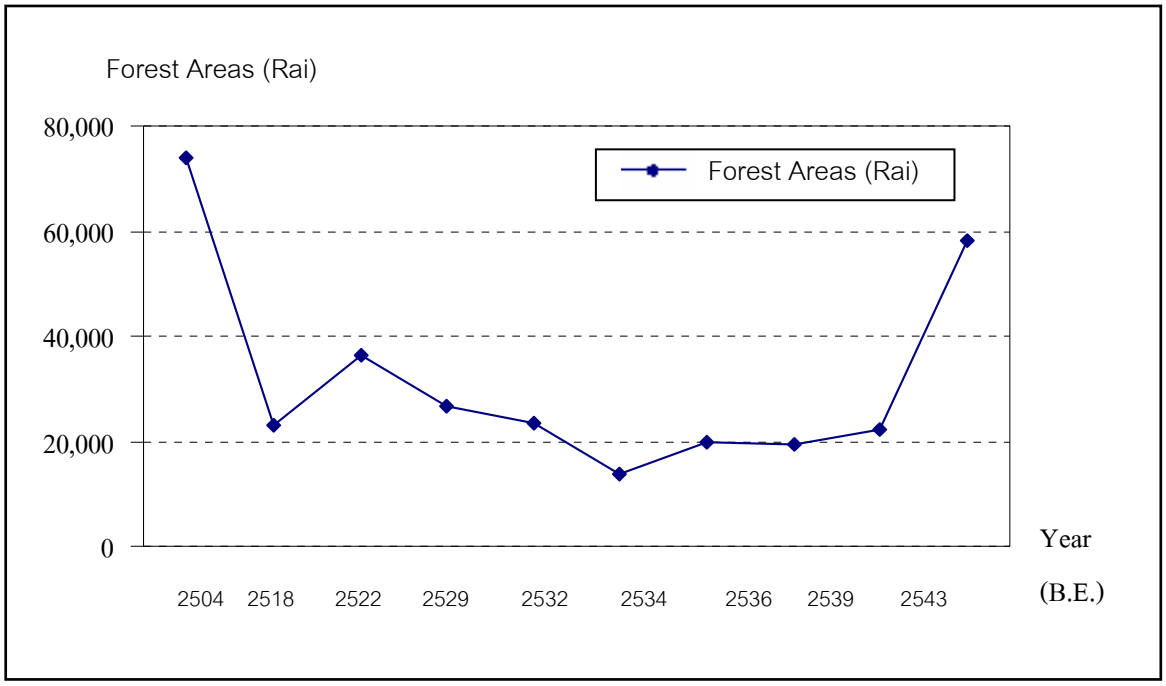


Figure 3.5.1 Mangrove Forest Areas in Surat Thani from B.E. 2504-2547 (1961-2004).

Source: Mangrove Resource Administration and Management Division 4 (B.E. 2550)

The initial period of changes for mangrove forests in this area, which occurred between 1961-1991, showed that the forest areas had decreased. In 1961, there were 73,769 Rai of the forests, but in 1991, there were only 13,775 Rai left. The changing rate was about 2,000 Rai per year. The mangrove forest declination was caused by deforestation and other exploitations, such as prawn farming, aquatic animal breeding, road construction, residential development, industrial factories, piers and fishing by using push nets in newly regenerated mangrove forests. In addition, there were natural destructions from wave and wind that caused shore erosion (Coordination Office of Environment and Natural Resources Exploitation, B.E. 2534). The second period of change had occurred between 1993-2004. The areas of mangrove forests had increased from 19,775 Rai in 1993 to 58,127 Rai in 2004.

3.5.2 Forest Status Analysis and Forest Fertility

Findings from secondary data and interviews with officials, conservationists and local people can be analyzed as followed:

3.5.2.1 Forest Status and Forest Fertility

Forests in Ban Don Bay and offshore islands, both terrestrial and mangrove forests, have continuously changed. Terrestrial forests have low fertility, because the forest areas have been divided and scattered. Forests have been destroyed by merchant capitalists. Villagers also extend their rubber plantation into the forest areas. In addition, many of the basin areas that are less fertile have been granted to local villagers. All these cause the forests to be scattered, and cannot be wildlife habitats. Most wildlife found in the area are small animals, such as monkeys, boars, lizards and birds.

For mangrove forests, because of the reduction of the forest areas in the past, communities nowadays have started to realize the importance of forest resource conservation. Villagers form a group to manage the resources such as for a sesarmid crab farming and ecotourism groups in Liled sub-district. Since the number of prawn farming has decreased, and those who still have prawn farms tend to avoid deforestation, the forests have been safe from destruction. The local communities then benefit from this. However, illegal logging and non-sustainable exploitation of the forests can still be found in some areas.

Forest conditions of problematic sub-districts that need urgent solutions can be summarized as followed:

1) Tha Chana District

The terrestrials forest area that requires immediate conservation is Khan Thuli swamp forest. Since this is the original swamp forest with biological diversity, it has been the water and food sources for local people since in the past. (Figure 3.5.2) Since the conditions of swamp forest can change, it can also be called secondary swarm forest. In this forest, the major trees are cajeput. Because of the change, cajeput has been replaced by palm plantation.

The interviews with local people showed that Tha Chana district did not have mangrove forests. However, from the survey, mangroves and nipa palms could also be found in the areas near canals and the sea. Therefore, there has been no exploitation of these trees. Since there are no vast areas of mangrove forests in this area, together with the seashore erosion, the mangrove forests are scattered along the canals. Wang sub-district does not have terrestrial forests. Few of mangrove forests can be found in the lower areas.

Figure 3.5.2 Current Conditions of Khan Thuli Swamp Forest A.) Nature Observation Center B.) Khan Thuli Swamp Forest (Pictures taken on January 3rd, 2007)

2) Chaiya District

Principle forest resources are mangrove forests in national reserved areas. At present, local people in some sub-districts, such as in Takrob, Phum Riang and Lamet, in Lamet sub-district, under the supervision of the Royal Forest Department, used to be a watershed area. However, there has been deforestation at present. In Chaiya district, the forest areas that need immediate conservation and management are the forests in Thung sub-district, Khlong Thanian Mangrove National Reserved Forest and Klong Phum Riang mangrove forest. These areas have continuously faced illegal logging and trespassing.(Figure 3.5.3) The forest areas have continuously been reduced.

Figure 3.5.3 Governor of Surat Thani Province and officers surveyed the national reserved forest in Thung Sub-district, Chaiya District on February 6th, 2007. They found forest trespassing in 17 patches (1,000 Rai of forest areas).

Source: http://www2.suratthani.go.th/ (Searched on May 20th, 2007)

3) Tha Chang District

Tha Chang district locating adjacent to the sea. The district has Tha Chang Mangrove National Reserved Forest. In Khao Than sub-district, people have formed a group called fiddler crab group. These include the knowledge about a sesarmid crab farming, food processing and marketing management. The mangrove forest conservationists also set common rules and punishment guidelines in the communities. These benefit people to have food and extra-income sources. These findings have shown that mangrove forests can be preserved in this community. Tha Chang sub-district at present, nobody burns trees for charcoals, but some areas of the mangrove forests have been changed into agricultural plantations. Mangrove forests in Tha Khoei sub-district. Villagers use trees for conservation. For terrestrial forests in the area, at present, these forests have been made into rubber and palm plantations as a result of land sharing policy for local residents. Therefore, terrestrial forests nowadays are scattered in the areas that belong to villagers with land ownership documents.

4) Phunphin District

Liled sub-district. Now there is no vast area of terrestrial forests. There are only some types of trees left. For mangrove forests, the original tree in this area is cork (*Sonneratia caseolaris)*, which has grown more in the regenerated area. (Figure 3.5.4) Villagers have corporately initiated conservation groups and ecotourism programs as a means to preserve and manage mangrove forests.

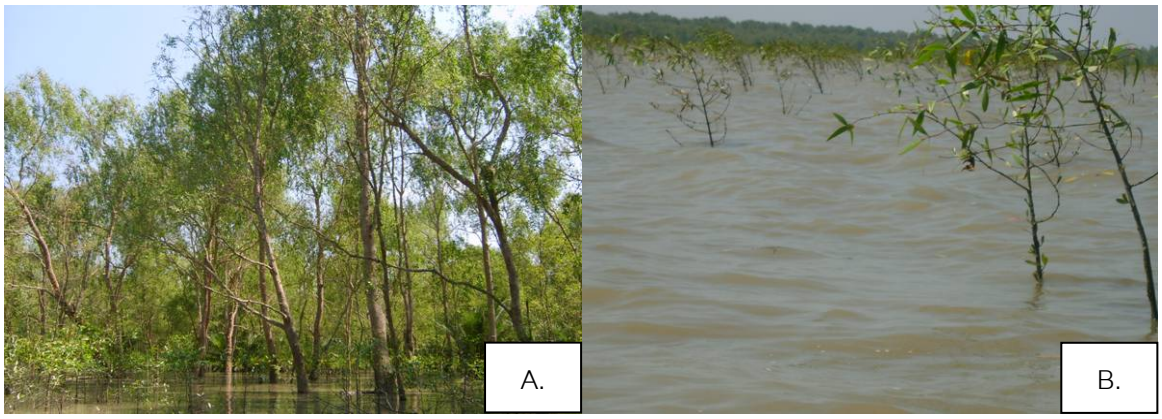


Figure 3.5.4 Mangrove Forest Conditions in Liled Sub-district A.) Original Sonneratiaforest in the area B.) Regenerated Sonneratiain the coastal area (Pictures taken on February 3rd, 2007)

5) Mueang Surat Thani District

Mangrove forests are mainly found along the canals and around the coastal area. Nowadays villagers have formed a group to preserve the forests. Therefore, mangrove forests

are likely to increase and remain in the areas. The problems of forest resources in these areas are caused by tree exploitation, especially the use of *Sonneratia caseolaris*. Currently, young *Sonneratia caseolaris* have been dug and sold. This causes the reduction of *Sonneratia caseolaris* in the area.

6) Kanchanadit District

Because of the loss of mangrove forests in the past, there have been some attempts to regenerate mangrove forests. For example, villagers have formed conservation groups. The Office of Mangrove Forest Resources Development, Division 14 (Don Sak Surat Thani) has worked together with the villagers to manage the mangrove forests in the area. Result that the forest areas are likely to increase. The mangrove forest conservation group in Moo 4. Thathong sub-district. They have built nature study trails, organized activities for forest plantation and released aquatic animals into the forest for community food sources.

7) Don Sak District

In the past, the mangrove forest declination was caused by deforestation and other exploitations, such as prawn farming and aquatic animal breeding. Nowadays the number of prawn farming has decreased, and those who still have prawn farms tend to avoid deforestation, the forests have been safe from destruction. In addition to the forests in national preserved areas, another mangrove forest area that villagers are willing to preserve is in Bon island. This area was destroyed by piers and merchant capitalists. (Figure 3.5.5) The forest in this area is an important freshwater source for the community. In the past, local people benefited from this forest. In order to preserve the forest for food and freshwater sources, urgent solutions are needed. The terrestrial forests, the trees found in high mountains. For the basin area, it has mostly been changed into rubber plantation area.

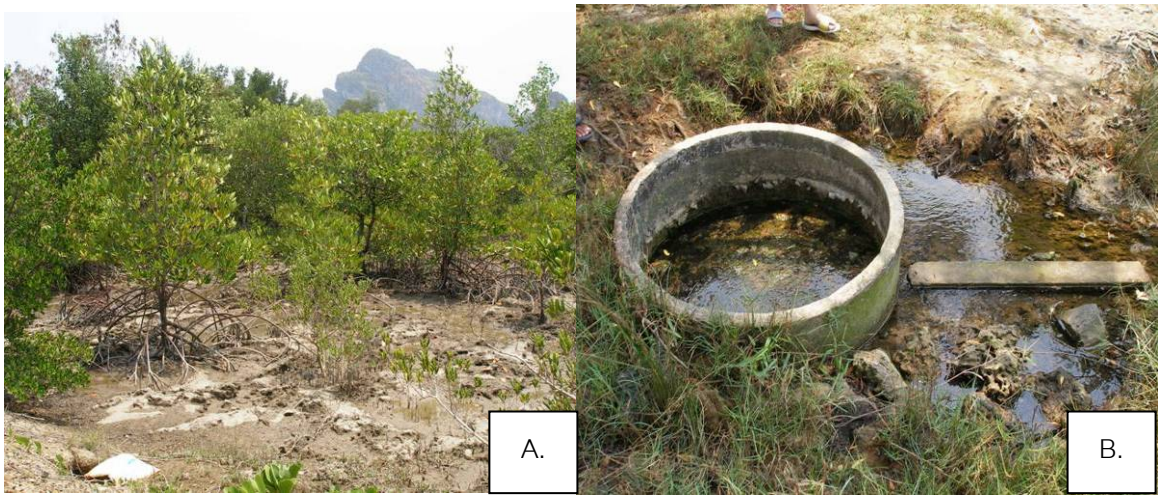


Figure 3.5.5 A.) Destructive Mangrove Forest B.) Freshwater Source in Mangrove Forests for Villagers' Consumption (Pictures taken on March 10th, 2007)

8) Ko Samui District

Currently, forest and wildlife resources on Ko Samui have been threatened by private agencies and merchant capitalists. Occupying the forests for Tourism and road construction through the watershed area cause deforestation and ecosystem degradation.(Figure 3.5.6) In addition, officials in the area lack effective coordination and cooperation in protecting the watershed forests from illegal logging and burning (Department of Public Works and Town and Country Planning, 2004). Terrestrial forests in Hinlard Waterfall National Reserved Forest and Namueang Waterfall Forest Park are biologically diverse. Therefore, government agencies and local leaders should participate in nature conservation and seriously evaluate the destruction rate of the natural resources.

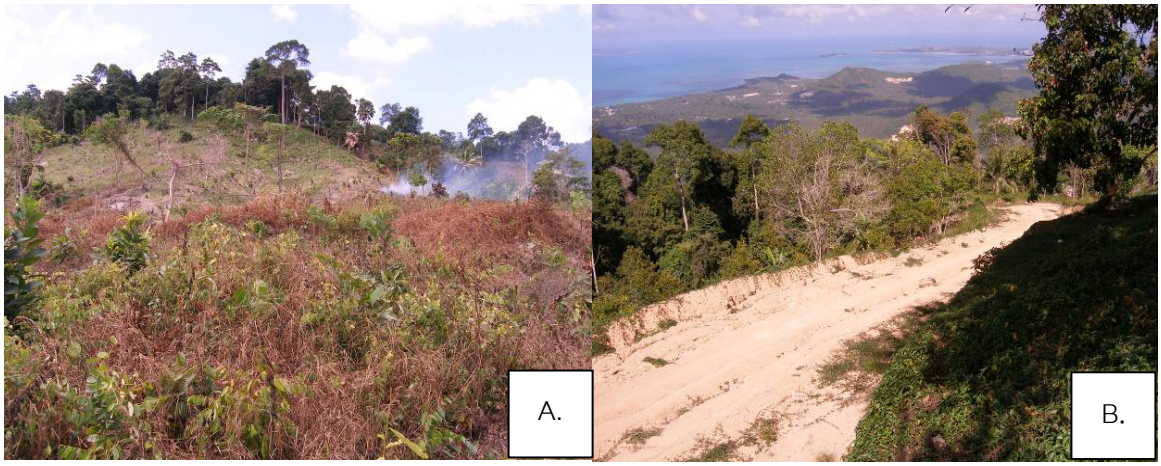


Figure 3.5.6 The Developed and Destroyed Forest Areas on Ko Samui A.) Deforestation B.) Road Construction in the Mountain (Pictures taken on February 24th, 2007)

9) Ko Pha Ngan District

Most forest areas in Ko Pha Ngan district are still fertile. Most of the terrestrial forests in this area have not been proclaimed Than Sadet Pha Ngan island National Park. Therefore, authorities cannot fully enforce National Park Act to arrest those who committed illegal logging and destroyed the forests. Besides, the forest boundary lines are not clear. Hence, it is necessary that this area be soon proclaimed a national park. Forests are not only watershed areas for Ko Pha Ngan communities but also famous tourism sites with both sea and mountain attractions. .

Most of the problems found in Ko Pha Ngan are about illegal logging, forest trespassing for agricultural plantation, and constructing facilities for tourism purposes. Another problem found in this area was digging up forest lands for burial grounds.(Figure 3.5.7) This resulted in vast areas of soil erosion and deforestation.

Figure 3.5.7 Changes of the Forest Areas in Ko Pha Ngan A.) Road Construction through Forest Areas B.) Erosion caused by Surface Soil Digging by Merchant Capitalists (Pictures taken on February 17th, 2007)

3.5.2.2 Types of Forest Exploitation

From the information, it can be summarized that the major groups of people who exploit the forest areas are from local and surrounding communities. They earn their livings by fishing in coastal areas. These include people from outside the communities. In addition, there are some merchant capitalists who encroached on forests for illegal logging.

The mangrove forests, the way people are currently exploiting the forests is different from 10 years ago. In the past, people exploited mangrove forests for different products; for example, charcoals, wood fuels, construction poles and other agricultural and fishery equipments. Nowadays, people are trying to preserve the mangrove forests for aquatic animal habitats, food sources for local communities, fishery equipments and local herbs. In addition, because of the environmental awareness, both government and private agencies pay attention to the ecosystem, which is balanced by the existence of the mangrove forests.

3.5.3 Summary and Suggestions on Forest Resource Management

From the problems found in Ban Don Bay forest areas, the sustainable forest management can be done by balancing natural resources and considering how to exploit and regenerate the forest resources. Moreover, problems found in each area should be taken into consideration for effective forest management. The situations and the level of seriousness of the problems in Ban Don Bay areas can be shown in Table 3.5.1

Table 3.5.1 Forest Situations and the level of seriousness of the problems in Ban Don Bay and offshore islands

Forest Situations and level of problem seriousness	Problems found in the area
Level 1: Areas with few problems. Forests are fertile	1. Communities can protect the forest resources. However, they still lack Support from responsible agencies.
Level 2: Areas with problems that need solutions, since problems continuously occur. Forest resources will be affected if no action is done.	1. Forest trespassing for economic plantation 2. Natural shore Erosion 3. Officials cannot entirely protect the areas/ineffective protection.
Level 3: Areas with serious problems and need immediate solutions. These areas have lost biological diversity, which directly affect communities, societies and economy	1. Terrestrial forests are reduced and destructive as a result of forest trespassing, illegal logging and constructing of houses and other facilities. 2. Plants and wildlife become extinct and result in the loss of biological diversity. 3. Forest areas decrease until the ecosystem cannot be balanced.

From Table 3.5.1, it summarizes problems that are found in Ban Don Bay and offshore islands, and ranks the problem levels in order to suggest relevant solutions to these problems.

3.5.3.1 Forest Management Suggestive Solutions

From the problems found in Ban Don Bay, collaboration is needed to find solutions to these problems. Here are some suggestions:

1) Promote and create community strength

Communities need to set up funds and support activities that promote nature conservation, including regeneration of the forest resources, wildlife and biological diversity. In addition, people should be trained and taught on how to conserve the forest, create community networks for conservation, and take advantages of local wisdom and academic knowledge on how to regenerate the forests.

For communities that already conduct activities for forest conservation, they should be continuously supported. Furthermore, social motivation and conservation awareness should also be developed. For example, villagers in Moo 1, Khao Than sub-district, Tha Chang district formed a group for a sesarmid crab farming in mangrove forests. Another example is the ecotourism group at Liled sub-district, Phunphin district.

Expected outcome: Strong community and collaboration for forest protection

2) Sustainable Forest Resource Exploitation

Nature study and ecotourism in the forest need to be promoted, including the awareness on the importance and values of the forests. Sustainable forest resource exploitation and appropriate use of technology should also be supported. One example of the sustainable use of the forest resource is wood vinegar to fulfill the needs of industrial sector.

Expected outcome: Yield forest products that are in accordance with people's needs. Forests are sustainably preserved.

3) Forest Areas Management

In forest management, the issue that needs to be taken into consideration is zoning, which should be appropriate with the ecosystem of both terrestrial and mangrove forests. Benefits that people get from the mangrove forests are in many forms. An example of the community that conducts zoning is Liled community in Phunphin district. There is a zone for aquatic animal habitat, which villagers will not catch the animals in that area. For the permitted zone, the area is fertile because of the conservative area. This increases the forest and aquatic animal food sources for the community.

Therefore, the idea of zoning should be extended to the other areas. Some areas should be preserved for plants and wildlife conservation in order to keep the areas fertile, so that young aquatic animals can be nurtured. For the permitted zone, it can be used as the buffer zone between the communities and the preserved forests.

Another way to take the most advantages from the mangrove forests and cause the least effect to these forests is the application of the multiple use system. This method is widely accepted in many countries that have mangrove forests (Sanit Aksornkaew et al., 1999). Therefore, the areas in Ban Don Bay should follow this principle in order to have sustainable mangrove forests.

One important issue is to promote community forestry. Communal forests should be set up as many as possible. Logging in the future should be done with planted forest, not from the natural or watershed forests.

Expected outcome: The widely accepted forest management that is appropriate to the forest ecosystem is established. This will benefits both local communities and the ecosystem.

4) Development of knowledge, conservation and exploitation with collaboration from every sector

This can be done by constructing the learning procedure and raising the awareness on forest and wildlife conservation and biological diversity. Furthermore, databases that support

forest management, such as information databases and forest maps should continually be updated and precise. They are necessary tools for keeping up with changes of the forest areas. They can also be used as authorized references and law enforcements.

Expected outcome: Every sector is knowledgably equipped with current information databases that can be effectively used for forest management.

5) Forest protection for sustainable preservation and exploitation

This method of forest management aims to effectively improve the procedure of forest protection and arresting those who trespass and destroy natural resources. It also supports the application of knowledge and modern technology for forest protection. In addition, it attempts to create and develop alliances and networks of collaboration in every sector, establish procedure for natural disaster protection, evaluate and enforce the laws.

Expected outcome: There are alliances, organization networks, modern technology and equipments to protect the forests; and enforce the laws.

6) Forest resource regeneration

The destructive forest should be regenerated to improve the forest and wildlife ecosystem and the biological diversity for the sustainable forest resources, especially the areas that are trespassed for illegal logging and agricultural plantation. Hence, clear solutions are needed for forest regeneration and improvement. It should be noted that careful study of the impacts and methods is needed before any decisions can be made.

Expected outcome: The balance of the forest ecosystem and biological diversity

3.5.3.2 Suggestive Solutions for Forest Management in each sub-district of Ban Don Bay and offshore islands.

These solutions are the results of careful considerations of the problems found in each area. These problems are varied and have different levels of seriousness. Therefore, in order to directly solve the problems, the following 3 suggestive solutions are needed:

Solution 1 This solution is for the forests with Problem Level 1, that is the forests that are still fertile and have slight problems. The solutions are:

1) Promote and create community strength

2) Sustainable Forest Resource Exploitation

3) Forest Areas Management

The expected outcomes from this solution are the promotion of community strength and collaboration for forest conservation. It will also yield forest products that meet the peoples' needs. In community management, responsible agencies should set up zones and guidelines

that are appropriate to the forest ecosystem and are accepted among different sectors. This type of forest management will support both local communities and the preservation of the forests.

Solution 2 This solution is for the forest with Problem Level 2. The forests in this area have problems that require solutions, since the problems continuously occur both directly and indirectly. Forest resources will be affected if no action is done. The suggestive solutions are:

1) Develop and raise awareness on forest conservation and exploitation with collaboration from every sector
2) Promote and create community strength
3) Sustainable Forest Resource Exploitation
4) Forest Areas Management
5) Forest protection for sustainable forest preservation and exploitation

These solutions added the development of knowledge and awareness raising on forest conservation and exploitation among communities and responsible agencies. The idea behind these suggestive solutions is that one of the causes for destructive forests is people's inadequacy of knowledge. It also aims to increase the effectiveness of forest protection and preservation. Responsible agencies should be ready in terms of officers, vehicles and budgets, etc.

Solution 3 This solution aims to deal with the forest areas that face harsh problems, and immediate solutions are required. These forests have lost biological diversity, which directly affects communities, societies and economy. The solutions are:

1) Develop and raise awareness on forest conservation and exploitation with collaboration from every sector
2) Promote and create community strength
3) Sustainable Forest Resource Exploitation
4) Forest Areas Management
5) Reforestation for the balance of forest resources
6) Forest protection for sustainable forest preservation and exploitation

The six solutions above will be integrated in order to balance forest production and exploitation. Some of the main problems found in these forest areas are the loss of the biological diversity and the ecosystem. Reforestation is needed for the balance of the natural resources. Royal Forest Department and other responsible agencies should assign specific officials who

can closely protect these forests and create understanding and support from the majority of the people in the areas.

For the forest areas in Ban Don Bay and offshore islands in 9 districts and 36 sub-districts, the researcher has collected the problems and provided suggestive solutions for sustainable forest management. Each area should follow different solutions, as shown above. The summary of the forest management in each community can be shown in Table 3.5.2

Table 3.5.2 Summary of Forest Management Solutions in Ban Don Bay and Offshore Islands in Each Sub-district

Location	Management Solutions			Notes
	Solution 1	Solution 2	Solution 3	
1.Tha Chana District				
Khan Thuli Sub-district			✓	Khan Thuli Swamp Forest
Tha Chana Sub-district		✓		Tha Chana National Reserved Forest
Wang Sub-district	✓			No preserved forests
2.Chaiya District				
Takrob Sub-district		✓		Mangrove forest
Talat Chaiya Sub-district				No forest areas
Thung Sub-district			✓	Khlong Tha Nian Mangrove National Reserved Forest and Klong Phum Riang Mangrove Forest
Phum Riang Sub-district			✓	Khlong Tha Nian Mangrove National Reserved Forest and Klong Phum Riang Mangrove Forest
Lamet Sub-district			✓	Khao Phut Thong National Reserved Forest
3.Tha Chang District				Nam Khem Tha Chang Mangrove National Reserved Forest
Khao Than Sub-district	✓			
Tha Khoei Sub-district		✓		
Tha Chang Sub-district		✓		

Table 3.5.2… (continued)

Location	Management Solutions			Notes
	Solution 1	Solution 2	Solution 3	
4.Phunphin District				Original and regenerated Sonneratia forest
Liled Sub-district	✓			
5.Mueang Surat Thani District				
Khlong Chanak Sub-district		✓		Mangrove Forest
Talat Sub-district		✓		Mangrove Forest
Bang Kung Sub-district		✓		Mangrove Forest
Bang Chana Sub-district		✓		Mangrove Forest
Bang Sai Sub-district		✓		Mangrove Forest
Bang Baimai Sub-district				No forest areas
Bang Pho Sub-district				No forest areas
6.Kanchanadit District				Don Sak Mangrove National Reserved Forest
Kadae Sub-district			✓	
Takhianthong Sub-district		✓		
Thathong Sub-district			✓	
Tha Thongmai Sub-district			✓	
Plaiwat Sub-district			✓	
7.Don Sak District				Don Sak Mangrove National Reserved Forest
Chonkhram Sub-district		✓		
Chaikhram Sub-district		✓		
Don Sak Sub-district			✓	

Table 3.5.2… (continued)

Location	Management Solutions			Notes
	Solution 1	Solution 2	Solution 3	
8.Ko Samui District				
Ang Thong Sub-district			✓	Hin Lard Waterfall National Reserved Forest Mu Ko Ang Thong National Park
Lipa Noi Sub-district				No forest areas
Taling Ngam Sub-district				No forest areas
Na Mueang Sub-district			✓	Na Mueang Waterfall Forest Park
Maret Sub-district				No forest areas
Bo Phut Sub-district		✓		Ban Bangrak Mangrove Forest
Maenam Sub-district				No forest areas
9.Ko Pha Ngan District				Areas to be proclaimed Than Sadet Pha Ngan Island National Park
Ko Pha Ngan Sub-district		✓		
Ban Tai Sub-district		✓		

In summary, the suggestive solutions shown above should be applied during the period that problems occur. If there are changes in the forest areas, solutions should be adjusted in accordance with the problems found. In addition, forest management needs careful study to ensure suitability with current situations.

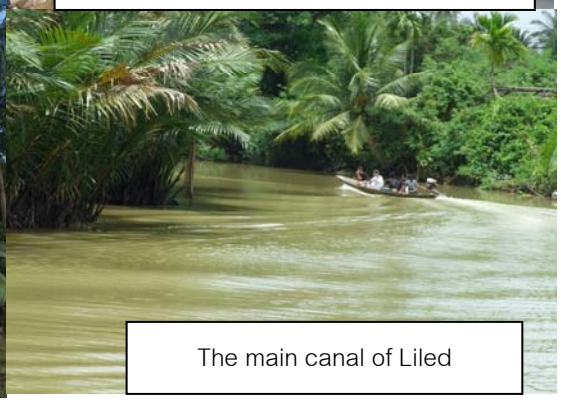
3.6 TOURISM PRODUCTION BASE

The analysis and examination of tourism production base of Ban Don Bay and offshore islands covered 36 sub-districts in 9 districts of Surat Thani Province and Phaluai Island could be categorized through Tourism Area Life Cycle. Dynamic Constraint under the Optimal Control Theory was used to find out the vulnerability and sustainability of tourism production system. The data was collected from tourism departments' documents, focus group, in dept interview, and observations.

Ferry Port of Pha Ngan Island

In depth interview with the leader of

Pha Ngan Island Environment



The main canal of Liled

According to the study of tourism production systems of Ban Don Bay and offshore islands by using Dynamic Constraint Analysis under Optimal Control Theory, the following tables show the distinctive tourism product and the venerability of tourism area.

Study Area	Distinctive tourism product	Venerability of tourism area	Recommendations
Tha Chana District	There are natural and cultural tourism areas, especially at Boyee and Somred beaches. Tourists come to relax and eat at small restaurants.	Lacking of tourism facilities. Comparing with other areas, the tourism attractions are not attractive enough.	It should support nature education study center and cultural tourism, and make linkage traveling route with to other areas.
Chaiya District	Cultural tourism areas are prominent.There are religion tourism areas as in Suan Mokkh International Monastery. For community's products, Phum Riang silk is famous.	Phum Riang orginal unique silk is disappearing due to lacking of followers.	To develop sustainable tourism of Chaiya is to remain area statuses, and sustain product quality such as supporting weaving silk profession.
Tha Chang District	The tourism areas are not distinctive.	Tourism market is still small. The evidence is collected from the hotels which went out of business.	If tourism areas in Tha Chang are supported, it could be developed into a gateway through other parts of the province.
Phunphin District	Liled community tended to develop tourism in ecotourism management system due to its potential resources, management, strong leader, and readiness of management as shown in Liled tourism management information in the following case study.	Increasing of water pollution in canals and rivers.	To promote tourism as an initial area of community base ecotourism management and use tourism as a tool to conserve natural resources.

Study Area	Distinctive tourism product	Venerability of tourism area	Recommendations
Mueang Surat Thani District	Tourism is as as ecotourism form and able to be connecting attractions to others, for example, tourisms can make one to two days eco-tourism trip. Moreover, there are sufficient accommodations to stay overnight before journeying to Samui Island.	Lacking of funding to support tourism promotion.	Build up tourism network with other districts and do public relation about tourism attractions continuously.
Kanchanadit District	Its tourism tendency is in ecotourism form due to its plentiful resources especially mangrove. Moreover, there are seafood in Kadae, Tha Thong Mai and Takhian Thong sub-district where are oyster culture. Aqua animal is a tourism affinity.	Lacking of area development and tourism promotion.	To promote farm-stay tourism and mangrove study.
Don Sak District	There are various tourism such as beaches, community life style, mangrove, aquaculture, swallow bird nets, and agriculture.	Lacking of tourism management guideline.	To train tourism management in community.

Study Area	Distinctive tourism product	Venerability of tourism area	Recommendations
Ko Samui district and surrounding Island, Phaluai Island.	In overall, tourism in Ko Samui is in highest developed level. There are up-to-date facilities which obviously fulfill tourists' needs. There is highest physical changing, more new hotels construction. There are many accommodations on the beach area. Ko Phaluai which is the surrounded island of Ko Samui is wealthy of various marine sources. It will be analyze to be a potential sustained tourism attraction in the future.	In particular, Chaweng beach is a tourism center of the island. It is the most crowded beach. Its natural condition is changed by the increasing of tourists. There are environmental, economic and social problems in tourism areas. Therefore, we have to analyze Maximum Principle and Portfolio Balance to consider venerability and sustainability of tourism base and tourism entrepreneurs.	Details of recommendations are revealed in Ko Samui District case study.
Ko Pha Ngan District	Evolution of tourism area is in development step. There is development of facilities to meet the tourism market needs and some places in the island were changed to tourism accommodation.	There are problems from increasing of tourists such as, more solid waste, changing of old local culture, and more crimes. We have to analyze what is the venerability and trend to sustainability from focus group, involved researches, and secondary information from government sections and private organizations.	Details of recommendations are revealed in Ko Pha Ngan District case study

Diversity of ecosystem and remaining of original tourism area in Pha Loey Island.

Vulnerability and Sustainable Tourism Production System Analysis

Case study: Exploration Tourism Area at Phaluai Island (Ko Phaluai)

There are various outstanding places on Ko Phaluai. For example Sam Bo Cave is very beautiful and vast cave with the length approximately a kilometer. In the earlier period this cave was extremely important for inhabitants on this island. Due to the water from the cave flowing down, that is for the inhabitants consuming in their living. In the East of the island there are several small white sand beaches such as Had Song Pee Nong that used to be a part of Pee Ser Samud Movie, Had Ta Yo, Had Son and so on. However, the vulnerabilities of Ko Phaluai is the Inhabitants have no right to be landowner and do business such as restaurants and accommodations because most of them are the immigrations from Samui Island and they still have no sense of belonging the resources.

Then, the way to develop and sustain tourism destination at Phaluai Island are as follows.

- To encourage the inhabitants working as a union.
- To promote the knowledge of the tourism management for the inhabitants.
- To facilitate public utilities.

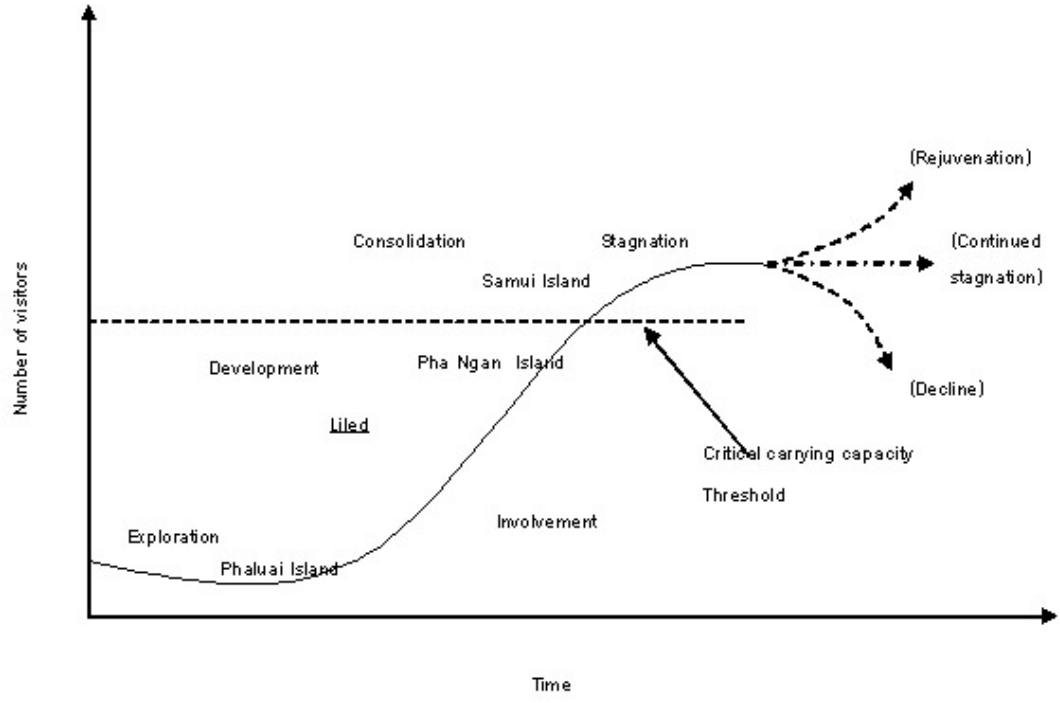


Figure 3.6.1 The positioning of tourism areas that are selected as the cases study

Vulnerability and Sustainable Tourism Production System Analysis

Case study: Involvement tourism area and moving to the step of development tourism area at Liled sub district, Phunphin District

At Liled, there are mangrove forest with perfect diversity of ecosystem, strong community group, and strong leader of community. Moreover, the community has been supported by REST association to develop their tourism. However, they are still lacking of tour guide skill, international language skill, local wisdom promotion, and standard infrastructures

The outstanding position of village is the attractions of ecotourism that mean mangrove forest, historical park, working group at home and good relationship witan community and to visitors.

The interesting of natural resources and culture are new emerging mangrove forest in the area 3,000 rai and rare art that is called Likepa.

Communities grouping are formed as tour operation group, home stay group, boating tour group, and household working group.

Figure 3.6.2 Photos from Thairat Newspaper, no.17981 on Sunday April 15, 2007

Internal conflict of community has not happened yet

Community production are based on fisherman and agriculture

Critical problems and community's needs are lacking of water resource solid waste, communication between tourists and villagers, finances, and rights for taking into custody.

Then, the ways to develop and sustain community base ecotourism at Liled are as follows.

- To encourage basic public utilities such as providing water supply system in the village, improving the road condition into home stay and providing solid waste eradication system

- To promote how tourism can support local resources conservation to the community.
- To promote the connection between tourism in their community and other neighbor area. Also contribute the understanding with the member in the community.
- To continuously create the tourism marketing such as marketing position, product development and public relation.

Implications of tourism development at Liled can be divided in 4 parts:

1) Tourism Activity

- To enhance growing the mangroves, bird-watching, grab shells during the water descent

2) Accommodation

- To increase the home stay member
- To emphasis on the hygienic and home stay quality standard

3) Food & Beverage

- To highlight local food (not too spicy)

4) Tour guiding

- To require the tour course such as language and speaking
- To reduce the noise from the boat engine

To increase the security

Vulnerability and Sustainable Tourism Production System Analysis

Case study: Development tourism area at Ko Pha Ngan District

There was a study of Ms. Thipkesorn Nuansri and party during 2-28 February, 2007 found out factors that affects tourists' behavior on Pha Ngan Island concerning on Sea Sun Sand and Sex tour. This collected information from 400 foreign tourists by face-to-face interview. From this study, it found that most tourists were male between the aged of 15 and 34, from England, Australia, Canada, German, Sweden and America. Their revenues were between 15,000 and 35,000 bath a month. And the most favorite activity was sun bathing with 42.86%, sand was the next factor in relaxation and doing other activities on the beach with 29.77%. Thirdly, sex mean to all kinds of entertainment, like Full Moon Party, Sex tourism and other entertainment in 16.06%. Lastly, sea factor was for snorkeling, diving, kayaking, skiing and parachute only 11.31% of all tourist activities.

From the above, it revealed that relaxation and sunbathing purposes were the significant factors contributing foreign tourist traveling to Pha Ngan Island. However, Full Moon Party was one of imperative effects in tourism economic growth. From interview with Full Moon Party planner, he said that there were at least 3,000 tourists per night joining the party, most of them were foreigners. Revenue was a minimum of five million baths per night from selling liquor, alcohol drinks, beverages and drugs. Furthermore, Black Moon Party (once a month) and Half Moon Party (twice a month) were offered with the ticket fares: 500 bath for foreigner and 300 bath for Thai. Total amount of participants were approximately 1,500 people a night.

Jatupol Chujan (2003) quoted to the problems of tourism on Pha Ngan Island as following:

1) Changes of natural environment, seasons including global situations have affected the decline of the number of tourists.
2) Atmosphere and other resources that contributed the tourism growth were diminished as a result of misunderstanding in tourism management and natural conservation tourists.

To sum up, the vulnerability of tourism product system at Pha Ngan Island were from:

1) It was lack of efficient controls in major number of business and enterprises. As a result of that, scenery and beach sides were destroyed and exploited.
2) It was no standard solid waste incinerator. With increasingly solid waste around the island, they destroyed gorgeous scenery.

3) After booming in tourism, new immigrants have increasingly moved in. That refers to less conservation awareness on their new homes.
4) Tourist activities were not various to attract more high quality tourists. From the survey and questionnaire, it found that most tourists admired in gorgeous scenery and sunbathing. Full Moon Party is also another significant attraction.
5) Drugs were found in Full Moon Party, Black Moon Party and Half Moon Party have been mentioned into one of major problems.
6) Villagers have continuously sold their own lands to capitalists for constructing hotel accommodation.

Therefore, to maintain sustainable ecotourism on Pha Ngan Island the significant issues should be realized as following:

1) Building construction should be systematically controlled.
2) Solid waste collection should be more standard.
3) Consciousness on environmental conservation and local resources should be educated.
4) Cultural tourism and activities should be promoted.
5) Buildings and other constructions along the beachside should be out of sight.

Remark

To boost up the sustainable ecotourism on Ko Pha Ngan, administrative and local developers should revise Samui case study because of similarity of tourism transformation

Road system at Pha Ngan Island

Beautiful and clean beach at Pha Ngan Island

Vulnerability and Sustainable Tourism Production System Analysis

Case study: Consolidation and Stagnation Tourism Area at Ko Samui District

Mass tourism can bring Ko Samui into many problems such as environment problem, economic problem and social problem in tourism area. If it was like that, Samui District would go into declining stage, or continued stagnation or rejuvenation stage of tourism area development. Then, to forecast the vulnerability and sustainable tourism production system at Ko Samui District based on Optimal Control theory can be analyzed as following:

Maximum Principle of Samui District studied the term of the producer from hotel business and tour operators. It can be identified that there is high potential expansion in both hotel business and tour operators with an excellent satisfaction in profits. But in the long term, the main issue should be highlighted on tourism resources on the island.

Principal hotel businesses have been developed and built up in order to serve the tourists. Most business owners were recognized as outsiders. Majority of hotels on the island were classified as fifth level, which is the price lower than 500 bath / night, running by local residents. From this reason, it related the service potential or consumers' future trend or the type of backpacker tourist who still consumed the low price tourism products without considering the quality. Therefore, future plan should be considered to the resources conservation in tourism.

After discussion, most luxurious hotels with minimum 2,500 bath per night were satisfied with not only the large number of tourists but also the length of stay increased. Hence to add high value into hotel business all kinds of facilities will go on the improvement and enlargement such as swimming pool and spa. Nevertheless, the growth of hotel business without controls has faced to price competition. Even though the room rate increases every year, hotel renovation are very costly. In order to reduce the cost, other divisions are cut down to reduce costs, for instance recruitment and wages. On the other hand, especially low wages can affect to lower standard in quality and working skills.

In tour operation sector, most businesses are still owned by local residents. And their business are just operated and engaged in the local area. Problems and constrains are the great number of competition in the travel business gradually more. This leads to make the price of the tour program drop. Refer to the tourist attractions on the island; there are still lots to response the tourists from the business owners' opinion. On the other hand, local cultural tourism has not been promoted. Labor costs are not the main problems for some tour operators as they don't need many employees. Also they are operated by the owner directly.

Study of tourists' satisfactions to tourism products and environment resources to value the price from interviewing the samples of hotel business sector, tour operators and the tourists who were traveling on the island during April 2007, 55 Thai tourists and 166 foreigners, it shown that values of tourism depend on natural resources such as beaches and marine life. The main reason for Thai tourist traveling on Samui island is for relaxation and sightseeing, 37%, and entertainment, 19%. For international tourists is counted in 22% for relaxation and sightseeing and 19% for shopping. Most international tourists expend 30.56% for accommodation, on the average of 795.13 baths per person in 2005 and rose to 31.62% on the average of 842.86 bath per person in 2006. For Thai tourists, most expenditure is accommodation and then was shopping. The accommodation was identified into 24.73% on the average of 551.29 baths per person in 2005 and rose to 27.30%, on the average of 568.32 per person in 2006. Shopping was 25.33%, which was 568.97 baths per person in 2005 and declined to 21.15% with 440.46 baths per person in 2006

It can identify that the most valuable resource attracted the tourist is natural resource. As this study found that the tourist attractions on Samui Island was determined by the international tourists as very satisfaction, by Thai tourists as the most satisfaction. Moreover most revenues from tourist expenditure in Samui District were from accommodation and souvenir shops.

Portfolio balance of Samui Island was a study of balance between tourism resources and producers or users to find out the real value of resources. But there were some limitations founded out from interviewing about the value of business property. Thus analysis based on opinion questions was chosen. It could be summarizing that room rate and tour package price were rising every year. That might be caused from the high transportation cost. Anyway the tour operator and hotel business can be constantly run.

Dynamic Constraint of Samui District was analyzed into resources in the tourism production base. These natural tourism production bases still existed while human made production like hotel accommodation have been growing. Moreover, the numbers of rooms are still increasing to support the mass tourism especially in 2006 there were 1,030,523 visitors to this island and gradually increased within 11 years in 2.7%.

Yet the tourism value in the district dropped as the significant factor was from the hotel construction and buildings without controls. Due to tourists' pessimistic opinions, they emphasized on the terrible environment around the district, for example, noises, dust from constructions and flooding on the road because water flowing way was blocked by the hotel construction.

Considering the balance of tourism production base on Ko Samui from the number of sustainable resources and limited tourism activities, the number of accommodations were increasing and response the tourists' satisfaction. Those mean to the tourism production base in the balance of Dynamic Constraint was still stable. On the other hand, some weaknesses were made out as following: the concept of nature conservation that nature attractions were destroyed by the tourists, the increase of solid waste under low quality eradication, including threats from influence people cheating the taxi charges. Those made the tourists feel less confidential in security.

In conclusion, the weakness of tourism production base on Ko Samui counted on the management system. That was the controls of number of building, construction, design, and other regulations such as taxi system, the standard of tourism and service staff.

Therefore, to maintain the tourism production base on Ko Samui all concepts should be regarded as

1) To evaluate the environmental impact before building any kinds of big constructions in Samui District.
2) To control and advise the waste treatment for small hotel enterprises.
3) To encourage the training for employees to develop the skills as professional in service and tourism. And to be more efficient and focus on international standard were also imperative issues.
4) To evaluate abilities for mass tourism in the future
5) To develop solid waste eradication
6) To launch the rules and regulations to control the taxi and local taxi charges by setting up the price standard.
7) To promote tourist activities by revitalizing traditional living style like coconut production business based on community participants.
8) To promote more tourism public relation.
9) To support and develop local products to sell to tourists.
10) To preserve natural and cultural attractions.
11) To design the places as the public area for community's purposes like relaxation and meeting points.

The routine situation at Samui ferry that receive a lot of tourists to Ko Samui District

Conclusion Implication of Tourism Production Economic System Development at Ban Don Bay and offshore islands

In conclusion, the tourist attraction at the area of Ban Don Bay and offshore islands and the implication to develop the tourism area can be categorized by the evolution of the tourist attraction as follows:

Evaluation step of tourism area:Area	Tourism Area Characteristics	Implication
Exploration Tourism Area: Khan Thuli, Wang at Tha Chana District Kao tan, Tha Khoei, Tha Chang at Tha Chang District Takrop, Thung, Talat Chaiya at Chaiya District Lamet, Chonkhram, at Don Sak District Chaikhram, Thathong at Kanchanadit District Bang Pho, Bang Sai at Mueang District Ko Phaluai at Ko Samui District	These areas are some traditional tourist attractions such as temples and small beaches where are as a local travel. These tourist attractions have not been changed and damaged; yet, no one manage them for the tourism. Also, the local do not participate to develop the areas.	• To look for outstanding tourist attractions to develop as “Unseen Thailand”. • To promote the tourist attraction by connecting with high potential tourist attractions. • To build a cooperative procedure from the community for tourism management.

Evaluation step of tourism area:Area	Tourism Area Characteristics	Implication
Involvement Tourism Area: Tha Chana at Tha Chana District Phum Riang at Chaiya District Don Sak at Don Sak District Tha Thongmai, Thakhian tong, Kadae at Kanchanadit District Bang Chana, Khlong Chanak, Bang Baimai at Mueang District Liled at Phunphin where still in the second step of involvement tourism area but moving to the third step of development tourism area.	The tourist attractions in these areas are very interesting among tourists. Although, the tourists flowingly come, it is not a large number when compares to whole area in Surat Thani province. However, these areas have been primarily developed a public utility.	● To support the knowledge about the tourism management and the tourism management in the local area such as training of tour guide, meaningful transmission of the tourism, the development of the tourism attractions, etc. ● To support the knowledge about services of tourism management such as the training of accountancy, residential reservation, service of personnel management, etc. ● To capital support to public utility development ● To support realization about the tourism management by the community and they have to realize that the tourism is like a tool to support the income, also have to preserve the local resources, and develop the life quality

Evaluation step of tourism area:Area	Tourism Area Characteristics	Implication
Development Tourism Area: Ko Pha Ngan District	The tourist attractions in Ko Pha Ngan district are during the process of public utility development in order to be more modernized. There is the construction of hotels and residences to meet the tourist market requirement; additionally, there is the internal change in some area on the island. On the other hand, the tourist inbound flow influences the community in the factor of used water sufficiency and living area sufficiency. Conversely, some tourism entrepreneurs on the island require an airport construction to attract more tourists.	● To study about potentiality of physical support of the tourist attraction on Ko Pha Ngan, define real estate plan on the island, and lay down measures to control building design and environment appropriate for the island condition. ● To develop natural tourist attractions where currently exist to be most remain. ● To specify the market target for tourist enlargement, especially highlight on Niche Market Group who pays attention to natural tourism in the community. ● To develop the basic structure to proper and harmonize with the natural tourist attractions. ● Develop an extra tourist attraction, especially folkway restoration to be a selling point. ● To support the tourism investment for the community. ● To support the realization and cooperation between

Evaluation step of tourism area:Area	Tourism Area Characteristics	Implication
		government sector and private sector to preserve natural tourist attractions.
Consolidation and Stagnation Tourism Area: Ko Samui District	Particularly, Chaweng beach where locates in Bo Phut sub-district is now very interesting. Nevertheless, from the interview of the community, the entrepreneurs, and the tourist tends to be unsatisfied the crowded because of the tourist and the area support increase. In Ko Samui district, the entrepreneurs are satisfied in the turnover; however, there are important problems caused by the growth of the tourists that are solid waste problem, the building disturbs the scenery, and flood problem on the island because the hotel construction block off the waterway.	To Integrate development implementation of 4 sectors private sector, community sector, government sector, and tourist. (More detail see full report)

3.7 URBAN EXPANSION BASE

3.7.1 Introduction

The expansion of community will be varied in accordance with the increasing number of population in that particular area, which results in some changes such as the need of four necessities, the immigration, the emigration, the congestion, the striving for resources, and the convenience from public utility development. Some of these changes cause the lost of opportunity to gain benefit from the resources in that community, for example the transferring of land possession, the land invasion for economic purpose, and the unsustainable utilization of resources, which are the impact of human being's behavior. Hence, to obtain the sustainable utilization of resources, the attention and the study of community expansion are necessary.

Ban Don Bay and island beyond the coast in Surat Thani Province not only possess a variety of natural resources such as muddy shore forest, seagrass, and coral reef, but also are dwelling, spawning, curing embryo place and are the source of food for all kinds of aquatic animals. Moreover, they are the places for fisheries, for breeding aquatic animals, and for tourism. As a result, there is a continuous expansion of community in these areas.

In 2004, the district, in Ban Don Bay and the island beyond the coastal areas, having the most population is Mueang Surat Thani District, then Kanchanadit District, Phunphin District respectively, and Ko Pha Ngan District is the least populated region.

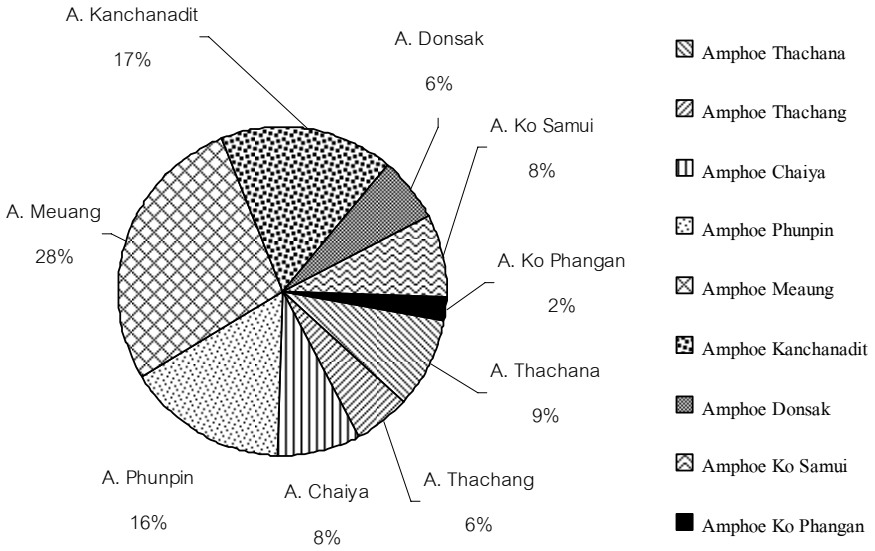


Figure 3.7.1 circle diagram showing the dissemination of population in studying area at district level for the year 2004.

3.7.2 Population Information and Community Expansion

3.7.2.1 Overview of Community Expansion

Surat Thani Province is one of the provinces in upper south of Thailand, which are compose of Chumphon, Phangnga, Krabi, Nakhon Si Thammarat, and Surat Thani. Surat Thani, itself, has 12,891.41 sq. km, and 963,846 populations. The district having the most population is Mueang Surat Thani District, Kanchanadit District, Phunphin District, and Nasaan District respectively, and Ko Pha Ngan District is the least populated region (Figure 3.7.2)

In the area of Ban Don Bay, which is the place for this study, the variety of resources is suitable for fisheries, for breeding aquatic animals, and for tourism. Consequently, more people come and make use of resources in the region. Of each district in studying area, the average increasing population number per year from the year 1996-2004 reveals that Ko Samui District has the highest average increasing rate of population per year from the year 1996-2004 (1,466 people per year), then the Mueang District (1,038 people per year), Tha Chana District (879 people per year), Kanchanadit District (717 people per year), Chaiya District (566 people per year), Ko Pha Ngan District (349 people per year), Tha Chang District (333 people per year), Don Sak District (310 people per year), Phunphin District (20 people per year) respectively, especially Ko Samui District and Ko Pha Ngan District tending to have higher rate of population increment.

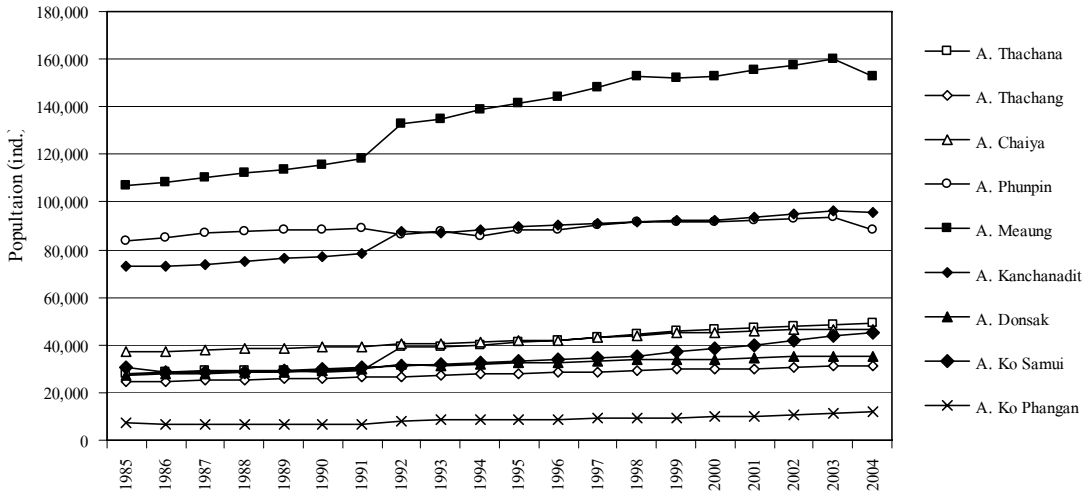


Figure 3.7.2 Graph showing number of population in each district of Surat Thani Province from the year 1985-2004

Source: Town Plan Information Center and the Administration of Surat Thani Province

When considering the rate of community expansion in the studying area of Ban Don Bay from the year 1985-2004, number of population tends to increase whose average rate is 1.53% compare to those of last year (Table 3.7.1)

Table 3.7.1 showing rate of population change in Ban Don Bay area from the year 1985-2004

District	Average rate of population change compare to last year's
Tha Chana District	3.20
Tha Chang District	1.26
Chaiya District	1.24
Phunphin District	0.30
Mueang District	1.93
Kanchanadit District	1.47
Don Sak District	1.32
Ko Samui District	2.20
Ko Pha Ngan District	2.63

Source: Town Plan Information Center and the Administration of Surat Thani Province

From the year 1996-2004, birth rate is more than death one, which average 10 - 5,109 people per year, immigration rate is higher than emigration one, average 79 – 977 people per year, except Mueang District having less immigration rate than that of emigration (Table 3.7.2)

Table 3.7.2 showing the average difference between birth-death, immigration-emigration from the year 1996-2004

District	Average difference between birth-death (people)	Average difference between immigration-emigration (people)	Naturally increased of population more than immigration
Tha Chana District	151	997	X
Tha Chang District	79	223	X
Chaiya District	253	257	X
Phunphin District	196	308	X
Mueang Surat Thani District	5,109	-2,468	/

Table 3.7.2… (Continued)

District	Average difference between birth-death (people)	Average difference between immigration-emigration (people)	Naturally increased of population more than immigration
Kanchanadi District	407	568	X
Don Sak District	207	79	/
Ko Samui District	724	544	/
Ko Pha Ngan District	10	273	X

Source: Town Plan Information Center and the Administration of Surat Thani Province

3.7.2.2 The Expansion of Community in Studying Area

In this study of community expansion around Ban Don Bay area, we have collected all the population information which is number of male and female population, density of population per sq. km, career and side occupation, and religion. Furthermore, we also based on Tambon adjacent to the coastal line in Ban Don Bay to present the problem that the population in the area has encountered, which are in village and Tambon lever information (studying area of the project)

- The density of population in the area: from the Tambon level information, we can divide the density of population into 2 groups: which are group of Tambon having more than 100 people/sq.km of average population density per area and Tambon having less than 100 people /sq. km. of average population density per area. (Details of number of male and female population, number of household, size of land, and average income of each Tambon can be read from full report, Expansion Base of Community part). It's noticeable that community of the area having more than 100 people/sq. km average density level mostly is downtown. Majority of population is merchants and has other side occupation. On the other hand, community of the area having less than 100 people/sq km. average density level is not as densely as that of downtown, majority of population is farmers and fishermen.

The highly populated region is the area containing more than 200 people/sq. km density level, mostly are Tambons in the tourism area such as Ang Thong Tambon in Ko Samui District which has 318.93 people/sq. km of average population density per area, and Lipa Noi Tambon in Ko Samui District having 416.26 people/sq. km of average population density per area. (For more details, please read from full report of Coastal System Analysis: rban Expansion Base)

- Problem of community: the characteristics of the problem in each region are nearly the same, which we can divide into 3 major problems as the problem of occupation and income, the problem of fundamental public utility, and the problem of polluted environment. (For more details of Tambon level, please read from full report of Coastal System Analysis: Urban Expansion Base)

3.7.3 Result of the study

From the secondary information gathering from communities in the area and the Focus Group, the characteristics of problems arising from community expansion in each area are nearly the same, which can be divided into 3 major problems as the problem of occupation and income, the problem of fundamental public utility, and the problem of polluted environment. (For more details of Tambon level, please read from full report of Coastal System Analysis: Expansion Base on Community) From the community expansion, we can conclude the problems and the sustainable development methods of each district as:

3.7.3.1 Problems from community expansion

1) Tha Chana District

In this area, mostly is local people, in the past, they were farmers planting coconut tress and fishing. At present, they mainly do fisheries, while gardening such as oil palm, rubber, and fruit garden is side occupation. The community in Tha Chana District cannot be widely expanded since its surrounding area is for agricultural purpose.

Crucial problems of population expansion are

- Do not have its own land to make for living
  - To rent the land from official land (fisheries community living adjacent to the shore)
  - The land and protected area overlap
- Inconvenient transportation
- Flood such as due to water route obstructed by road construction
- Solid waste; insufficient space for solid waste

2) Chaiya District

Most of villagers have their own land, which is the heritage from their ancestors.Some of them rent the land from official land and monastery. In the past, they are farmers such as cultivating land and fishing. However, at present, they alter to grow oil palm since government sector supports and non local labors move in as hired hand such as cutting rubber, taking care of shrimp farm, and trading.

Crucial problems of population expansion are

- Do not have its own land to make for living
  - To rent the land from official land (fisheries community living adjacent to the shore)
  - To rent the land from monastery
- Solid waste; insufficient space for solid waste
- Flood such as due to water route obstructed by road construction
- Water problem
  - Salt water flows into canal creating water problems for consuming
  - Lack of water

3) Tha Chang District

Most of villagers are farmers and fishermen, and are hired hand for agriculture and non agriculture sector since there are 2 industrial facilities in the area which are palm oil Industry and seafood product processing Industry (china seafood). Foreign and non-local labors move in to work in the industrial factories and to work as hired hand for cutting rubber.

Crucial problems of population expansion are

- Problems of stealing the property (by both local and non-local) such as stealing scarps of rubber, stealing ox, and burglar
- Solid waste: insufficient space for solid waste
- Environment problem: pollution from industrial plants
- Water problem
  - Lack of water for agriculture
  - Flood
- Drugs

4) Phunphin District

Most of villagers are fishermen and also breed shrimp as their career, and are hired hand as side occupation. At present, since there is a promotion on preservative tourism in Liled Community, it is well-known in tourism aspect and has better economy.

Crucial problems of population expansion are

- Lack of water
  - Lack of water conservancy: insufficient natural water resource. Agriculture has to depend on rain.

- Water for consuming: during the drought, well water is contaminated with color and smell, no natural water resources

- Inconvenient transportation route: most of the roads are soil, in rainy season, they become bumpy and rough which is not convenient for transportation
- No righteous documents on the farming land
- Drugs problem

5) Mueang Surat Thani District

Majority of villagers go into business and are farmers, their side occupation are fishing and hired hand. Large number of population immigrates to this area such as non-local population at studying age move in to study about foreign labor. In the future, there is a high tendency that more population will move in, since government office supports Surat Thani Province as the center of transportation between the Andaman – Gulf of Thailand countries.

Crucial problems of population expansion are

- Lack of water
  - For consuming
  - For agriculture
- Flood
- Insufficient public utility system such as electricity, water, telephone
- Inconvenient transportation
- Problem of public land management

6) Kanchanadit District

Majority of villagers are fishermen such as breeding (shell-fish, shrimp), going out into the sea, and are farmer such as growing rubber trees, oil palm trees. Foreign labors immigrate to work in industrial factories and work as hired hand in fishing boat.

Crucial problems of population expansion are

- Do not have its own land
- Water
  - Lack of water
    - For consuming
    - For agriculture
  - Flood
- Insufficient public utility system such as electricity, water, telephone
- Problem of public land invasion

- Problem of robbery such as steal shell-fish from the farm, steal machinery for cultivation

7) Don Sak District

Most of villagers are farmers and fishermen. Foreign labors move in to be hired hand.

Crucial problems of population expansion are

- Unemployment problem
- Labor problem
  - Foreign labors are fishing boat crew
  - Non local labor from north east of Thailand move in to be hired hand for cutting rubber trees
- Capitalists rush to buy land
- Problem of land for making a living
- Robbery problem
- Densely populated community (especially fishing village nearby the shore)
- Public land invasion such as invading the river way
- Lack of community regulation management
- Solid waste in community

8) Ko Samui District

People in Ko Samui always settle down in the area depending on what they do for living such as if they run business for living, they will stay in the market, if they are fishermen, they will live nearby the shore, and if they are farmers, they will be in mountain area. Most of villagers occupy in tourism business, fisheries, and trading. Population immigrating into Ko Samui are both non-registered, which are for work and for pleasure, and registered. Ko Samui at the moment is so well-known for its tourism that the number of population is continuously raised and tends to be much more increased. Hence the town community is rapidly expanded. If there is no appropriate town plan system, problems may arise. Due to the rapid expansion of the city, there are structures obstructing the water way, invasion of the forest in the high mountain area from both local people and capitalists. Moreover, people on the island cannot thoroughly make use of public utility system, anyone who has money (capitalists), can use more, for example tap water, the owner of the hotel Is capable of buying many water-pumps, as a result, villagers around the hotel cannot use tap water since their pumps' capacity cannot compare to those of the hotel.

Crucial problems of population expansion are

- Non-local residents
  - Strive for career
  - Destroy resources (small aquatic animals)
- Population on the island cannot thoroughly utilize resources
- Water
  - Lack of water for consuming
  - Flood
- Structures obstructing water way
- Land to make a living
  - The land and preserved forest overlap
  - No righteous documents on the land
- Invasion of preserved forest
- Public utility is insufficient for the need of population on the island
- Drugs coming from tourists

9) Ko Pha Ngan District

In the past, villagers are farmers and fishermen, however, they now turn to run tourism business, while their side occupation are fishing, farming, and gardening. Average income per year of the population is approximately 60,000 baht. Ko Pha Ngan at present is world widely well-known for its tourism site such as Rin Beach (Full Moon Party), as a result, a large number of population moves in both for work and for pleasure.

Crucial problems arising from non-local residents of Ko Pha Ngan District are

- Solid waste (In the past, only 3 solid waste trucks per day will be used, now it is 10)
- Lack of water (In the past, they consume 10,000 liters per day, now it is 30,000)
- Teenagers from other places move in to be gangsters, they drink, are drunk, and fight (government hall area)
- High demand while low supply of natural resources
- Insufficient public utility system such as school and hospital
- Non-local residents
  - Moving from north east of Thailand to shorten life cycle of living beings (eat small living beings) and to strive for the jobs
- Government sector does not support for non-local residents' expense

- Land to make a living: overlap with preserved forest and no righteous documents on the land
- Drugs coming from tourists

3.7.3.2 Method to prevent and solve the problems due to community expansion

From the listed problems, we can conclude method to manage community expansion to face the least problems. Many methods can be suggested which is to study and to determine the area by considering of

1) The suitability of the area for each activity that will be the least effect from the erosion and conform to timing

2) Method to prevent the erosion

3) Effects of the change and development of the area to community's way of life and environment

4) Capability to support population moving into the area

- To support integrated resources management and be part of it by every party
- To formulate the town plan in advance to support the change

Each of the method can be related to other topics as shown in Table 3.7.4

Table 3.7.3 Show the relation between the method to prevent and to solve the problems from community expansion

Type	Interesting Topic	Relation	Method to solve problems
- Possession of land and utilization - Business owner and non-local labor in potential economic area	- Open land surface and increase empty land - The erosion of soil by nature - The erosion of soil by other activities - Invasion of public property and overlapping of land and forest - Lost of opportunity to make use of public place such as beach - Contamination in water source from the erosion - Capacity of the area and pollution such as solid waste and waster water treatment - Public utility system - Safety of life and property	- Landscapes and pollution during rainy season and drought - Tourism activity and community, fisheries, and others - Resources for tourism and fisheries - Water resources	- The study to determine the area by considering 1. The suitability of the area for each activity that will be the least effect from the erosion and conform to timing 2. Method to present the erosion 3. Effects of the change and development of the area to community's way of life and environment 4. Capability to support population moving into the area - To support integrated resources management and be part of it by every party - To formulate the city plan in advance to support the change

3.8 INDUSTRY PRODUCTION BASE

3.8.1 Introduction

The first thing to consider for a Industry's establishment is the raw materials which will feed into the production process. Regional Thai areas are considered to have high capacity in production of agricultural goods; thus, most factories that are spread out in the regional areas are engaged in agriculture-related industries.

In the study area of "Ban Don Bay", a preliminary survey shows that most factories in the locality are align with the local agricultural production; that is to say, they are engaged in related industries which mainly utilize raw materials from the local agricultural sector.

3.8.2 Industry in the study area

The study area, the Ban Don Bay and Islands Management Planning Project, consists of 7 districts surrounding Ban Don Bay namely Amphoe Tha Chana, Amphoe Chaiya, Amphoe Tha Chang, Amphoe Phunphin, Amphoe Mueang Surat Thani, Amphoe Kanchanadit, and Amphoe Don Sak; and also 2 island districts namely Amphoe Ko Samui and Amphoe Ko Pha Ngan.

The study on production systems of factories in Ban Don Bay area this time covers factories located in sub-districts on the coastline.

According to the Office of Industry, Surat Thani Province, in 2549 B.E. there were 176 factories in the study area.(As shown in Figure 2.7 of the *Full Report on Base for Industry Development*) With considerations on raw materials, products and production processes in the study area, the factories can be categorized into a number of production groups. Distinctive industrial groups based on their prominent features are the agriculture, the wood and forestry, the food, and the minerals and land dumping groups.

3.8.2.1 Growth of factories in the study area

The upward trend of the factories around Ban Don Bay is in the same direction as that of the whole Surat Thani Province. (As shown in Figure 2.8 of the *Full Report on Base for Industry Development*)

Between 2530 B.E. and 2535 B.E. the factories in the area grew slowly. The growth accelerated during 2536 B.E. to 2538 B.E. and again during 2545 B.E. and 2547 B.E. whereas the year 2541 B.E. saw a slump. (As shown in Figure 2.9 of the *Full Report on Base for Industry Development*)

As for employment in the manufacturing sector, most factories in the study area employ fewer than 50 workers each. As a whole, however, more than 5,000 workers are employed. The number of persons employed in the manufacturing sector each year increases with the number of factories. (Appendix Khor 10 of the *Full Report on Base for Industry Development*)

3.8.2.2 Categorization of factories for studying

According to the Office of Industry, Surat Thani Province, in the locality of interest there are 176 factories registered with the Department of Factories or with the Office of Industry, Surat Thani.

In this study, factories are divided into three groups namely the large, the medium, and the small factories groups in accordance with the number of workers employed in the production line. Large factories are those with more than 200 workers; medium, between 51 and 200; and small, fewer than 50. (Table 3.8.1)

Table 3.8.1 Number of factories by size

Size	Workers in production	Number of factories	Percent
Large	> 200	5	2.84
Medium	51 – 200	8	4.54
Small	0 – 50	163	92.6

Source: Office of Industry, Surat Thani Province, 2550 B.E.

3.8.3 Result

3.8.3.1 Industry size

Large factories The factories categorized as “large” are those with more than 200 workers. As shown in Table 1, in the study area, there are 5 large factories, equivalent to 2.84%. With regard to the variety of manufacturing inputs, it was found that the large factories’ group exhibits no clear distinctiveness in terms of the inputs used except for one large Industry (out of 5), namely Safegloves Co., which makes rubber gloves from raw rubber. The factories and their production activities are as listed. (As shown in Table 3.1 of the *Full Report on Base for Industry Development*)

Locations of the factories agree with information obtained through local resident’s forums. At the forums, when asked about impacts from the factories, local residents from 3 areas responded that the factories caused pollution to the communities. At the Amphoe Ban-shang’s forum, it was stated that factories caused air pollution and water pollution. At Amphoe Mueang’s forum, smell from factories was stated. At Amphoe Don Sak’s forum, waste water, odor, noise and chemical residuals in the water were stated as problems.

Medium-sized factories As shown in Table 3.2, there are 7 medium-sized factories, equivalent to 4.54% of all factories in the area of interest. Compared with the large Industry group, this group exhibits higher variety of production activities.(As shown in Table 3.2 of the *Full Report on Base for Industry Development*.)

Small factories Because factories in this group comprise the majority, that is about 92.6% of all in the Ban Don Bay area, for an analytical purpose it is necessary to categorize the small factories into sub-groups within each the manufacturing inputs are similar. (Appendix A 1 of the *Full Report on Base for Industry Development*)

3.8.3.2 Production and Production Factors

1) Amount of raw materials per year

Large factories The demands for raw materials of the large Industry's group in the study area are detailed in Table 3.3 of the *Full Report on Base for Industry Development*. Four of these factories process aquatic animals. The other makes rubber gloves.

Medium-sized factories Two of the medium-sized factories process seafood. The others make asphalt cement, concrete products, smoked rubber or crude palm oil. The demands for raw materials are detailed in Table 3.4 of the *Full Report on Base for Industry Development*.

Small factories Grouping small factories based on similar key production factors, Appendix A 1 of the *Full Report on Base for Industry Development* details the demand of the 12 sub-groups.

2) Yearly output

The output by factories around Ban Don Bay is considered relatively high in terms of quantity produced. For example, large factories altogether produce more than 12,000 tons of frozen shrimps each year. Production outputs can be detailed for each Industry group as follows.

Large factories Table 3.5 of the *Full Report on Base for Industry Development* shows the output levels that large factories can produce at the full machine capacity and labor utilization, given suitable conditions in terms of raw materials, labor, fuel and other production factors.

Medium-sized factories The yearly maximum production capacity of the medium-sized factories, given suitable conditions in terms of raw materials, labor, fuel and other production factors, is displayed in Table 3.6 of the *Full Report on Base for Industry Development*.

Small factories Individually the capacity of a small-sized Industry is much lower than that of a large or medium-sized Industry. However, collectively the small factories which spread

almost through out the area contribute to a considerably high production amount. (Appendix A 2 of the *Full Report on Base for Industry Development*)

3) Costs of production factors

Main production factors of a manufacturing Industry are the raw materials which are brought into the production process to yield the outputs. In this study, prices of raw materials necessary for manufacturing factories are collected in order to make forecasts into the future.

The data on raw materials demanded by factories collected in this study show that aquatic animals are the most demanded raw material, amounting more than 50,000 tons yearly.

Prices of raw material Raw material costs are the components of production costs which are highly important to a Industry's production system. Furthermore, the raw material prices impact the products' prices and also the operators' profits.

Here the study on costs of raw materials focuses on those from the agricultural and fishery sectors. This is due to that fact that most factories in the area are engaged in activities continuing from the two sectors. The prices shown in this report are mainly the one-year-average settlement prices of various raw materials in the respective middle market. Details are as follows:

Prices of aquatic animals

A study on the condition of fishery resources around Ban Don Bay shows that the resources have deteriorated. Fishermen are of the opinion that the quantities of aquatic animals caught have declined. Also research and survey by government agencies indicate that fishery resources have deteriorated whereby the animals caught presently comprise mainly of trash fish and the animal sizes get smaller. Hence, the price of aquatic animals is the key variable determining what fishermen presently earn. From the prices of aquatic animals collected from the Fish Auction Organization between 2545 B.E. and 2549 B.E. and from the adjustment of the Bank of Thailand's Aquatic Animal Price Index with 2545 B.E. as the base year, it can be seen that prices of almost all aquatic animals were clearly declining. Exceptions were seen for some animals namely the macherel, the white pampidae, the Indian prawn, the cockle, the cuttlefish and the mantis-shrimp of which prices increased, though minimally. (As shown in Figure 3.1 – 3.6 of the *Full Report on Base for Industry Development*) In contrast, shred fish made of trash fish clearly has risen in price since 2548 (B.E.).

Prices of agricultural commodities

Another main industry in Ban Don Bay area besides aquatic animal processing is the agricultural commodities' group. The commodities have seen different price adjustments since 2539 B.E. (As shown in Figure 3.7 of the *Full Report on Base for Industry Development*) For

example, rubber did not exhibit much year-on-year price change between 2539 B.E. and 2545 B.E. That is the price fluctuation had been normal until 2545 B.E. when the price curve started to slope upward abnormally. This shows that the rubber price went up greatly during the period. In comparison, the price went up about 7 baht between 2544 B.E. and 2545 B.E. The slope of the curve that rose significantly until 2549 B.E. indicated that a notable increase started in 2545 B.E. and continued further in subsequent years. Looking at the yearly data, the whole-year average price of rubber went up to 53.57 baht.

Also, a study on coconut price was conducted in the study area where coconuts are mainly fed to small factories. A comparison of the coconut price against its quantity in tons since 2539 B.E shows no significant year-on-year movement in price except for in 2541 B.E. and 2542 B.E. when the price went more than other years. (As shown in Figure 3.8 of the *Full Report on Base for Industry Development*)

As for the price of palm oil, during 2539 B.E. to 2548 B.E. the individual year's average price fluctuated in the range of 1 to 4 baht. (As shown in Figure 3.9 of the *Full Report on Base for Industry Development*) In fact in the later years, between 2545 B.E. to 2548 B.E. the price stayed higher than 2 baht. Considering the average price's trend on a yearly basis, the palm oil price next year will not be very high and the impact on the Industry's raw material cost will not be of a great concern.

4) Other production factors

The labor cost considered in this study is the minimum wage for Surat Tani Province as announced by the Ministry of Labor and Social Welfare, year 2548 B.E. for large factories employing 200 workers or more. (As shown in Figure 3.10 of the *Full Report on Base for Industry Development*) Any wage rise would have impacted the hiring cost figures of the factories.

The fuel cost considered in this study emphasizes only the diesel using its average price from 2540 B.E. to 2549 B.E. It is found that the fuel cost did not change significantly during the period. (As shown in Figure 3.11 Base of the *Full Report on Base for Industry Development*) It can be seen that in the price rose 4.58 baht during the one-year period from 2547 B.E. to 2548 B.E. Again the 2549's price rose 3.92 baht from the previous year. That is in the two-year period the diesel's price increased about 8.50 baht.

3.8.3.3 Problems and suggested solutions

The main problems of factories in the study area can be categorized into two parts: the production and marketing problem and the surrounding community problem. Detailed analysis of each problem and suggested solutions are below.

Production and marketing problem: The main problem for factories around Ban Don Bay is the off-season shortage of intermediate goods in some agricultural-related factories such as rubber, oil palm and in fishery-related factories such as frozen shrimp, frozen squid, crab and shellfish.

The problem arises when factories cannot find enough intermediate goods to meet the full production capacity of factories during the off-season period. Moreover, the cost of intermediate goods during the off-season period is higher thus raising production costs during the period.

The suggested solutions for the intermediate goods shortage problem are the following:

1. Reduce capacity during the off-season period such as layoff and machine closure.
2. Find intermediate goods from other sources besides local areas. Due to different geographical area in Southern Thailand whereby mountain divides Southeast from Southwest, the crop season in these two areas are different and hence finding intermediate goods from other areas is practical for the factories.
3. Build frozen chamber to store excess intermediate goods during the crop season and can be used as a buffer to the shortage problem during the off-season period. This solution is practical for agricultural- and fisheries-related industries.

Apart from the production problem in the off-season period, another crucial problem is the shortage of labor supply especially in big factories which required at least 200 workers such as processed-frozen fishery factories and rubber globe factories. The problem arises because most manufactured workers are from agricultural sector during the off-season period. Since 2546 (B.E.) the commodity prices has increased dramatically especially rubber price. This causes the labor movement to migrate from the manufacturing sector to agricultural sector.

Other facet of labor problem is lifestyle adjustment. Normally the targeted group of these factories is local people whose previous occupations are in agricultural and fisheries sectors. The nature of these occupations is freedom and less rigid in work lifestyle compared to Industry work. These people when moved from their previous occupation to factories are usually subjected to rigid working hours and rules and regulations. Less freedom and more rigid work lifestyle usually hinder the workers from moving into manufacturing sector.

The suggested solutions for the labor shortage problem can be categorized into the short-run and the long-run solutions:

1) The short-run solution is to hire labor from nearby areas without imposing too much cost on the factories. This solution, however, could harm local labor condition in the

long run. Thus the factories should employ this method only when there is a severe shortage of labor.

2) The long-run solution which is better to balance the local labor market condition is to educate and promote the industry work lifestyle to local community.

The marketing problem is not as serious as the production problem. The export figures of manufactured products between 2540-2549 (B.E.) showed that export value and domestic price of most manufactured products tended to rise year-on-year. This suggested that manufactured sector is still competitive.

Surrounding community problem: From focus group study of local community, the environment surrounded big factories has been deteriorated including the air and water pollutions.

Local community usually has a negative bias toward factories. They often condemn factories as the prime suspect of environmental damage. For example, when local rivers are polluted and lots of living creatures downstream dead, people usually blame a nearby Industry without significant study of the cause. This proves the negative bias of local people toward factories as the main source of environmental contamination.

The practical solutions for surrounding community problem are the following:

1) Hire local people thus mitigating the negative bias toward factories. However, there is a risk of work lifestyle adjustment problem as mentioned above. Factories should familiarize their activities with local community at early stage.
2) Improve public relation. The first step factories should do is to familiarize local community with the factories. Get to know and inform the local about the factories' activities such as production process, recycle process, and sewage treatment process.
3) Involve with the local community activities such as leading the alms giving activities during Buddhist holidays and making donation to local schools as a means to know their attitudes, problems and concerns and hence to better response to their needs in a positive manner.

3.8.4 Analysis and summary

The final section of this study focuses on the sustainable development approach for entrepreneurs both environmental-friendly and local community-friendly. This section uses three

analysis frameworks, that is, Maximum Principle, Portfolio Balance and Dynamic Constraint. The detailed analysis is the following:

Maximum Principle Equilibrium

The equilibrium notion mainly focuses on the business profit of factories. The production process of factories could be sustained as long as entrepreneurs can maintain maximum profit level.

Applying to the industry area around Ban Don Bay, it shows that local entrepreneurs are able to maintain their equilibrium profit according to the following equation:

Profit = Revenue – Cost.

Since revenue is confidential, this study used export value and export price as proxies to manufacturing factories revenue.

The study showed that although material costs, labor costs and oil prices have been rising, there is no significant impact to manufacturing factories because the export value and export price have also been increasing. Also, the managerial problems regarding the shortage of intermediate goods and labor supply can be solved using the suggestions mentioned above as guidelines.

Portfolio Balance Equilibrium

This equilibrium integrates an intrinsic value of resources within the business perspective. The concept lies on the fact that the growth in value of material being used by a Industry should equal to the growth in value of other materials, that is the resource value should be price competitively.

Because finding an intrinsic value of input material is time-consuming, the study used market price as a proxy. Additionally, estimation on amount and value of prospective resources will be derived from export volume or domestic sale.

Ban Don industrial area offers a low range of production variety. Core business concentrates on fishery such as frozen shrimp, frozen squid, frozen fish and canned fish. These businesses suffered from a decline in export value during the past years. Processed canned seafood, however, provided a good opportunity due to its higher exporting volume.

The Industry setup and trade balance database suggested that macroeconomic condition is a crucial factor affecting the balance of manufacturing factories. For example, during the financial crisis between 2540-2543 (B.E.), the macroeconomic condition as well as

export volume deteriorated in line with the contraction in manufacturing factories and labor market conditions in the study area.

The problems of manufacturing factories are of two parts. First, the problem which can be solved by factories themselves such as the production and labor shortage problems. Second, the problem which required government policies such as macroeconomic recession.

Looking at the different perspective, local factories can view their close proximity to natural resources as their strength. Close proximity to fishery and farming areas means freshness of products and hence improvement in quality of products.

Dynamic Constraint Equilibrium

This equilibrium is taken into account the amount of resources factories used as input. The dynamic constraint equilibrium of the resource occurs when the utilization rate equals the replacement rate.

Most factories in the study area are relating to processed agricultural products. Hence the study of utilization rate and replacement rate is primarily focused on agricultural and fishery sectors. The analysis of dynamic constraint resource equilibrium does not only take into account the amount of resource *per se* but also the environmental issue.

The focus group study of local community living nearby small and medium factories indicated no significant environmental impact from the factories. These small and medium factories are not heavy-industry thus insignificant impact to local community. Moreover, big factories in the area are equipped with the water treatment system, mitigating water contamination into local rivers.

From the fishery production database, the number of large fish caught in most study area has declined year-on-year except “Trash Fish” (lit. duck fish) which increased during the period. This indicated that local fishery input fed into the production process might not meet the demand of local factories in the near future. Those factories producing animal feeds whose basic materials based on “Trash Fish”, however, expanded during the same period. If these factories continue to expand robustly, fishermen are likely to catch fish regardless of their size and hence jeopardizing other factories using fishery input.

The practical and sustainable solutions for factories regarding substitution of fishery input are:

1) Use farmed fishery input whenever possible. This method has been widely used in the medium and large factories.

2) Import fishery input from other areas when farming is not possible. Usually factories set up stalls in targeted areas to purchase fishery input.

Primary inputs for agricultural products factories are rubber, oil palm and rubber wood. The main problem is the shortage of intermediate goods during the off-season period. The practical solution for factories in the study area is to find intermediate goods in the areas which have different crop seasons

9. SOCIAL CONDITION OF THE COMMUNITY AROUND BAN DON BAY AND ITS OFFSHORE ISLANDS

3.9.1 General Information

Recognized as the commercial center, most long-established communities around Ban Don Bay and on offshore islands are located in Surat Thani Province. These communities have developed along with many other ancient neighborhoods. In the past, around the Buddhist Era 10 (B.E. 10), major communities had the lowlands along the Chaiya canal as their center where the interfusion of Bhramanism and Theravadin Buddhism was observed. The communities, especially the historical sites around Ban Don Bay, were highly well-known as the focal inheritor of the deep-rooted Srivijaya civilization, during the prosperous Srivijaya period around B.E. 13-17. Archaeological evidence indicated that the local geography greatly influenced the residents'lifestyle and the cities' development.

During the Rattanakosin Period, certain communities around Ban Don Bay, as displayed below, were urbanized.

Having moved the highly populated "Thathong Town" from Thapetchra Canal to the commercial harbour city of "Ban Don," King Rama III promoted the removed town into a level 4 city under the direct administration of the municipality of Bangkok and designated "Kajanadit" as its new name. The towns of Chaiya, Kanchanadit, Langsuan and Chumphon made up "Chumphon Circle." Moreover, Kanchanadit was merged with Chaiya. In the period of King Rama VI, he moved Chumphon Circle to settle at Ban Don. He gave the name of this town is "Surat Thani", meaning the town of righteous people, on July 29, 1915.

The information above shows that several amphoes of Surat Thani Province were former major communities, especially those around Baan Don, which, throughout their long history, were sharing the same stock of resources.

Nowadays, Surat Thani is composed of 18 amphoes (known as Amphoe in Thai) and 1 tambon (known as King Amphoe in Thai), including Amphoe Mueang Surat Thani, Amphoe Phunphin, Amphoe Khiri Ratthanikham, Amphoe Phanom, Amphoe Kanchanadit, Amphoe Ko Samui, Amphoe Don Sak, Amphoe Chaiya, Amphoe Tha Chana, Amphoe Tha Chang, Amphoe Ban Na San, Amphoe Phrasaen, Amphoe Wiang Sa, Amphoe Khian Sa, Amphoe Ban Ta Khun, Amphoe Ko Pha Ngan, Amphoe Ban Na Doem, Amphoe Chai Buri, and King Amphoe Wiphawadi.

Besides housing diverse resources including mangrove forests, seagrasses and coral reefs, Ban Don Bay also accommodates animal habitats, spawning grounds, lodgings for embryo development, and food resources for animals. Furthermore, it also helps secure the ecological and coastal integrity. It is also the center for fishery, marine animal farming, and tourism. In brief, it is an invaluable economical and social asset.

Most of the population in Surat Thani works in the agricultural sector; the main commercial plants include pararubber trees, palms, rambutans, durians and coffee trees. Moreover, livestock farming and fishery are also practiced. Popular farm animals include cows, buffalos, pigs, chickens and goats. The fishery is conducted in the marine, the estuarine and the fresh waters; the breeding of aquatic animals along the coast is also operated. The local industry is the processed agricultural products, such as the fish powder industry, the frozen seafood industry, the canned seafood industry, the palm oil industry, and the pararubber product industry. Furthermore, the is also the concession of the mining areas and of the bird nest harvesting on islands. Currently, the most popular profession is within the tourism business.

3.9.2 Social situation of the communities under the study

The Management of Ban Don Bay and offshore islands: the Analysis and Appraisal of the Coastal Structure, supported by he Coastal Habitats and Resources Management Project (CHARM), aims at the collection of relevant data for the analysis of the fragility and sustenance of the coastal resources management system.

The coastal areas under the project were of 9 districts or amphoes and 36 communes or tambons[3]: Amphoe Tha Chana (Tambon Khan Thuli, Tambon Tha Chana and Tambon Wang), Amphoe Chaiya, Amphoe Tha Chang (Tambon Khao Than, Tambon Tha Chang and Tambon Tha khoei), Amphoe Phunphin (Tambon Liled), Amphoe Mueang Surat Thani (Tambon Bang Pho, Tambon Bang Chana and Tambon Bang Sai, Tambon Bang Baimai, Tambon Khlong Chanak, Tambon Bang Kung and Tambon Talat), Amphoe Kanchanadit (Tambon Tha Thongmai, Tambon Takhianthong, Tambon Kadae, Tambon Plaiwat and Tambon Thathong), Amphoe Don Sak (Tambon Chonkhram, Tambon Chaikhram and Tambon Don Sak), Amphoe Ko Samui (Tambon Angthong, Tambon Maret, Tambon Bo Phut Tambon Maenam, Tambon Na Mueang,

[3] The word 'district' is used for the translation of the Thai word "amphoe" (sometimes also amphur, Thai: อำเภอ), which is the second level administrative subdivision of Thailand. Several amphoes make up a province. Each amphoe is further subdivided into tambon, which is usually translated as "commune" or "sub-district" in English.

Tambon Taling Ngam and Tambon Lipa Noi) and Amphoe Ko Pha Ngan (Tambon Ko Pha Ngan and Tambon Bantai).

The foci of the study are of the following 8 areas:

1) natural resources and environment
2) fishery
3) aquaculture
4) agriculture
5) forests
6) tourism
7) urban expansion
8) industry

For a thorough scope of the study, the following channels of data gathering were established.

1) Governmental offices – Each researcher was designated to contact offices to secure relevant information for his/her assigned study focus. The one who was responsible for the study of agricultural activities, for example, contacted the District Agricultural Extension Office in each district within the study area.
2) Literature review – Relevant pieces of literature and useful documents were compiled.
3) Focus group discussion – Focus group discussion was the major means of the data gathering. Project representatives were designated to survey each district and commune under the study. Research teams took charge in the organizations of the meetings with the locals.
4) Intense individual and group interviews – Each researcher conducted intense individual and group interviews in different study areas.
5) Questionnaires – Questionnaires were distributed to different private agencies: companies, shops, hotels, restaurants, etc.

Table 3.9.1 Schedule of the focus group discussions

Round	District	Sub district: Focus group area	Date
1	Tha Chana	Khan Thuli, Tha Chana, Wang (Mr. Kittisak's crab carapace removal Industry)	January 6, 2007
2	Chaiya	(Chaiya Market, Lamet) (Lamet's sub-district administrative organization)	January 20, 2007
3	Chaiya	Takrob, Thung (Takrob's sub-district administrative organization)	January 21, 2007
4	Tha Chang	Khao Than, Tha Chang, Tha Khoei (Tha Chang's sub-district administrative organization)	January 27, 2007
5	Chaiya	Phum Riang(Bhodharama School)	January 28, 2007
6	Phunphin	Liled (Liled Homestay Office)	February 10, 2007
7	Ko Pha Ngan	Pha Ngan Island, Bantai (Pha Ngan Island's district office)	February 17, 2007
8	Ko Samui	Ban Huathanon, Maret (a coffee shop in front of Ban Huathanon's mosque)	February 23, 2007
9	Ko Samui	Maret (Samrej Temple)	February 24, 2007 (in the morning)
10	Ko Samui	Ang Thong (Srithaweeb Temple)	February 24, 2007 (in the afternoon)
11	Ko Samui	Bo Phut (Ban Bangrugsa School)	February 25, 2007 (morning)
12	Kanchanadit	Tha Thongmai, Takhianthong (Bang Samrong School)	March 10, 2007
13	Kanchanadit	Kadae, Plaiwat, Thathong (Wachirapraditsa Temple)	March 11, 2007

Table 3.9.1… (Continued)

Round	District	Sub district: Focus group area	Date
14	Don Sak	Don Sak (Wat Wisuthichalaram School)	March 17, 2007
15	Don Sak	Chonkhram, Chaikhram (Chonkhram Temple)	March 18, 2007
16	Mueang Surat Thani	Talat, Bang Kung (Podhawas Temple)	March 23, 2007
17	Mueang Surat Thani	Bang Pho, Bang Sai, (Chotigaram Temple)	March 24, 2007 (in the morning)
18	Mueang Surat Thani	Bang Baimai, Bang Chana, Khlong Chanak (Bang Baimai Temple)	March 24, 2007 (in the afternoon)
19	Ko Samui	Phaluai (Angthong) (Ban Ko Phaluai's health care office)	March 31, 2007

As the focus group discussion with the locals during the time table above, it can conclude the social presentment within the study districts and communes as follows.

1) Amphoe Tha Chana

Historically known as Amphoe Prasong under the government of the old Chaiya City, Tha Chana is a long-established neighborhood the district office of which was at Ban Thakrajai.

The study areas included Tambon Tha Chana, Tambon Wang and Tambon Khan Thuli.

At Tha Chana, there is no mangrove forest. The agricultural areas are of 3 geographical zones: the coastal zone for coconut plantation, the upper section of the land for palm plantation and the inland section further up for fruit cultivation. Later on the groves of coconut trees were turned into shrimp farms. Community clubs include housewives' weaving clubs, fishery cooperatives, local fishermen clubs, saving clubs, Ban Paknamkrajai's fishing club, the volunteer housewife club.

Most of Tambon Wang, the forest areas of which are not officially delineated, is the agricultural plain. About 50 households possess private pieces of land; 150 rent the state-owned land. The villagers grow palms, coconut trees, para rubber trees and rice.

Most of the residents at Tambon Khan Thuli are engaged in the fishery career; some, using hanging methods, also do the farming of natural green mussels. Small-sized boats are

used for catching crab; medium-sized boats for squid fishing through the use of cast net with light luring. With loans, the villagers are able to own boats and pay for the maintenance costs. Fishing gears include crab traps, squid traps, crab seine nets, sand whiting seine nets, fishing hooks.

The group discussions with the locals in the 3 tambons led to the following problems: the decrease of aquatic animals, the unclear boundaries for the commercial fishing, the conflicts between local fishing and commercial fishing, the leniency of the government in enacting the laws, environmental problems caused by the discharge of wastewater and snail poison into shrimp farms, capitalists' and middle men's product price exploitation, the problems of shallow canals, the stagnation of the tourism business (partly due to the lack of convenience facilities). The residents also long for the establishment of factories which serve the needs of the locals. Agricultural problems include low prices of agricultural products, the upper hand status of middle men, high costs of fertilizers and petrol. The residents propose the following solutions: the improvement of the product quality, the establishment of agriculturists' union (e.g., a product-increasing fertilizer support group). Coastal erosion becomes a serious problem, especially during the monsoon season; residential coastal areas are damaging. There are problems with shallow coastal areas and obstructed mouths of canal. The government provides an easy solution by using sand bags to obstruct the water overflow but the problem still persists.

2) Amphoe Chaiya

Early Amphoe Chaiya was called Mueang Chaiya, acting as the center of the local government, of foreign trades, and of religious promotion. After that Burma's army declared warfare and destroyed towns left damaged facilities as mementos. Later, Mueang Chaiya moved to the coast of "Phum Riang." In 1897, under the government' circle administration system. Chaiya was merged as part of Mueang Chumphon and Mueang Langsuan; the consolidation of the three towns resulted in the institute of Chumphon Circle. In 1899, Mueang Chaiya and Mueange Kanchanadit were merged into Mueang Chaiya. In 1937, Amphoe Mueang Chaiya was changed into "Amphoe Chaiya."

The areas under the study cover the following 5 tambons: Takrob, Chaiya, Thung, Phum Riang and Lamet.

At Tambon Takrob, the residents inherit their private land from the ancestors. There is no immigrant in the area. Coconut trees were the indigenous plant. In the past, there were many huge trees. Today's forestland is the grove of newly grown trees. There are some mangrove forests along canals. Mangroves, bird-polls, bean, and cannonball mangroves are familiar

house plants. In the past, almost every household operated the shrimp farming business which was started in 1987; the shrimp farming was highly booming for 5 years before it became unprofitable in 1999. After 1999, certain financially capable investors turned to do the Whiteleg shrimp farming; others, due to financial losses, quit the shrimp farming business. Tourist traps include beaches, like Saikeaw Beach, Chintarha Beach, Niyom Beach, Nai Amphoe Beach; no restaurants are open on these beaches, however. Ithawararam Temple is a monk sanctuary that houses pristine forests.

The residents at Tambon Thung possess private land. In the past, they grew rice; nowadays, they turn to do the palm plantation. The region does not border anycoastal area but contains mangrove forests. Preserved forests are terrestrial forests. A current problem involves the capitalists' forest invasion for their operation of shrimp farming businesses. Fishery is subordinate to agriculture. Villagers catch aquatic animals, like mullet fish, meder's mangrove crab and fiddler crab, in Phum Riang Canal. Fishing gears include traps, bamboo fish traps, set bag nets, push nets, and Sergestid push nets. Blochs and Spiny eels are extinct aquatic animals.

Most pieces of land in Tambon Talat Chaiya are registered; the residents possess their private land and houses. Immigrants usually rent houses. Joint gardening practices are adopted as a life sustenance means. Around the remote areas, residents' careers include duck farming and salted egg production. The region does not border the seashore but its canal is connected with the sea. Canal fishing can be observed. For the past 10 years, fishes in its canal, as a result of the electric shock fishing system and the poison fishing, have begun to be extinct. Small number of tourists visits this area.

Tambon Phum Riang is a long-established district. Some residents possess land titles; others rent either from the Department of Royal Estate or from temples. Mangrove forests cover the area of around 2,000 – 3,000 rai (or 800 – 1,200 acres). The course of Phum Riang Canal flows through 5 villages. Rare marine animals, like dugongs and dolphins, can be seen daily. There are a lot of seagrasses. There used to be a number of sea turtles, eagle rays and dolphins. Palm trees become popular for the local plantation. Aquacultures include the farming of Whiteleg shrimps, mussels, clams and grouper cage culture. The black tiger shrimp farming, was replaced by the Whiteleg shrimp. Phum Riang's highlights are the old Suan Mokha, Ubol Temple or Nok Temple, Prathat Temple, Phum Riang silk and Bho Cape. Resorts were built 6-7 years ago. Most visitors are outsiders; tourists can be seen daily. Several part-time jobs include the laying duck farming for salted egg production.

Most of the residents at Tambon Lamed own their private land; some, however, rent from the Department of Royal Estate. They adopt the following career path for the daily life sustenance: rice farming, and palm, para rubber tree and coconut tree cultivations. Most of the fisheries are of the local level; there are about 30-40 boats in the community. Fishing gears, which are changed to suit the different seasons, are push nets, drift gill nets, crab lift nets, fishing hooks and traps. During the dry season, a number of crabs can be caught. In the past, the common shrimp species for the farming include the Tiger prawn and the Whiteleg shrimp. The grouper cage culture which used to be a common aquacultural practice become currently unpopular because of the following factors: the price decrease, the disease and the low water quality. Two tourist attractions are Internation Suan Mokkh and hot springs; local products for sale at Suan Mokkh are salted eggs and local desserts such as Taosao (crushed-bean-stuffed mini buns), Khaoniew Khoan (sweeten sticky rice pudding).

3) Amphoe Tha Chang

Amphoe Tha Chang was formerly under the jurisdiction of Amphoe Chaiya. In 1910, the Ministry of Interior turned it into “King Amphoe,” or a sub-district still under the jurisdiction of Amphoe Chaiya. On August 1, 1938, it became “Amphoe” or a district and has maintained the same administrative title till these days.

The study areas include the following 3 tambons: Tha Chang, Khao Than and Tha Khoei.

At Tambon Tha Chang, the residents own their private land. Popular commercial plants are para rubber trees, palm trees, rice, coconut. The villagers also own fruit orchards and joint gardens. Rice fields were turned into para rubber tree plantations. Common aquaculture includes the farming of Whiteleg shrimps, Tiger shrimps, Nile tilapia fish, Snapper fish, soft-shelled crabs. There is no preserved forest but there are mangrove forest cover the area of 10-20 rai or 25.30 – 50.60 acres. They are open for public use. Moreover 100 families are involved in the seasonal Sergestid fishery. Conflicts between fishermen of different interest groups can be observed, such as the discord between the group of Sergestid push net fishery and that of trap fishery. 3 factories cause environmental problems of foul odor and waste water. The villagers commute to work at factories located within and outside the region. One Tambon One Product artifacts include shrimp paste, chewy sweeten sticky rice, clams, crispy snacks, baked sticky rice in bamboo stem and Pad Thai (a Thai style noodle stir-fry with tammarine sauce). A coastal change phenomenon comes in the form of accretion, not erosion.

Most of the residents of Tambon Tha Khoei possess their private land. Agricultural plants include para rubber trees and palm trees, together with other fruit plants such as durians,

rambutans, and lonkongs. Nowadays, rice farming is no longer practiced. No other Industry, besides Paya Naga Pipe Industry, is established in the area. There is a meatball family business. Reserved mangrove forests make up the area of 10-20 rai (or 4 – 8 acres). An extinct aquatic animal is Shortfin Lizardfish. Factories located outside the region cause environmental problems, e.g., waste water at Tha Chang Canal caused by an alcohol Industry. The local soil which is of high acidic level is not good for agriculture. Fishermen from other villages trespass the prohibited zone. Villagers are in manageable debts. The MCS group lacks the required equipment and budget to manage mangrove forests.

Tambon Khao Than used to have the mangrove forests covering the area of 7,000 rai; however, they shrank after the boom of the tiger shrimp farming business started in 1977. Then the forests remained only 1,000 rai. However, from 1995 to 1996, shrimp farms were aBan Doned and mangrove forests were expanded. As a result, nowadays the area of the mangrove forests increases to the size of 7,000 rai. However, the trees in the forests are still young. The mangrove forests are useful for the fishery of Fiddler Crab. Nowadays, Tiger shrimp farming is not longer practiced but the Whiteleg shrimps are still cultured. Most of shrimp farm owner are outsiders. Environmental problems, such as waste water problems, foul odor problems from a palm Industry in Tha Chang occur. Moreover, an alcohol Industry also discharges the wastewater at Tha Khoei by truck.

4) Amphoe Phunphin

Amphoe Phunphin has been an important historical center of culture and archeological artifacts. Moreover, it is also an important economic center for Surat Thani Province.

The study area is Tambon Liled.

3 plants that are grown at Tambon Liled are coconut trees, palm trees and rice. Generally, the residents live together peacefully. The waste treatments include the following methods: burning, burying in landfills and producing fertilizers. The REST organization provides advice on waste treatments. A domestic natural resource is seagrasses which are the food for dugongs. Domestic aquatic animals are dugongs, dolphins and turtles. The observed coastal change is, not the erosion, the accretion. Aquaculture includes the Tiger shrimp farming, which is decreasing; some turns to raise Whiteleg shrimps, black crabs and white crabs. Every village established Bank in 2006. Whenever laying prawns are caught, they will be sold to the bank to be nurtured until the young are born. Then, the prawns of lower weight will be sold at a lower price than when they were bought from fishermen. However, the number of young prawns in canals will increase.

There are trainings for tourism. Reservationists work together to enforce ecotourism. Working teams were traveling to Kiriwong Village, Ko Yao Village to observe the local tourism business. Home stay businesses started in 2006. Tourist attractions include mangrove forests, the Srivichaiya archaeological site, the beetle farming group. Tour promotion activities are volunteers' cultivation of mangrove forests, the cruise around mangrove forests and waste management. In summer, there will be the mud-skiing activity for shellfish collection and sightseeing around historic sites. In the rainy season, popular activities include cruises as well as bird and monkey watches.

5) Amphoe Mueang Surat Thani

Amphoe Mueang Surat Thani is the center of administration, economy and transportation of the province. In the past, it was part of the Great Srivichaiya Kingdom, which, after its collapse, was divided into 3 cities: Chaiya, Thathong and Kiriratthanikom.

The current location of Amphoe Mueang is locally dubbed "Ban Don[4]," which Tapee River runs through the city from the south toward the north out into Ban Don Bay. The left side of the river is the plain with several branches of canal; the right side is the highland where the southern section is higher than the other parts. District offices, City Halls, many other state offices and trade centers are located in this city.

The study area includes 7 tambons: Tambon Khlong Chanak, Tambon Talat, Tambon Bang Chana, Tambon Bang Sai, Tambon Bang Baimai Tambon Bang Kung and Tambon Bang Pho.

Most of the population in Tambon Bang Sai and Tambon Bang Pho inherit their land from the ancestors. A popular agricultural plant is the coconut tree; however, today's cultivation starts to decrease. Most of the land is currently used as shrimp farms, and palm and para rubber plantations. The fishing gears are changed during the different seasons. Conflicts in the fishery business are caused by the use of different fishing tools. For tourism, villagers' boats are rented for the cruise around the mangrove forests at Tambon Liled. There is no Industry in this area. People are asking for the tap water facility. They also want to have a bay protecting dam as a solution to eroded river banks. Moreover, shallow canals needed to be tackled. Mobile medical units are also among one of the villagers' wish list.

Most of the land at Tambon Bang Baimai, Tambon Bang Chana and Tambon Khlong Chanak is the inherited land. There is no para rubber plantation in the region; the palm

[4] The word "Don" in Thai means the highland area.

plantations are the areas that used to be the coconut orchards. There is no internal conflict within community. There is no coral reef, no fresh water pool. The under neat pool can not be used because of salted and rusty water. At Tambon Bang Baimai has water tape service 70% and Tambon Klong Chanak has only 10%, and Tambon Bang Chana has no tape water service. Tambon Bang Chana contains 400 rai of mangrove forests; and Tambon Khlong Chanak 1,000 rai. Fishery problems are caused by outsiders' boat destroy aquatic animal habitats. Tourism activities are boating along canal, seeing firefly, sightseeing sea and islands.

There are both local residents and immigrants at Tambon Talat and Tambon Bang Kung. Most of foreign laborers are Burmese, whose number is around 1000. The locals have a 100% registered land owner. There are a number of hotels which tend to increase in the future. There are many reservation groups such as forest and sea group, ecological status of River-Ban Don Bay, Tapee conservation group, and Khlong Noi youth conservation group. Factories cause the following problems: foul odor from fish processing factories, condom factories and dust. The shipping of gypsum causes irritation to eyes and noses. It is locally proposed that the waste water is treated prior to the discharge into Tapee River. Locol people request to have ecological training and find out the fighter for environment conservation.

6) Amphoe Kanchanadit

Amphoe Kanchanadit is a historical district, established in BE 18-19. According to the legend of Nakhon Si Thammarat, Kanchanadit used to be named "Thathong."

The study area includes the following 5 tambons: Kadae, Takhianthong, Thathong, Tha Thongmai and Plaiwat.

At Tambon Kadae, the land possession comes in the form of the obtainment of utilization certificates and rents. The main careers are fishery and agriculture. Local agricultural plants are para rubber trees, palm trees and coconut trees. Today agriculture is not very popular. People started to build nesting houses for Swiftlet. Environmental problems are caused by pig farms, farms operated by Chareonpokapan Groups, and Seahorse Company; they cause waste water. Mangrove forests are invaded for the construction of restaurants along the waterfront line. Tourist attractions include Kiengle Seafood, Kiengle Farmstay in the bay area and Hainham Shrine.

Tambon Takhianthong does not have any fresh water source, rice cannot be cultured here. Residents grow coconut trees for consumption. In the future, palm cultivation, which is generally operated by private funds, tends to increase. Mangrove forests make up the area of 1000 rai. Waste water from pig farms are discharged when the areas are flooded. Moreover, an

alcohol refinery located at the upper end of the region also discharges waste water into rivers. The residents would like to see the promotion of mangrove forest tours, which was already started, for example, the on-going construction of walking lanes through mangrove forests which still needs more budgets. A problem of crowdedness is also present at Tambon Takhianthong.

At Tambon Thathong, most of the land belongs to the Department of Royal Estate. 70% of the residents are fishermen. Mangrove forests which are reserved areas make up the area of 300 rai. More forests are grown annually. Due to the capitalists' invasion, the forest areas decrease. The group gathering in the community consists of cooperative group, shell farm group. The emergency problem that people need to solve is water discharged from animal farms should be treated before the release into rivers.

At Tambon Tha Thongmai, there are fresh water, estuarine and salt water fisheries. A fishing location is at Khlong Thathong. Tourist attractions are the monkey training school, homestay services and mangrove forests. Local groups are a dry fish production group; dry fish is a famous product of the region. Tour groups provide the following services: cruises around mangrove forests, visits to shellfish farms at Prab Island. Tourists visit the region during the festival season.

At Tambon Plaiwat, most local people are fisheries. Most fishes can be caught at oyster farms where they can hide themselves at the farm boundary posts. CHARM promotes ecotourism at Tambon Plaiwat.

7) Amphoe Don Sak

Earlier, Amphoe Don Sak was under the control of Amphoe Kanchanadit; it was a sub-district in 1969. Later on in 1971, it was an amphoe.

The study area covers the following 3 tampons: Chonkhram, Chaikhram and Don Sak.

Most of the residents at Tambon Chonkhram inherit land from ancestors. There is no mangrove forest. Rice fields are turned into palm plantations. There are Tiger shrimp farms, most of which are operated by capitalists, such as CV, CP and Srisuban. There is waste water releasing from shrimp farm. Beautiful coastlines are eroding. Most tourists visit the town for meals and leave immediately.

At Tambon Chaikhram are owned by capitalists. Aquatic animals for natural culture include Whiteleg shrimps and Giant Tiger prawns. Nowadays, Whiteleg shrimps are raised in farms owned by capitalists, like CP Groups. The shrimp farms make up the area of 1,000 rai. Capitalists restricted parts of mangrove forests of which the locals cannot make use. Aquatic animals that can be caught include black crabs, snappers and mullets. In the past, aquatic

animals are of a bigger number and of a bigger size; the decrease in the number and the size may be due to the deepening of Khlong Kram in 1998 that brought about the presence of ammonia and the death of aquatic animally as a consequence. The mangrove forests and those in Amphoe Don Sak make up the reserved area of 14,000 rai.

Tambon Don Sak is populated with the locals and immigrants, the first generation of which was from Samui Island. The residents inherit land from their ancestors. Residents in the municipal area rent their houses. Some rent from the Department of Royal Estate by canals.There are palm plantation of about 200 rai. Most of the gardens are joint plantations. The possession of agricultural land is through inheritance and purchase. About 10,000 laborers are from Burma. The area of 10,000 rai of mangrove forests. Kho Lakphetch Cave at Tambon Don Sak was an ecological tourist attraction. A tourist access at the bay is current under the plan; homestay services are being prepared. Tourism projects, joined by CHARM and formed the group of tourism learing at Tong Aoe. The community problem is the capitalists restrict the villagers' access to the sea. Due to the channel excavation of a ferry port, the coastline is too shallow for ship sailing which needs to rely on the ebb and flow of the tide. Factories at Tambon Don Sak are Seahorse, Biodiesel, Parawood, 2 ice producing factories, 5 Crab meat processing factory, a boat building industry, 2 ferry ports and another one under the construction. Environmental effects from factories are waste water, air pollution caused by SEAHORSE, loud noises, chemical contamination in water sources, mud from ferries, and the death of aquatic animals.

8) Amphoe Ko Samui

Samui Island is located in the northeast of Surat Thani, 84 kilometers away from the province. Its area is about 252 square kilometers (157,273 rai). It is composed of 53 islands. 3 islands are populated; they are Samui Island, Phaluai Island and Tan Island.

The study area includes the following 7 tambons: Ang Thong, Lipa Noi, Taling Ngam, Na Mueang, Maret, Bo Phut and Maenam.

At Tambon Ang Thong, the number of nonregistered population is higher than that of the locals. The proportion of nonregistered population to that of the local is 1:3. Most of the residents own their private land. About 1,000 families rent from temples. The increase of the population size leads to the lack of water for consumption. At Tambon Ang Thong, there are few coral reefs most of which were destroyed by landslides from mountains. There are 3 canals at Tambon Ang Thong; they are Charakhe Canal, Lipayai Canal and Bangkham Canal; currently only Lipayai Canal is filled with water. However, if Hinladheng Waterfall dried out, Lipayai Canal

can also be dry. 30 years ago foreign traveled to the region by express boat and small ship cargos. More foreigners are coming with the introduction of ferries. The locals do not want to have an airport built in the region; moreover, they neither like to have any kinds of construction that would overtly disturb the nature. Tourism problems derive from the narrowness of roads which cause problems to the organization of the city according to the city planning. Popular plants are coconut trees, Para rubber trees and joint gardens that contain durians, rambutans, mangosteens and langsaad. It seems that the locals will not increase the number of fruit gardens due to the high price of the land and the lack of water. In the past, 70% of the residents were fishermen but today only 10% maintain the fishing job. The emergency problem is lacking of water supplies they would like to have many small dikes. The reverse osmosis project did not succeed much. They would like to have a fund for the maintenance and reservation of certain coconut species. They also are asking for a market for chemical-free produces in the community.

At Tambon Maret, the residents in this area are the biggest groups that hold title deeds. Most laborers are from the northeast, Burma and Cambodia. The size of the population is 5,000. There are 3 rai of forest areas. An environmental problem is the mismanagement of the waste piled at incinerators. The waste causes bad odor and pollutes water. Waste water discharged from big hotels without proper treatment. The incineration facility is not properly managed and causes foul odor; water used to clean waste is discharged into canals. A treatment repository is not used. Because of the rain, ashes are dissolved by soil. Waste is not separated prior to the incineration.

At Ban Huathanon of Tambon Maret have always been fishermen. The locals are immigrants from Pattani, Nakhon Si Thammarat who have been living at the region for 3 generations. Locals are only fisheries. The numbers of fishes are decreasing due to the increasing number of fishermen and the development of new fishing tools. A common fishing gear is the mini-trawl. Local proposed to plant artificial coral reefs. For 30 years, Tambon Maret started to have tourists in the area.

At Tambon Bo Phut, there are a higher number of non-registered populations than that of the registered. 1 in 3 citizens owns private land. The mangrove forests cover the area of 100 rai. Mermaid Group has planted artificial coral reefs in the sea. Villagers have to buy water for consumption. Environmental problems are the odor from diesel from speed boats, the airport discharges waste water in the sea and causes loud noises. For 40 years, the region has been welcoming foreigners. Earlier, the bungalow services were owned by the locals; later they were

transferred in to a Thai capitalist's hand before being changed into a foreigner's hand. The villagers no longer want to see big hotels in the area. Currently, there is a problem about the Peak Project's news regarding the forest invasion; the problem annoyed the villagers and do not agree with the construction on mountains.

In 1954, people moved in at Phaluai and settled down in 1957. There is no non-registered population. The land belongs to the Treasury Department. A conflict arose due to the institution of the residential areas to be national parks. The villages propose that those who have been living in the area since 1957 should have the right to the land ownership. On average, each resident would get about 30 rai. The locals prefer joint gardens where they grow mangoes and coconuts. Visitors, both foreigners and Thais, started to come in in 2004 by speed boat, traveling from Samui Island to enjoy seafood. Most of the visitors generally pay a day's visit for meals at Ang Thong Archipelago and return to Samui Island. The locals would like to see hotels, run by themselves, for tourists; however, they lack the financial means and the marketing knowledge to fulfill their wish. About 20 meters of the coconut orchards close to the coastline is eroding. For the past 20 years, due to the channel excavation, water currents have been flowing into the land and cause the coastal accretion. Locals are asking for roads, the tap water service and the electricity service. Currently, they are using the solar cell energy during the rainy season; they also use oil lamps. They would also like to have a ferry port for ease of traveling. They also want to enjoy the telephone service. Artificial coral reefs should also be planted. The cultivation of coconut trees were booming in the past and were not much practiced 2 years ago due to the pest problems. They changed coconut to be the para rubber plantations, moreover, the size of plantation area can be expanded to over 1,000 rai.

9) Amphoe Ko Pha Ngan

Amphoe Ko Pha Ngan, located on the continental shelf and in the center of the Gulf of Thailand, is about 100 kilometers to the northeast of Surat Thani. More than half of the district is composed of the mountainous area and is the highland.

Ko Pha Ngan consists of 2 Tambons: Ko Pha Ngan and Ban Tai. There are 6,000 rai of agricultural area. 70% of populations are agriculture, 30% of fisheries. There are non-registered residents. Outsiders move in for jobs. There are about 5000 Burmese laborers. Non-registered citizen cause the waste problems. In the past, only 3 waste collection trucks were needed per day; today, 10 trucks are needed. There is a problem with water shortage; before only 10,000 liters of water was needed per day but these days 30,000 liters is required. The government does not have means to support the expenses for non-registered residents. Then, the

participants in the group discussion proposed that the Cabinet Law 43 should be annulled because the region is a tourist attraction; moreover, laws about the ownership of the construction by the coastline should also be modified. Most of the land ownership belongs to the locals. About 50% of the businesses at Tong Nai Pan Beach are owned by outsiders. They would like to see efforts in reserving sea cucumbers. There have been natural and cultural conservation group for 3 years. There 100 member of this group. The fishing activity is the coastal fishing for squids. The tourism boom started in 1988 with the start of the full moon party, however, some disadvantages resulting from the tourism business involve waste, drugs, lacking of reliance relationship, and noise from entertainments.

3.9.3 Community problems as brought up by the villagers

The field work and community meetings with villagers in the study areas yielded similar problems, which can be classified as follow.

1) Land

The villagers do not own the land they live and work on. They either rent the land from private or government sectors: from the Treasury Department (the land on Ko Phaluai); from the Comptroller General's Department (parts of Amphoe Tha Chana, Amphoe Mueang, Amphoe Kanchanadit, Amphoe Chaiya); from the private owners (Amphoe Mueang); from monastery (Amphoe Samui, Amphoe Kanchanadit, Amphoe Mueang). The problem also takes place as investors bought big pieces of land for shrimp farms in Amphoe Kanchanadit. In some cases, palm oil factories invaded villagers' land, such as the Hua Born case in Don Sak. Finally, coastal erosion in Amphoe Ta Chana, Amphoe Mueang, and Amphoe Kanchanadit was also expressed as the problems.

2) Potable water

Several amphoes lack of potable water, especially in Amphoe Kanchanadit, Amphoe Samui, and Amphoe Mueang. In other places, the waste water from industry is released to canals without proper treatment, as in Amphoe Chaiya, and Amphoe Mueang.

3) Air pollution

The air pollution includes the dust from mine transportation, and wet disposal smell in Amphoe Kanchanadit, the bad odors from the solid waste trucks in Ko Samui, and from seafood Industry in Amphoe Don Sak.

4) Noise pollution

The noise comes from trucks during the night in Amphoe Kanchanadit, and by plane during taking off and landing in Ko Samui.

5) Conflicts

The conflicts occur between the groups of local fishermen and fishing industry; or between local fishermen and shell farm, particularly in Amphoe Tha Chana, Amphoe Tha Chang, Amphoe Chaiya, Amphoe Phunphin, Amphoe Mueang, Amphoe Kanchanadit, and Amphoe Don Sak.

6) Others

Other problems are related to villagers' ways to earn a living. For example, while the government encouraged the local to have sideline jobs, there is a lack of market for local products. In another case, the government allocates to the Muslim villagers in Tha Chana area the job of making dried fragrant flowers for Buddhist cremation, which does not correspond to the local needs.

The analysis and implications in terms of relationship among the villagers, and between villagers and the government have brought up the following conclusion.

The development of capitalism which spreads from urban area to local communities results in industrial expansion and urbanization. This causes several changes in social and cultural aspects. The family-like altruistic community has been replaced by benefit-driven minds and modern marketing systems. Money value has surpassed other social values. The shift from traditional support of kinship to daily wages, usually in cash, has become more obvious. The sharing community has gradually transformed into a competitive community. Higher values are placed on urban life than rural life; as evident in, for example, young children being educated in the city. Materialism forces people to build big houses, use mobile phones, and buy expensive household amenities. As a result, the communal relationship has been broken apart, leaving people with their selfishness. As some villagers need to change their career bases and immigrate from the agricultural society to industrial society, their relationships with the neighbors are also affected.

In term of development, the government sector has attempts to sway the rural society, especially economically. Resources from the rural area such as natural resources, human resources, investment, and labor force from agricultural community are exploited to support the growth of the city and industry. Such progression disadvantages the rural areas and hinders the

development of agricultural community and its local wisdoms, resulting in a wider gap between the rural and urban societies.

As the government's policy plays a big role in the directions of rural development, the relationship between the state and the local people are worth investigating. Followings are the patterns of state – local relationships.

1) The government offices are sincere in developing and managing the local resources to make the most out of it for the community. At the same time, the local do their best to collaborate for their own benefits. This kind of relationship usually assures tangible benefits to the community, as obviously seen in Amphoe Tha Chana.

2) The government sectors are sincere in their policy to develop and manage the local resources to make the most out of it for the community. However, the absence of appropriate communication results in no cooperation from local people as they see it the state duties to develop the country. The local only have to protect their rights and benefits.

3) The government sectors are weak as a leader for the community, caused by internal conflicts on financial and political benefits. Such conflicts make it difficult to put forward government policy for communal development. On the other hand, local communities are strong and cluster under specific purposes such as the Mermaid group (Nang-nguek) in Ko Samui. These groups are funded and supported on the know-how from external private sectors. Hence, it follows that the government sectors and the local communities have conflicts, particularly as the people perceive the government as seeking for profits. Thus, development in this pattern comes solely from the local people.

4) The government sectors are inefficient as communal leaders while the local people expect development brought in by the government. This results in low level of connection between the two entities. Such community is at high risk for the loss of resources to the outside investors.

To find solutions to these communal problems, cooperation and good communication are needed. The figure shows the pattern of ideal cooperation.

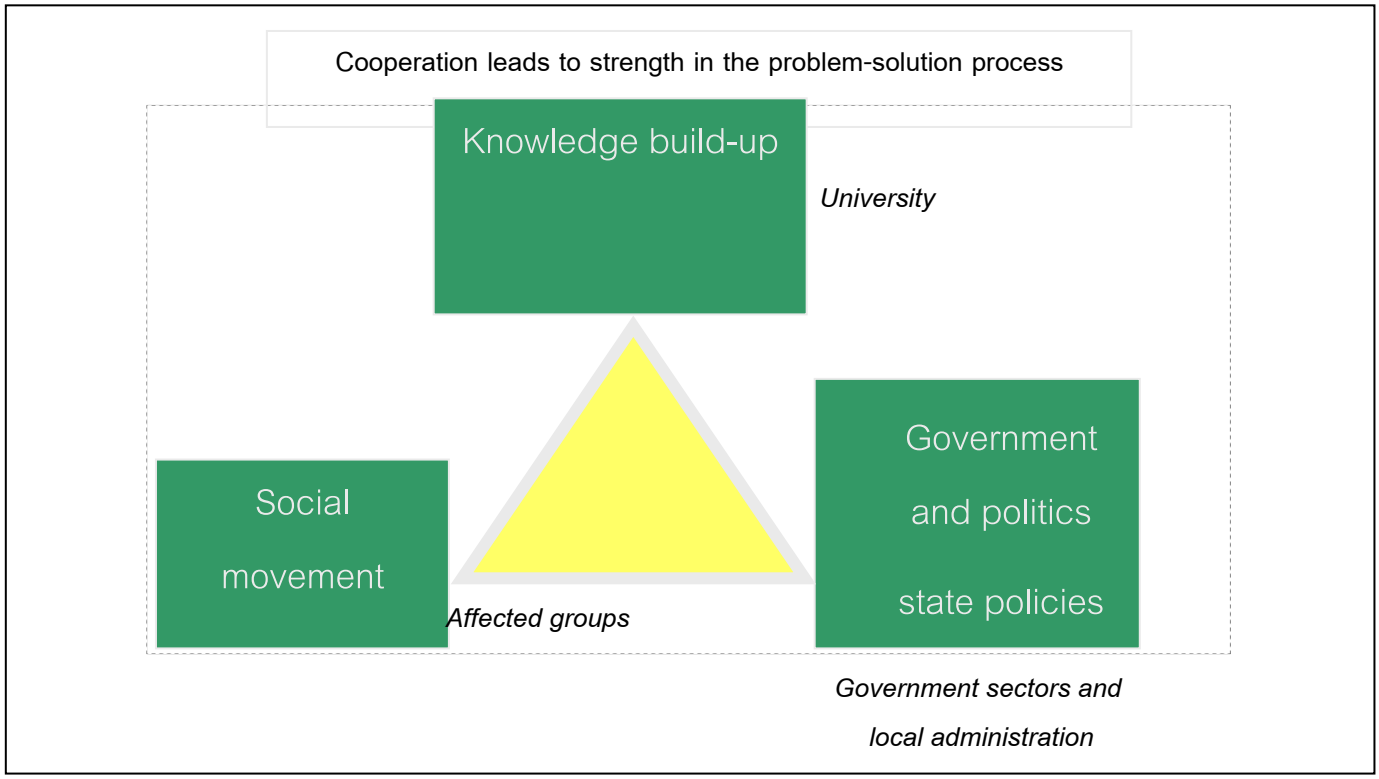


Figure 3.9.1 Cooperation leads to strength in the problem-solution process

Cooperation and appropriate connection from all sectors are crucial for the solution process. The local people need to understand their rights to the government service, and the roles to collaborate in and give directions to the state policies. People also have their role in networking with other communities, and organization such as universities. At the same time, the government, especially the local administration offices with their closest relationship to the local people, must be sincere, understanding, and respecting the community rights. Policies implementation must be concerned with community's economics, and culture. The government should not let themselves be used by any group, and should realize the importance of sharing and unity in the community. The government sectors need to accept the knowledge built by academic sectors such as universities. Vice versa, the universities need to be aware that they play an important role in giving knowledge to the communi

3.10 THE SUMMARY OF RESULT SYNTHESIS

3.10.1 Introduction

The summary of synthesis report of all natural resource and environment sectors in Ban Don Bay has been based on collected data and information presented by each sector. Within this summary, there are 3 main parts as follows: Part I: The Linkages of Ban Don Bay and Its Offshore Islands Natural Resource and Environment with Main Related Activities which shows and explains the main linkages in the system briefly, Part II Conditions and Problems which can provide the summary of the main problems found and finally, Part III: Guidelines for Problem Solutions which shows guidelines for these problem solutions based on the conditions provided from Part I - II, respectively.

As presented in Figure 3.10.1 it shows the whole picture of the synthesis structure, main linkages among all sectors and related activities, conditions and problems and the guidelines for problem solutions.

3.10.2 The Linkages of Ban Don Bay and Its Offshore Islands Natural Resource and Environment with Main Related Activities

This synthesis report has used the Ban Don Bay and its offshore islands natural resources and environment as the starting point due to their important roles of production base and of supportive environment for all main activities in the area. The main activities within the synthesis structure are tourism activities and processing activities. In part of agricultural, fishery and aquaculture activities, they have been recognized as the community-based activities due to the community's main uses and dependence. The "Institutions and Related Organizations" group has been referred to all related parties such as the Department of Fisheries (DOF), Royal Forestry Department (RFD) and Department of Marine and Coastal Resources (DMCR) from the Government that involve and being responsible for the natural resource and environment administrative and management roles. All academic institutions and Non-governmental Organizations (NGOs) can also be included in the institutions and related organizations group as well.

The main linkages of natural resource and environment in Ban Don Bay and its offshore islands with community can be further divided into 2 groups. The first group has been called "Resource Utilizations and Dependence." The resource utilizations and dependence can be

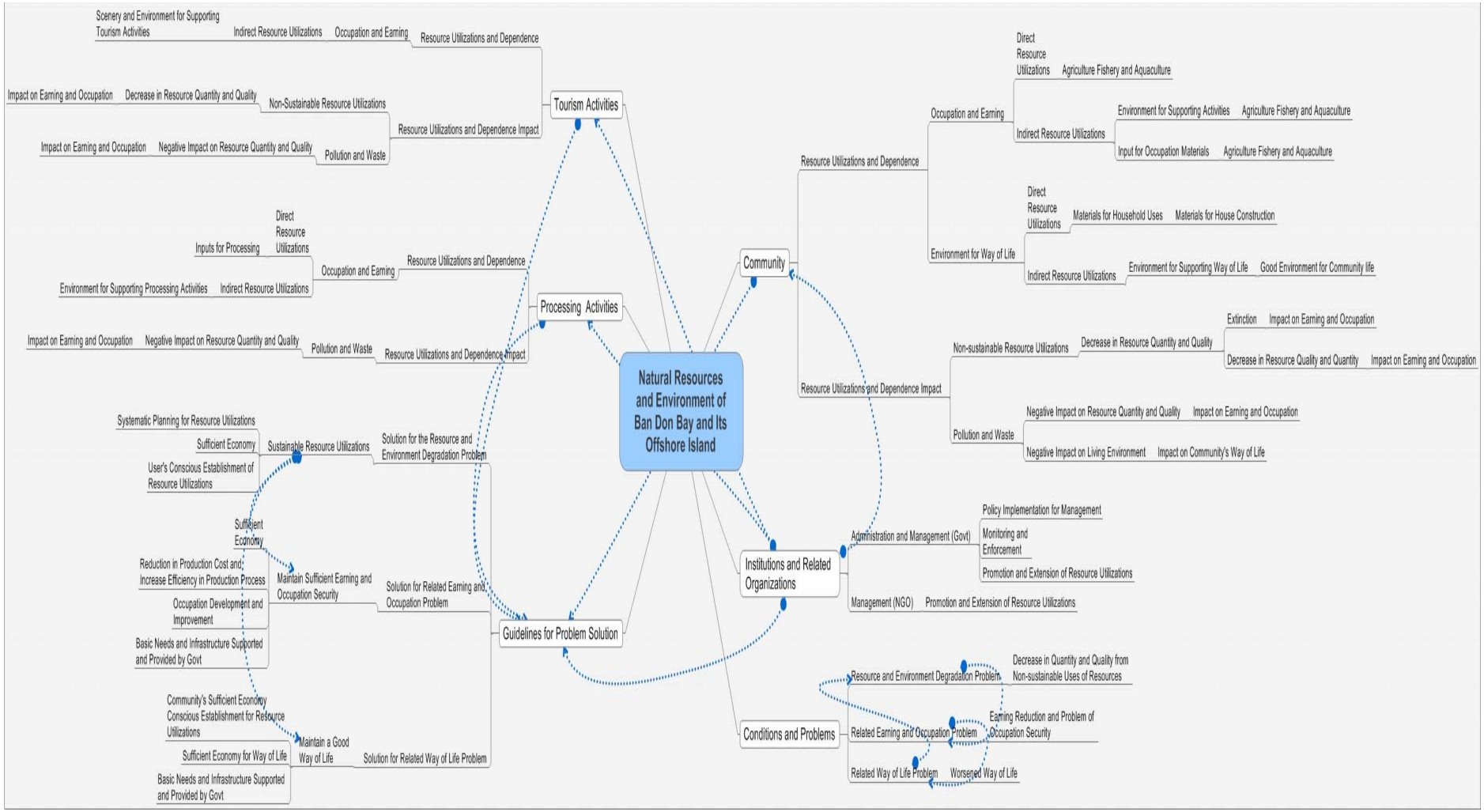


Figure 3.10.1 Result Synthesis of the Ban Don Bay and Its Offshore Islands: The Linkages among Main Activities, Conditions and Problems and Guidelines for Problem Solutions

Referred to the benefits of resource utilizations and dependence through users' earning and occupation. For example, agricultural activities have to involve with land and freshwater resources, fishery activities have to depend on stock of fish from fishery and coastal resources and aquaculture activities have their production bases built on the mangrove and coastal resources. Furthermore, these mentioned activities have been recognized as the direct resource utilizations due to their direct uses of the resources.

Within the first group range, the indirect uses of the resources such as, being environment for supporting these activities and being resource for building occupation materials have been also classified as the "Indirect resource utilizations" group. The agricultural activities, as an example, that being relied on freshwater resource and weather condition for their targeted production can be viewed as the use of environment for supporting activities. Another example with the same type of uses is from the fishery activities and aquaculture systems that have to rely mainly on the healthy level of coastal resources. Tourism activities from community level that have to use their natural resource and environment features to attract all tourists are fit within this type of use as well. Furthermore, the indirect resource utilizations also include the uses of resource for building occupation materials. For example, the local fishermen can build their fishing gears from the mangrove wood.

Another aspect of resource utilizations and dependence for the local community can be viewed through "environment for way of life" group. For example, the local community can use their resources and environment directly through their uses of these resources as input materials for their house construction purposes and their uses of freshwater from nearby natural water resource for their consumption and uses. Their indirect uses can be observed through the good environment for living that being blended within their ways of life.

Meanwhile, the continuously increasing in amount of resource utilizations demanded by the community may be resulted in a negative impact produced to their resources and environment. In addition to the resource utilizations and dependence group, the resource utilizations and dependence impact group has been treated as the second group. This second group can also be divided further to; "Non-sustainable Resource Utilizations" and "Pollution and Waste" groups, respectively. The non-sustainable resource utilizations can cause the decreasing trend in resource quantity and quality which unavoidably has an impact on a reduction in all activities earnings and occupation security. The over-uses of the resources and environment such as, over-fishing and deforestation problems can be used as an example for such uses. The pollution and waste discharged from the community can provide a negative

impact on the resources and environment which are the fundamental bases for their community earning activities and their ways of life and eventually, lead to the problem of their earning reduction and poor ways of life.

The tourism activities have been mainly relied on the quality and quantity of natural resources and environment for attracting all tourists which can generate earnings and occupation for them. Meanwhile, from their activities themselves, they can also cause a negative impact through the system if their activities being in a way of non-sustainable resource utilizations and being discharge carelessly pollution and waste and finally, lead to the problem of their earning reduction.

The processing activities have also directly used these resources and environment as their inputs to produce their final goods. These resources and environment in the system also play a role of supportive environment for processing as their (processing activities) indirect resource utilizations. Also, the negative impact from pollution and waste produced from these activities can reversely do harm to their resource and environment systems.

From the utilizations and impacts of the community, tourism activity and processing activity bases described above, the main utilization purposes have been provided to meet all demands of the community and operators. The resources and environment cannot only be used directly to produce the goods and services but also be used as the supportive environment for all parties to provide occupations and earnings to the community and all operators. As well as the role of occupation and earning generations, these resources and environment are also the bases for the community's way of life. Since the community expansion from the population growth together with the economic growth pressure can result in an increasing demand for resource utilizations from the limited amount of pool resources, therefore, a way of non-sustainable uses of the resource and negative impact from pollution and waste carelessly discharged have commonly been observed throughout the resource and environment systems.

In part of the institutions and related organizations, the linkage of this group with the resources and environment can be described through their administrative and management roles, monitoring and enforcement activities, promotion and extension services. Their roles, activities and services can also be linked with the community and all activity sectors.

3.10.3 Conditions and Problems

From the linkages of natural resources and environment with all sectors described previously, the conditions and problems can be summarized as follows (Figure 3.10.2):

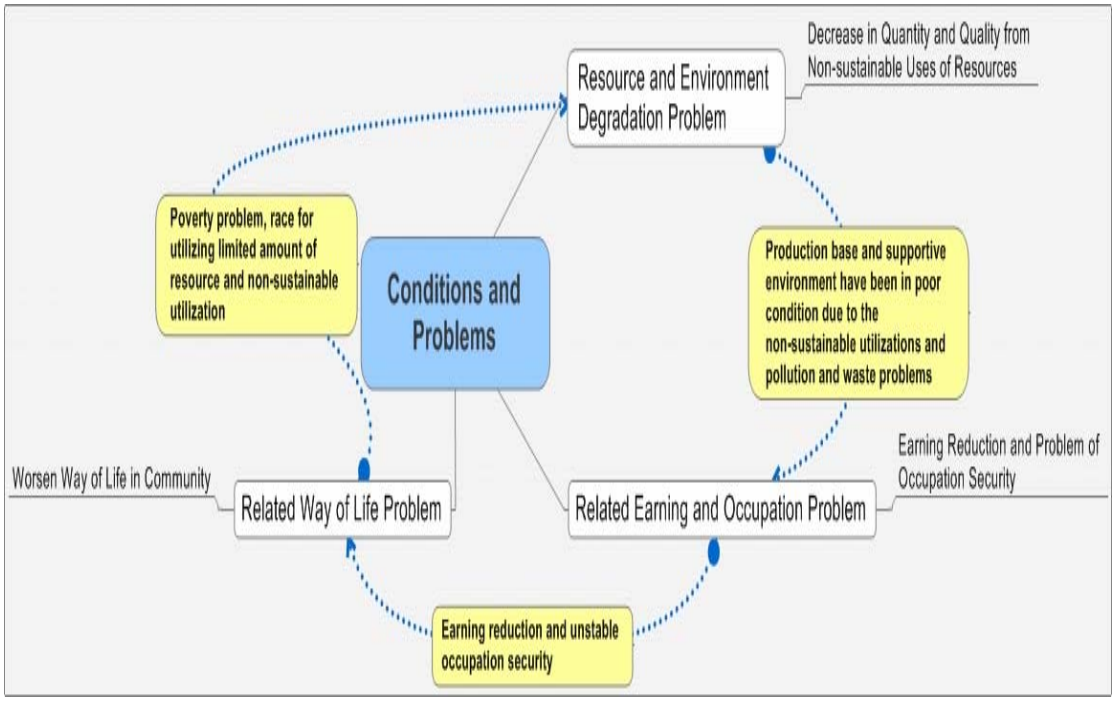


Figure 3.10.2 Conditions and Problems: Linkages among Main Three Problems

1) Resource and Environment Degradation Problems: Based on each main resource sector data and information, the general conditions for some resources can be briefly presented as;

- Forest sector: A decrease in terrestrial forest area due to deforestation for agricultural activity purposes and community wood product has been reported. Meanwhile, an increase in mangrove area from aBan Doned shrimp farms has also been reported. The current condition of forest sector has been linked with the lack of freshwater resource and decreasing amount of wildlife species problems.
- Marine coastal resources: Problems of coral reef and seagrass bed deteriorations which can have negative impact on fishery and tourism activities have been reported. The pollution and waste problems from the community and all activities have also been reported. Some natural coastal erosion has been occurred in some areas.
- Water resource: Problems of freshwater shortage for agriculture activities and community consumption and uses have been reported. The poor quality of water resources (for both sea water and freshwater) has been reported from the

problem of pollution and waste discharged by nearby industry, community and shrimp farm.

- Fishery resource: Problems of decreasing trend of marine species quantity and quality have been reported. Lack of natural seeds problem has been report in some aquaculture activities.

2) Related Earning and Occupation Problems: As a result of the problem 1) persists, the reduction in earning and unstable occupation security can be observed. These problems can be separated into 2 main issues. The first issue involves with the reduction in earning due to the degradation of natural resources and environment as both production bases and supportive environment. Also, the low commodity price in the market due to the amount of product supplied being far exceeded the demand has been recognized as another cause. The second issue involves with the rising trend of input cost due to the shortage supply of the main inputs. These two issues can have seriously impact on their earning and occupation security from all activities.
3) Related Way of Life Problems: As results of the problem 1) and 2) persist, the poverty problem, the race for utilizing limited amount of resources, non-sustainable resource utilization without users' conscious and living environment condition deterioration can force the community and all activities to commit more on problem

3.10.4 Guidelines for Problem Solutions

According to the conditions and problems listed above, the guideline for problem solutions can be presented as:

1) Solution for the Resource and Environment Degradation Problem: The sustainable resource utilizations must be used. The "sustainable" in this solution means the uses that being well continuously matched with the capacity of limited resources and environment and can bring about the balance of the system in the long run. The systematic planning for resource utilizations must be developed and implemented. This planning can only be obtained through the integrated planning of all resource types. The "Sufficient Economy" concept can seriously be applied as the first objective for all users. The community and all activities establishment of possessive conscious of their resources and environment must be continuously developed and maintained.

2) Solution for Related Earning and Occupation Problem: An attempt to maintain the sufficient earning and occupation security is the main target. According to the first solution provided previously, the “sustainable” in this solution can be obtained from the sustainable resource uses with the reflection of well planning in production process and produce the optimal amount of goods that conforms to the market demand and supply mechanism. The concept of “Sufficient Economy” can be used as the fundamental concept for all parties. The way to reduce the production cost and increase the production efficiency has to be developed continuously to maintain their competitive competence. The new occupation development and current occupation improvement also have an important role in this solution. The supportive roles from the Government about their basic needs and infrastructure such as, irrigation system and electricity have also been required.

3) Solution for Related Way of Life Problem: An attempt to maintain a good quality of life can be started from the establishment of the community possessive conscious of their natural resources and environment for their sustainable utilizations and their reduction on the negative impact produced back to the resources and environment systems. The concept of “Sufficient Economy” can be applied to their way of life since this fundamental concept can directly solve the problem from the beginning. The supportive roles from the Government about their basic needs and infrastructure such as, infrastructure and education have also been required.

In summary, all three solutions can only be effectively implemented through a serious cooperation and participation from the community, all related activities and institutions and related organizations. The institutions and related organizations can take their serious actions for their administrative and management role, monitoring and enforcement activities and promotion and extension services through/with the cooperation from the community and all related activities that have their roles as the users in the system. The well systematic planning for resource utilization, production and conservation can be developed through the cooperation and participation from all parties.

CHAPTER 4 DATA ANALYSIS

4.1 OVERVIEW

The study results of the EVI of each zone of Ban Don Bay are shown in Figures 4.1.1 to 4.1.37 and the calculation of IRI, EDI, REI values and summation of EVI value is shown in Table 4.1.1 to 4.1.9

4.1.1 Amphoe Tha Chana

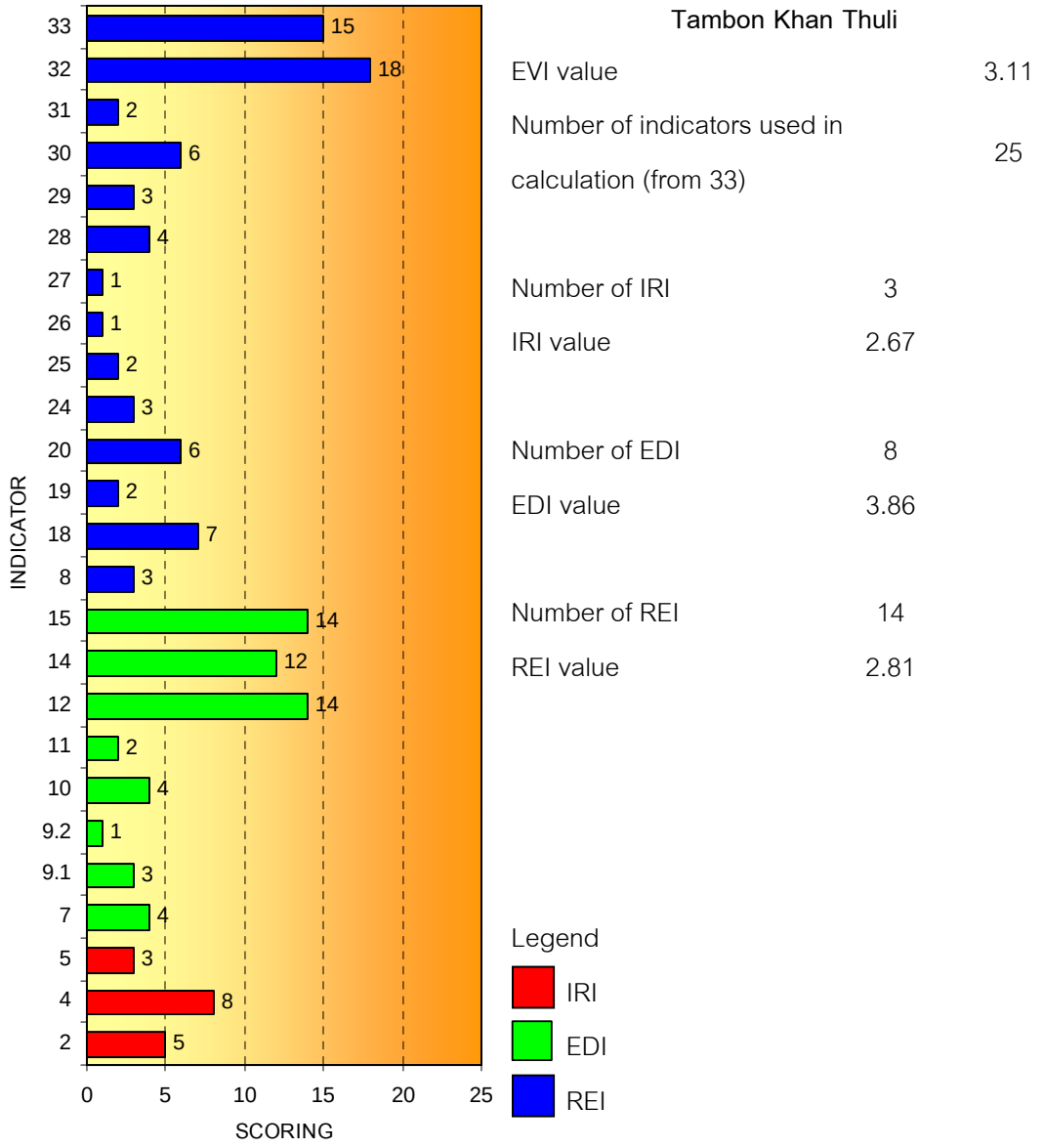


Figure 4.1.1 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Khan Thuli, Amphoe Tha Chana

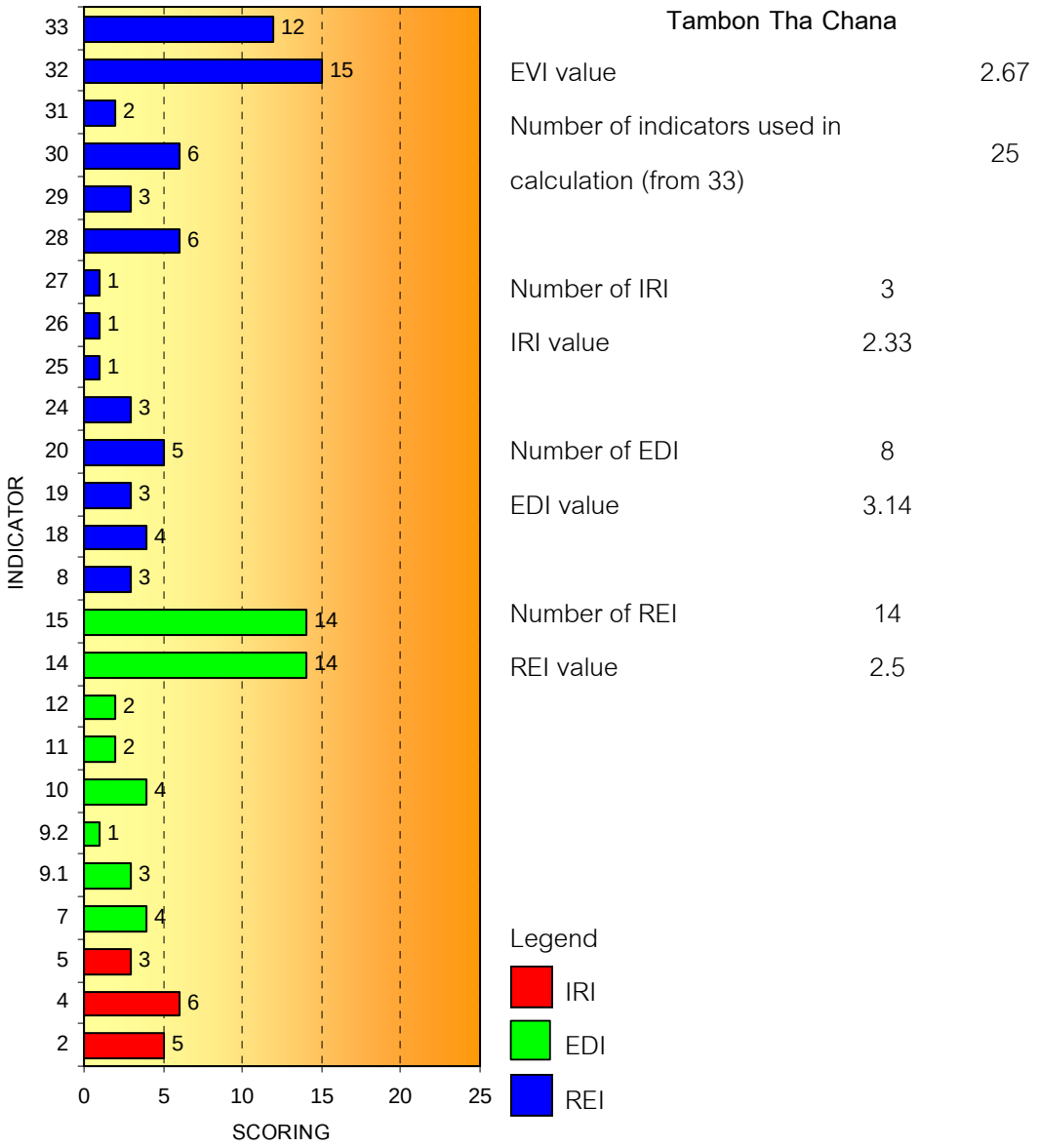


Figure 4.1.2 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Tha Chana, Amphoe Tha Chana

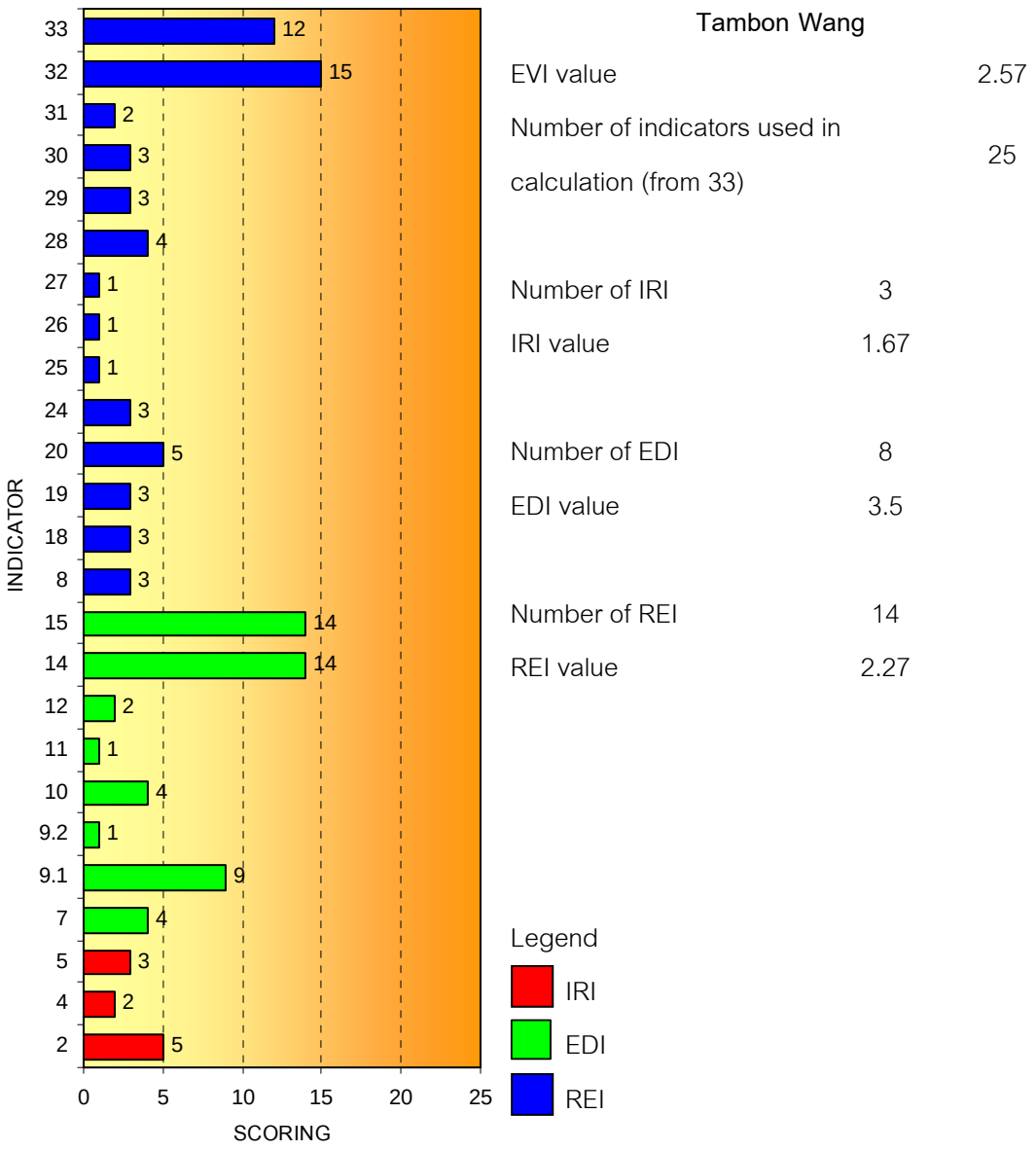


Figure 4.1.3 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Wang, Amphoe Tha Chana

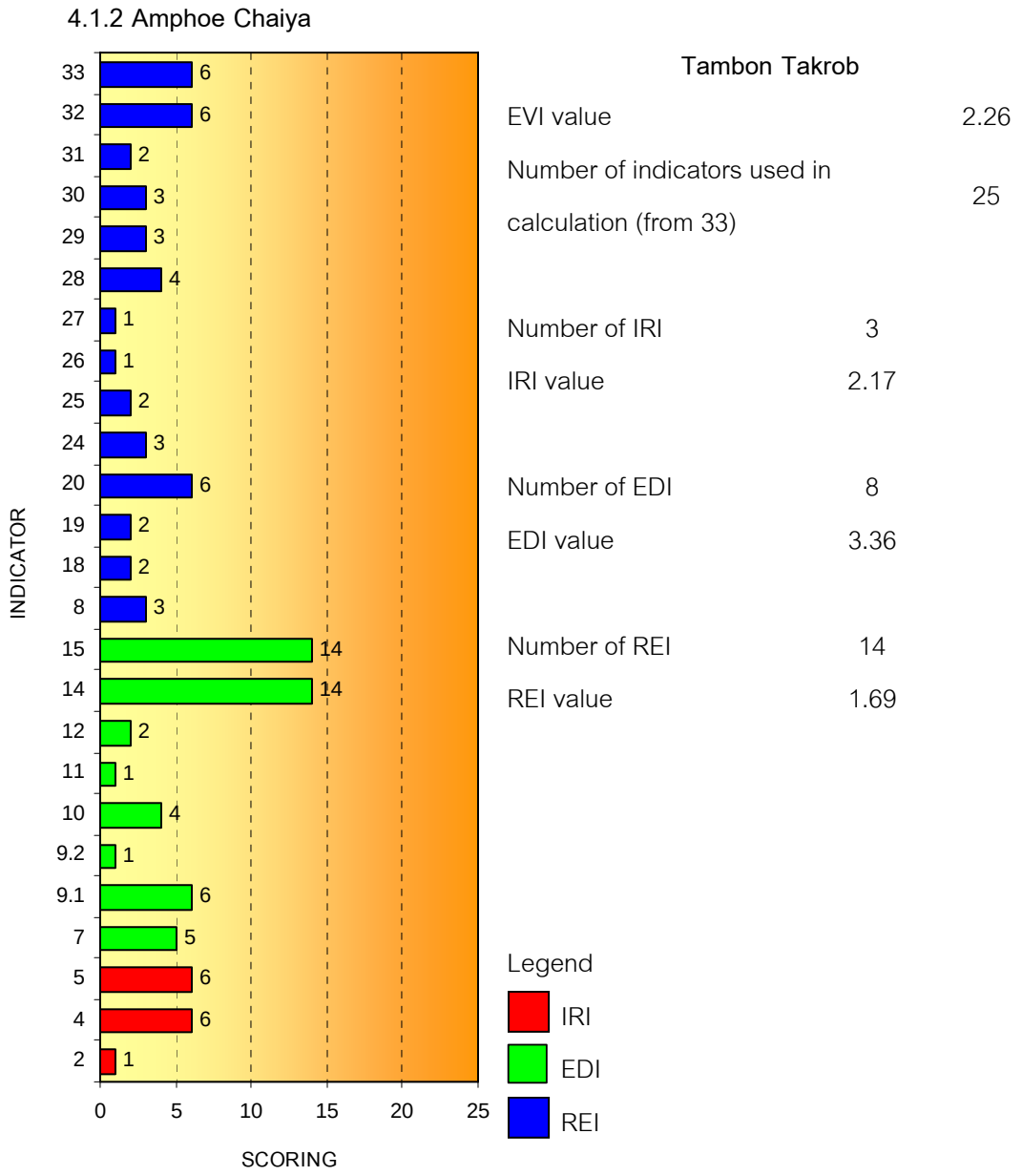


Figure 4.1.4 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Takrob, Amphoe Chaiya

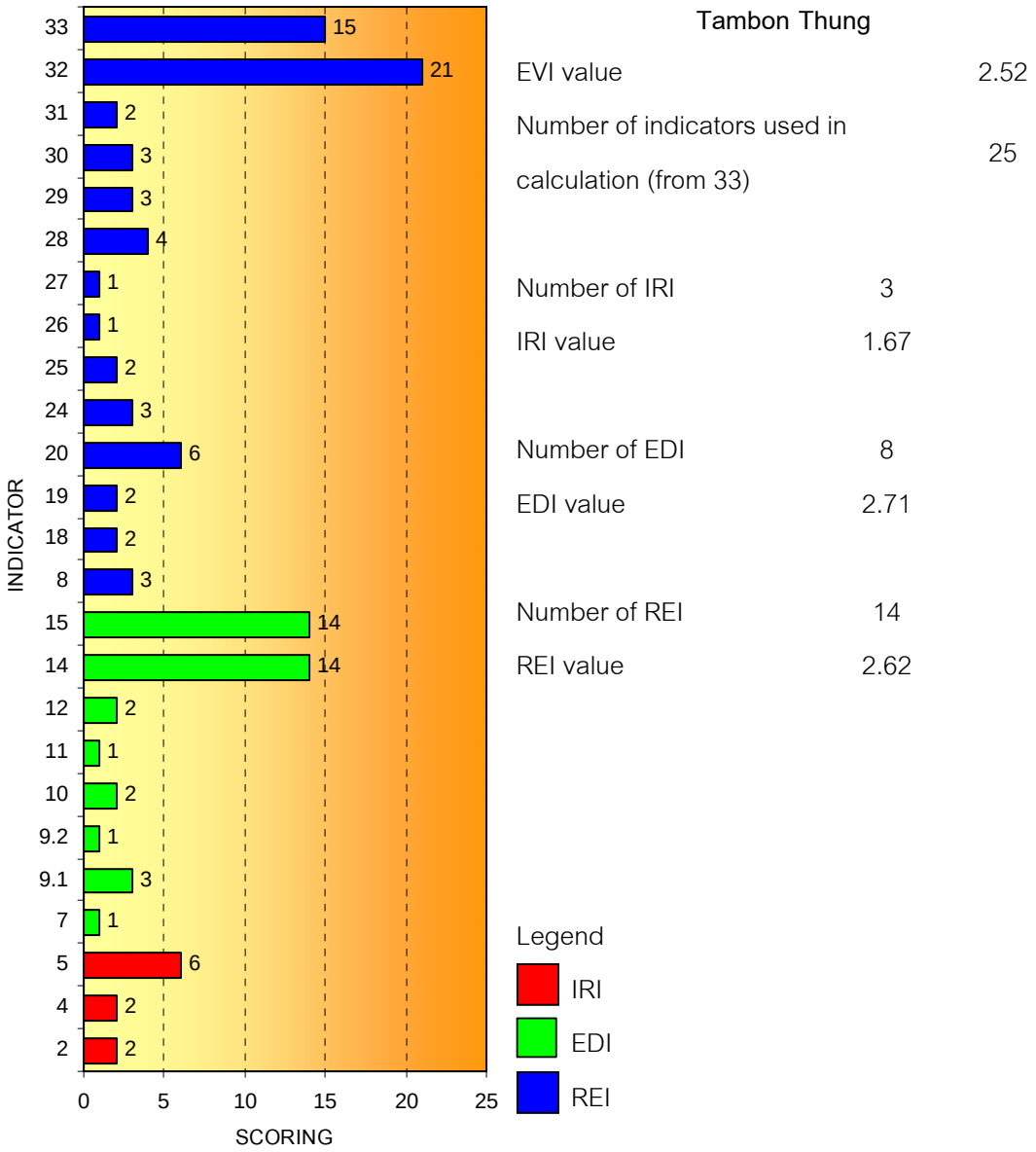


Figure 4.1.5 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Thung, Amphoe Chaiya

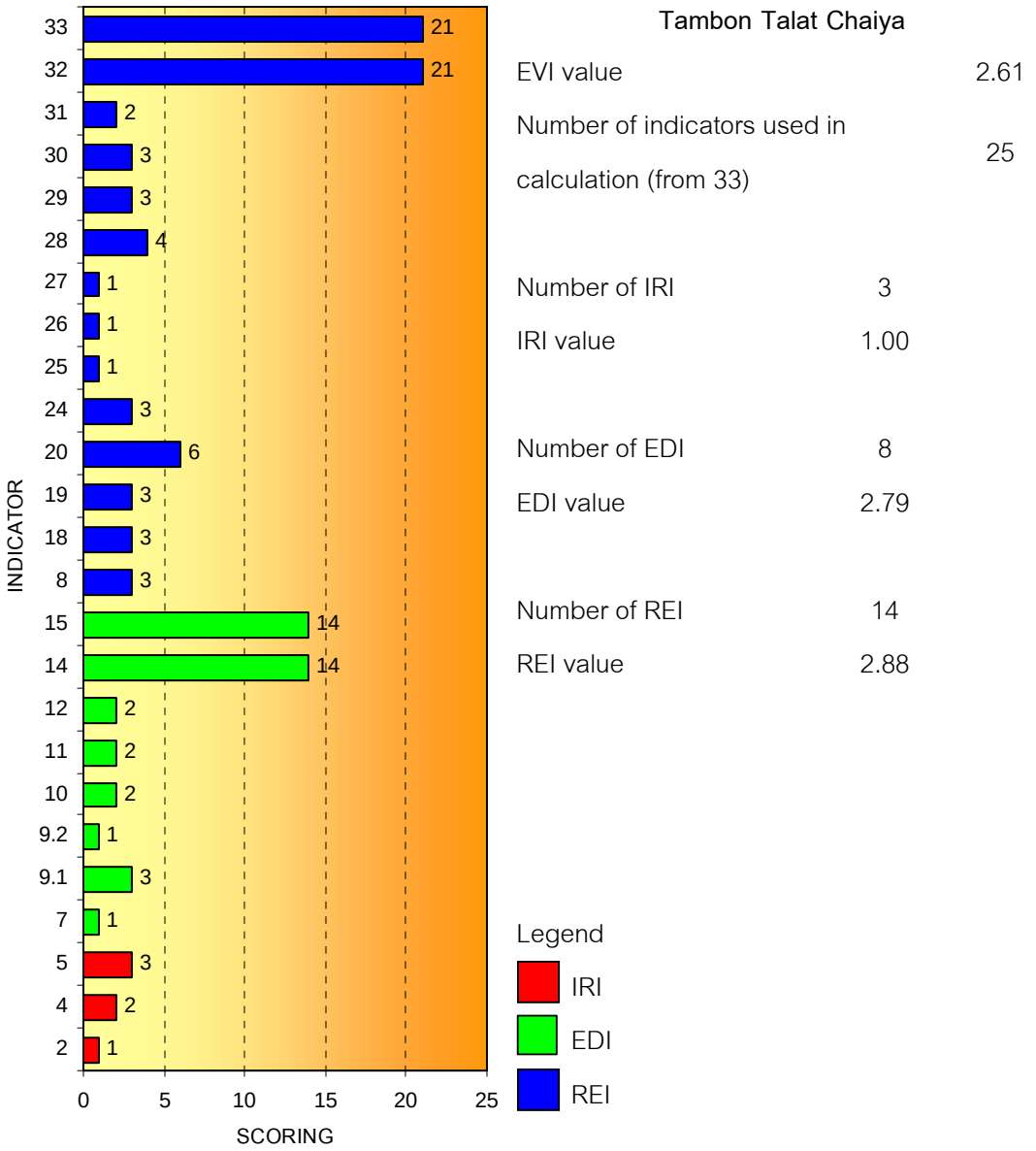


Figure 4.1.6 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Talat Chaiya, Amphoe Chaiya

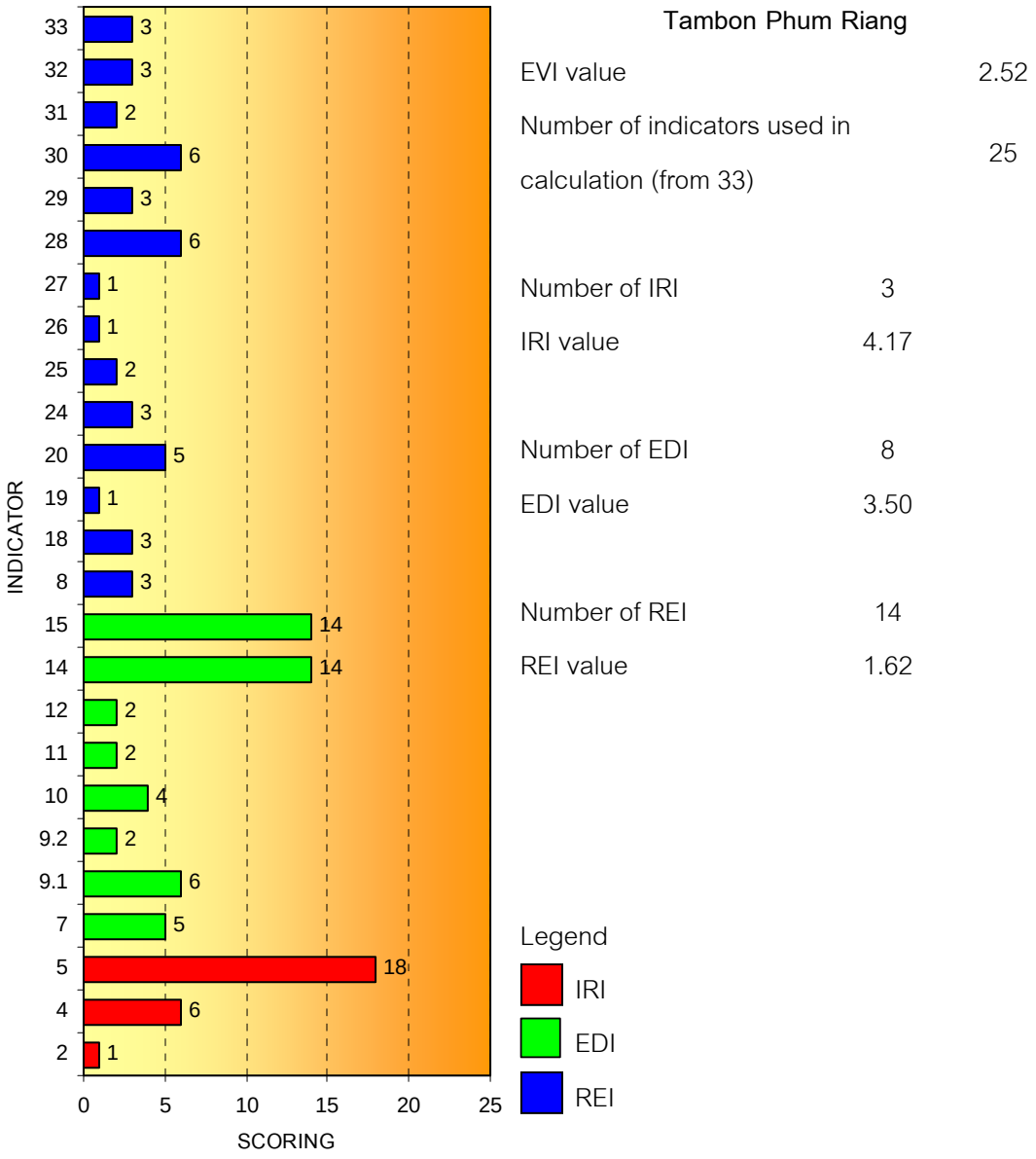


Figure 4.1.7 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Phum Riang, Amphoe Chaiya

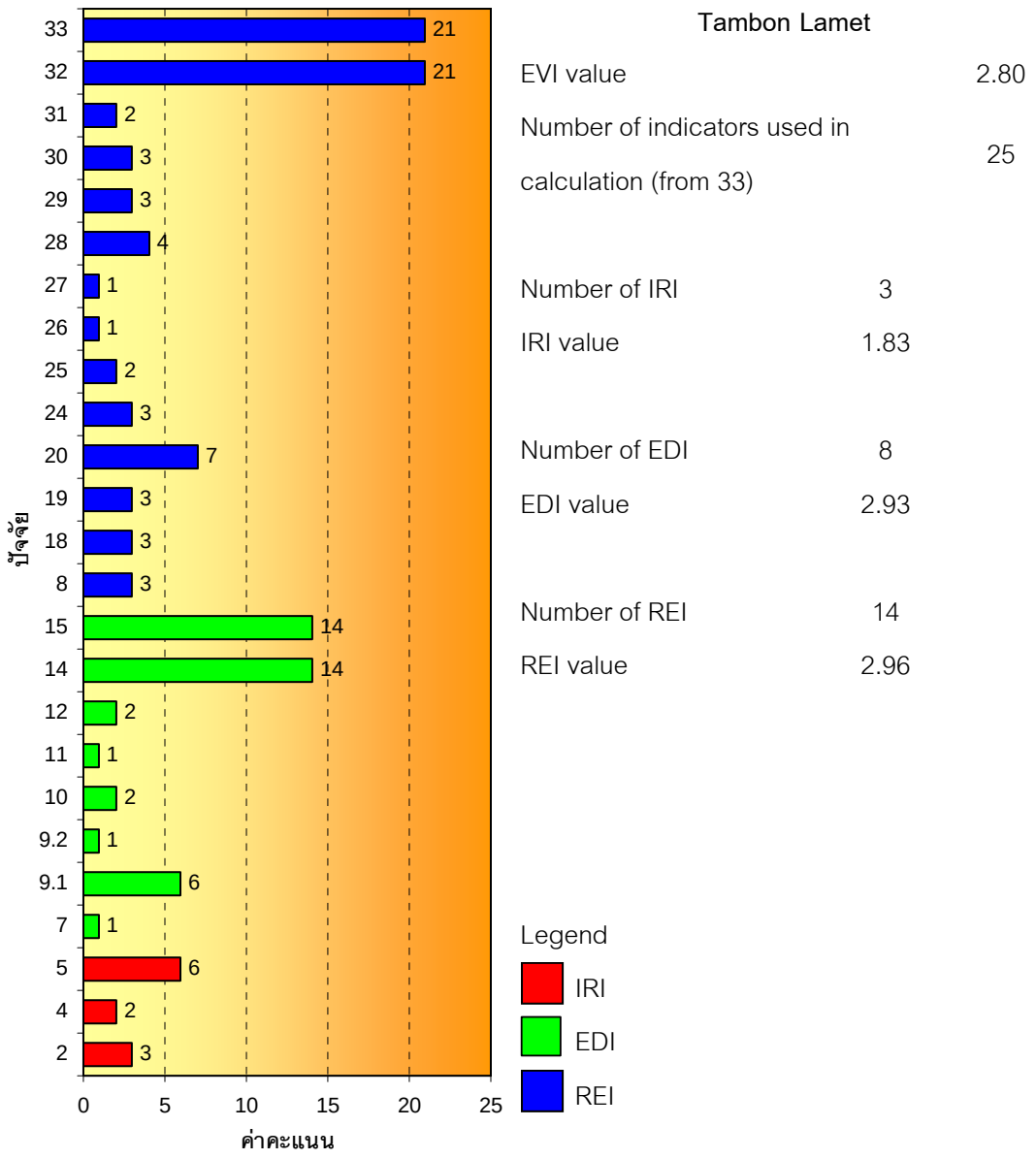


Figure 4.1.8 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Lamet, Amphoe Chaiya

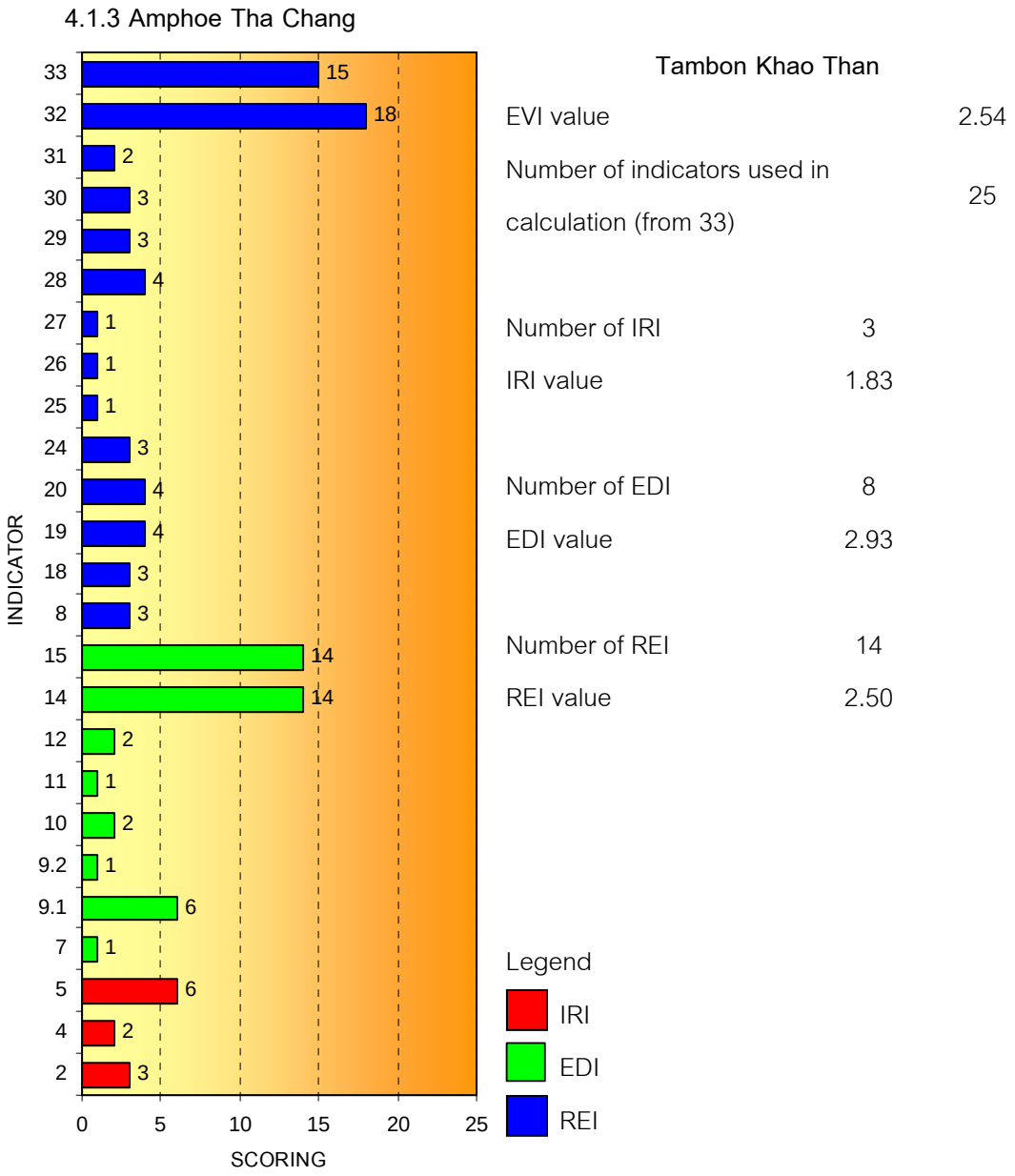


Figure 4.1.9 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Khao Than, Amphoe Tha Chang

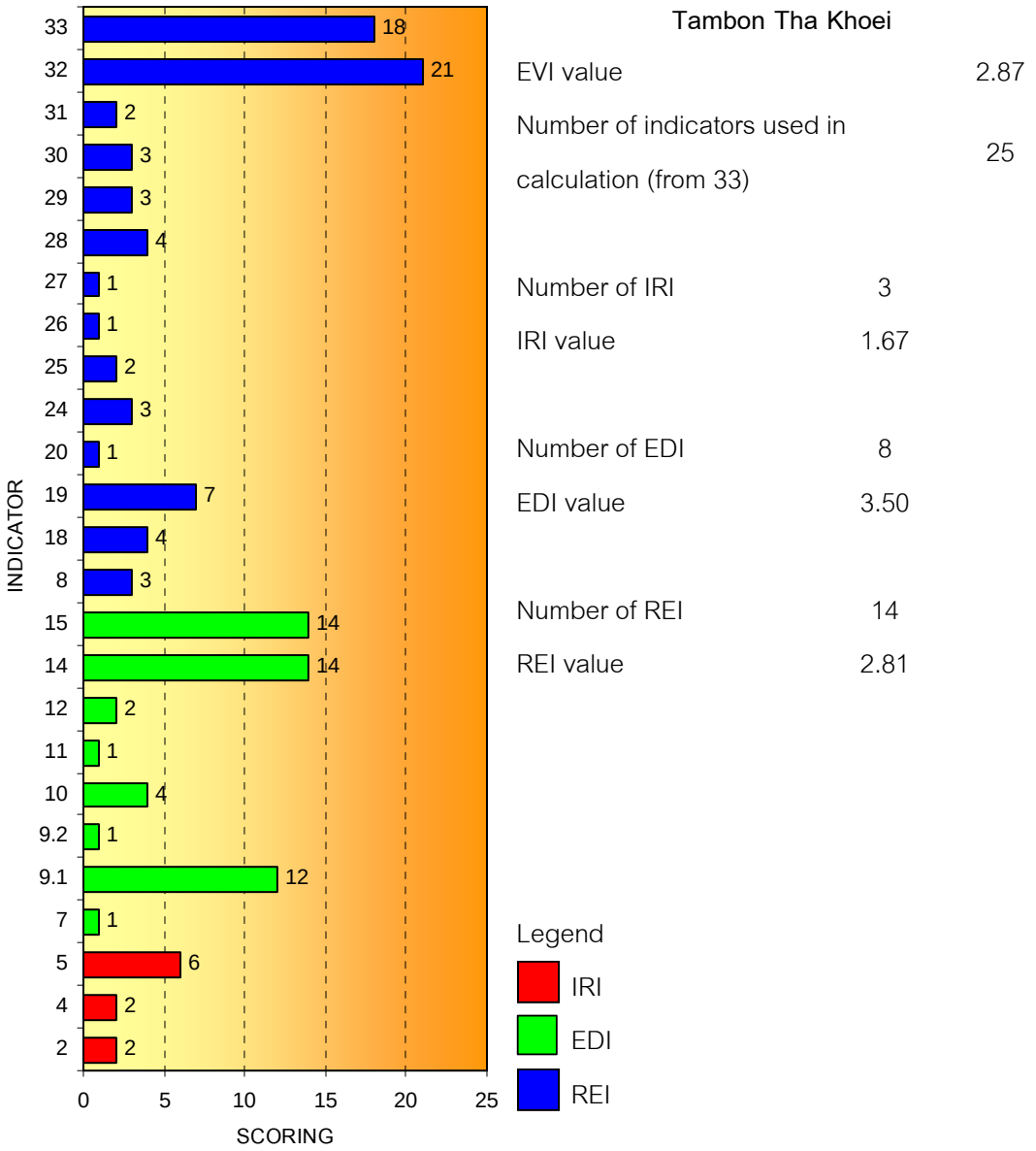


Figure 4.1.10 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Tha Khoei, Amphoe Tha Chang

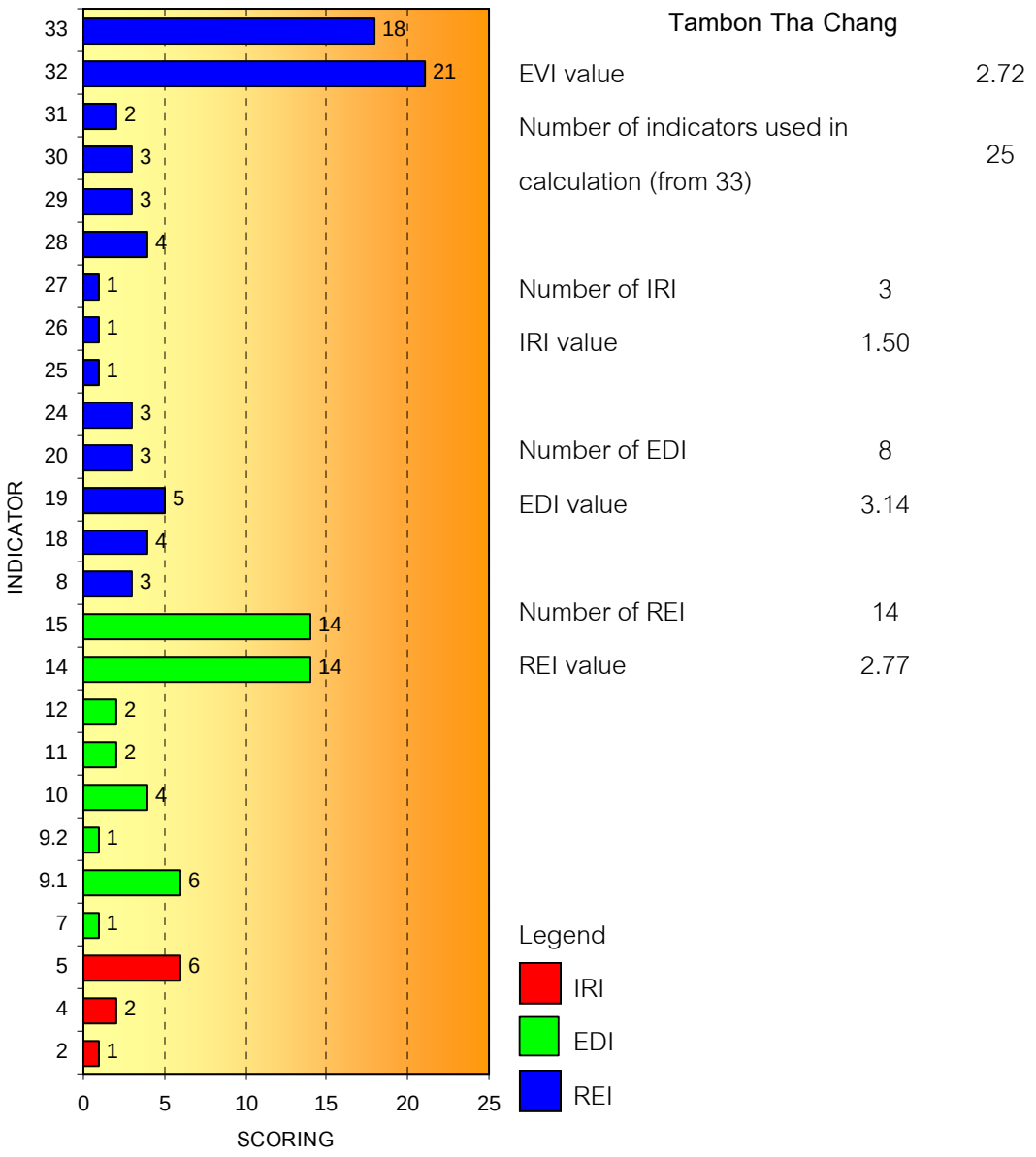


Figure 4.1.11 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Tha Chang, Amphoe Tha Chang

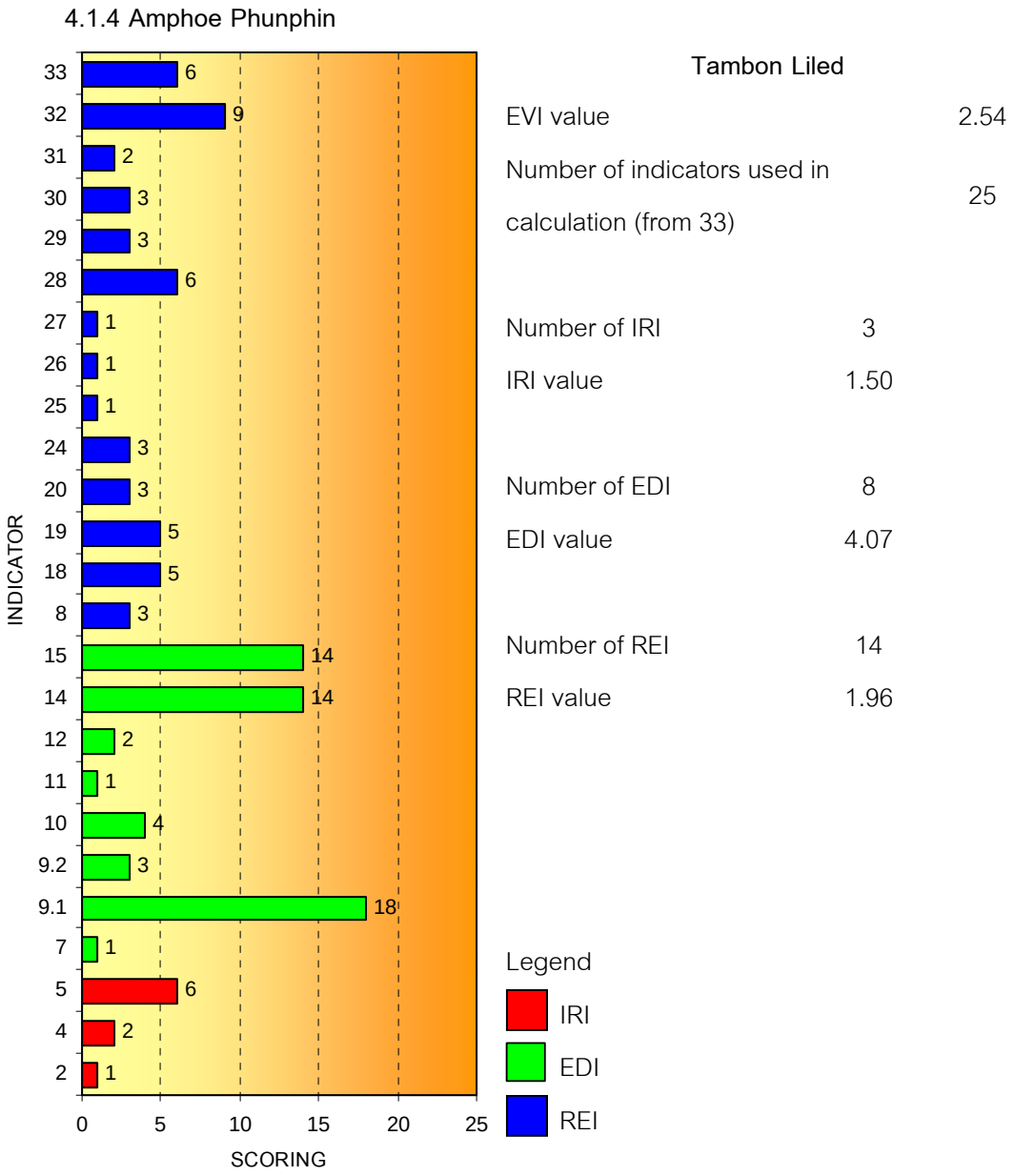


Figure 4.1.12 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Liled, Amphoe Phunphin

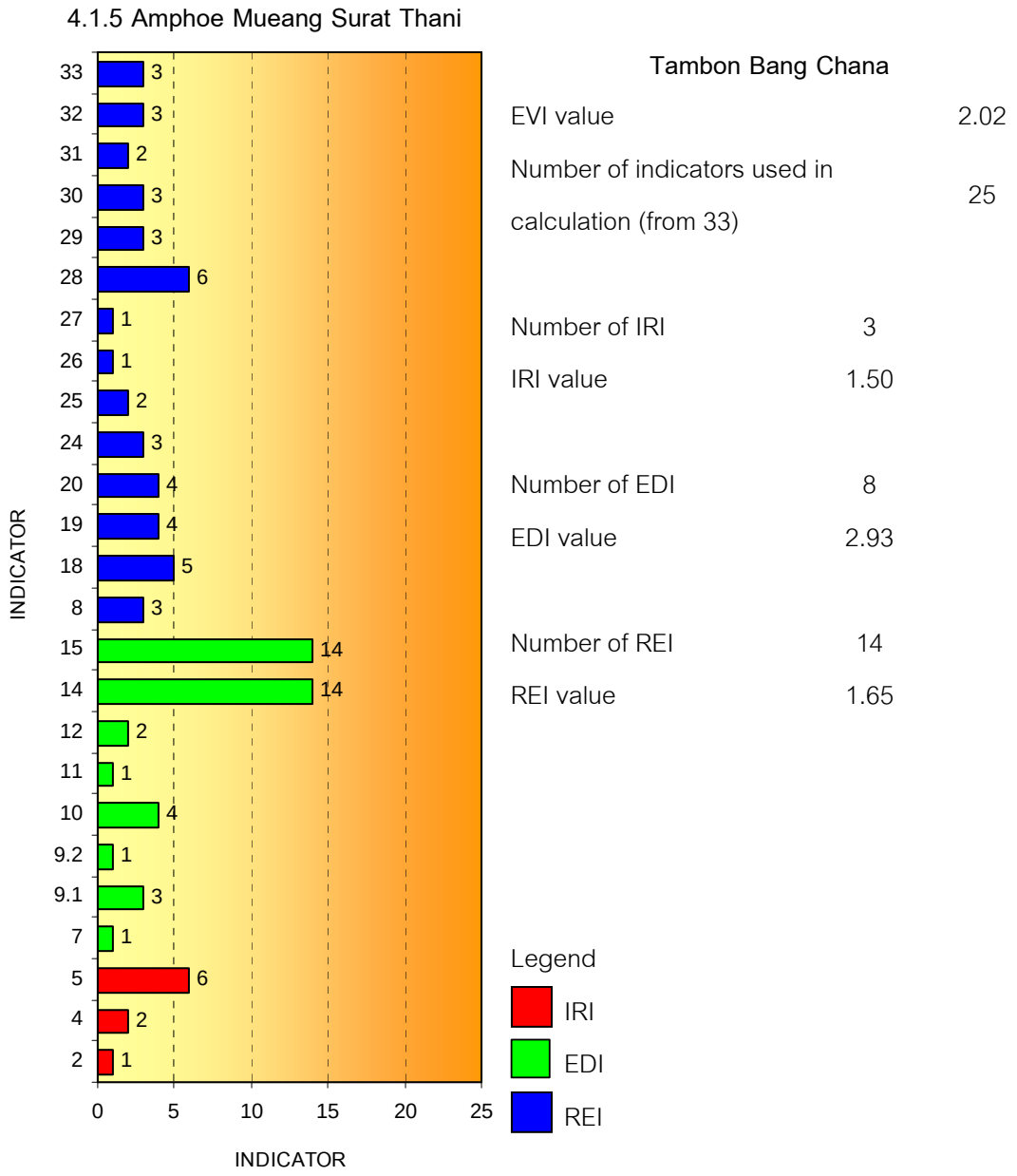


Figure 4.1.13 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Bang Chana, Amphoe Mueang Surat Thani

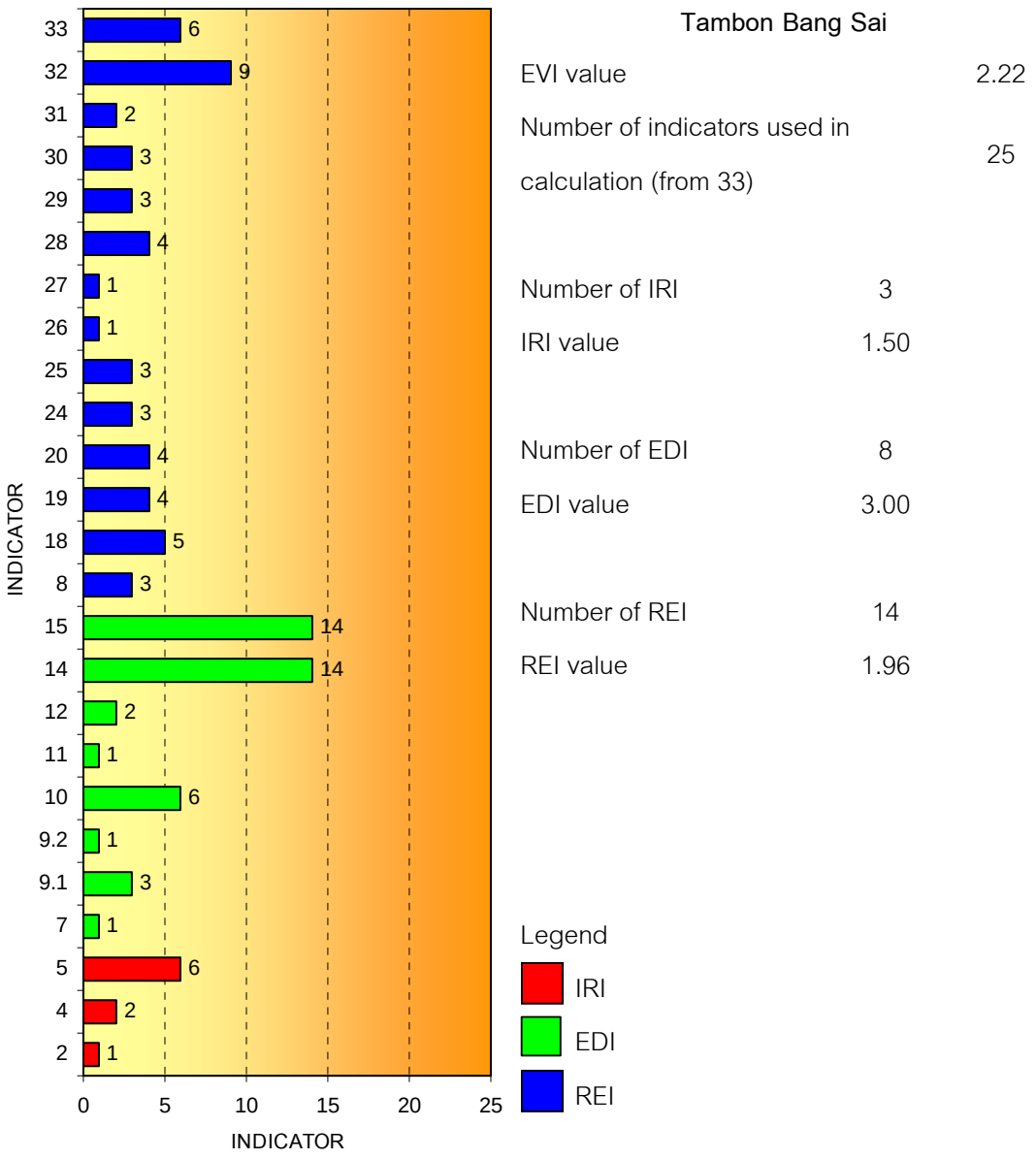


Figure 4.1.14 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Bang Sai, Amphoe Meaung Suratthani

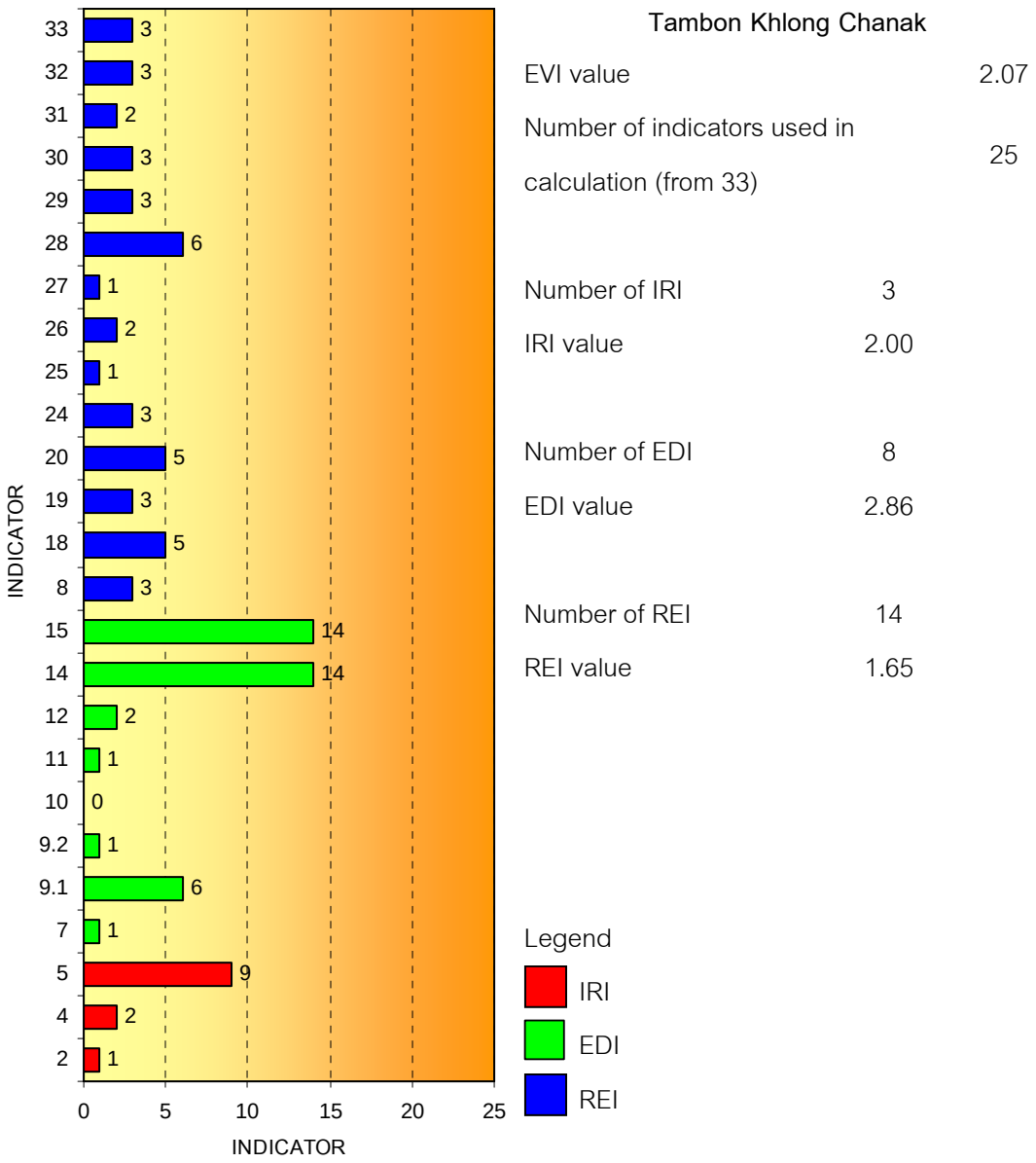


Figure 4.1.15 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Khlong Chanak, Amphoe Meaung Suratthani

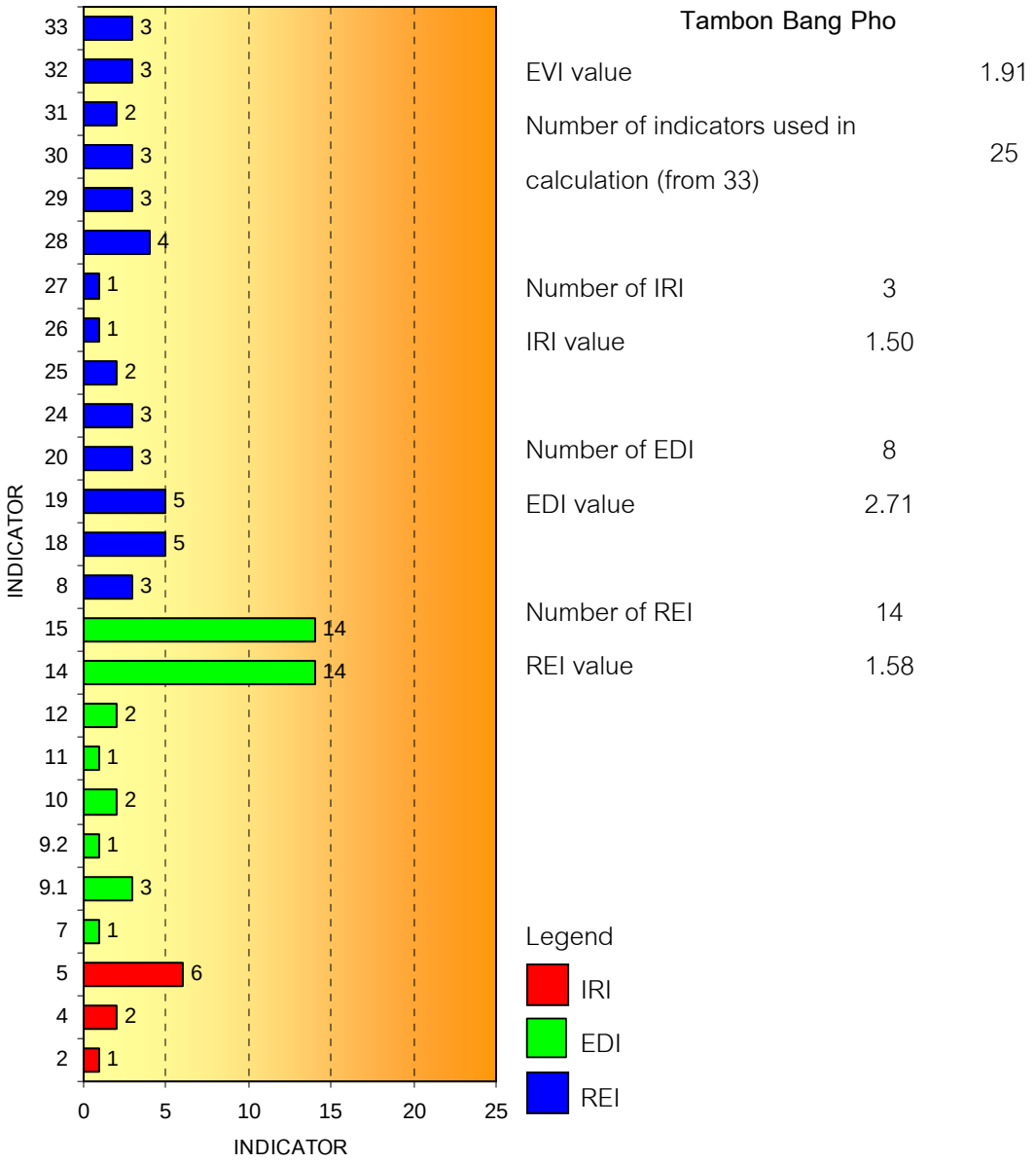


Figure 4.1.16 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Bang Pho, Amphoe Mueang Surat Thani

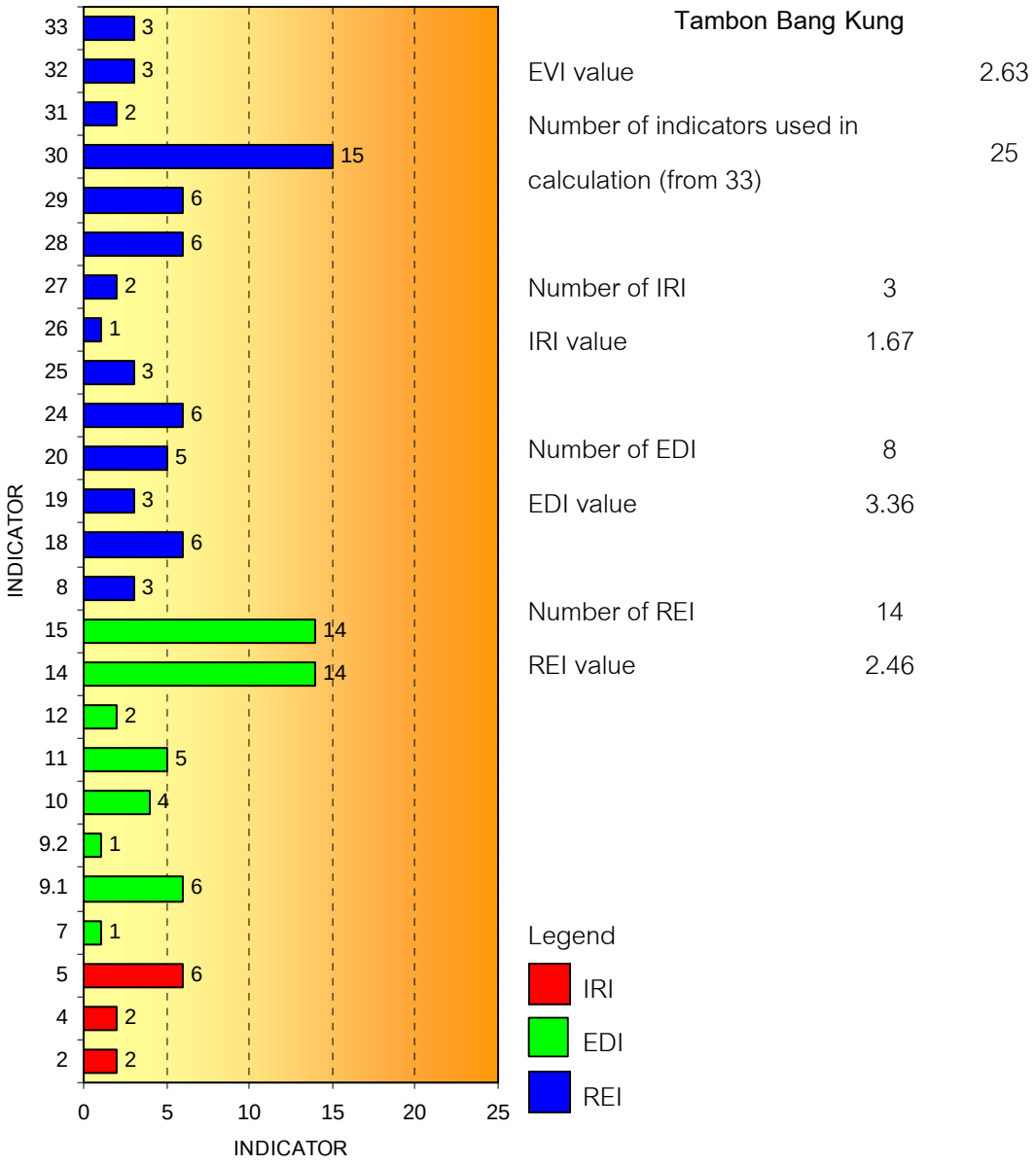


Figure 4.1.17 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Bang Kung, Amphoe Mueang Surat Thani

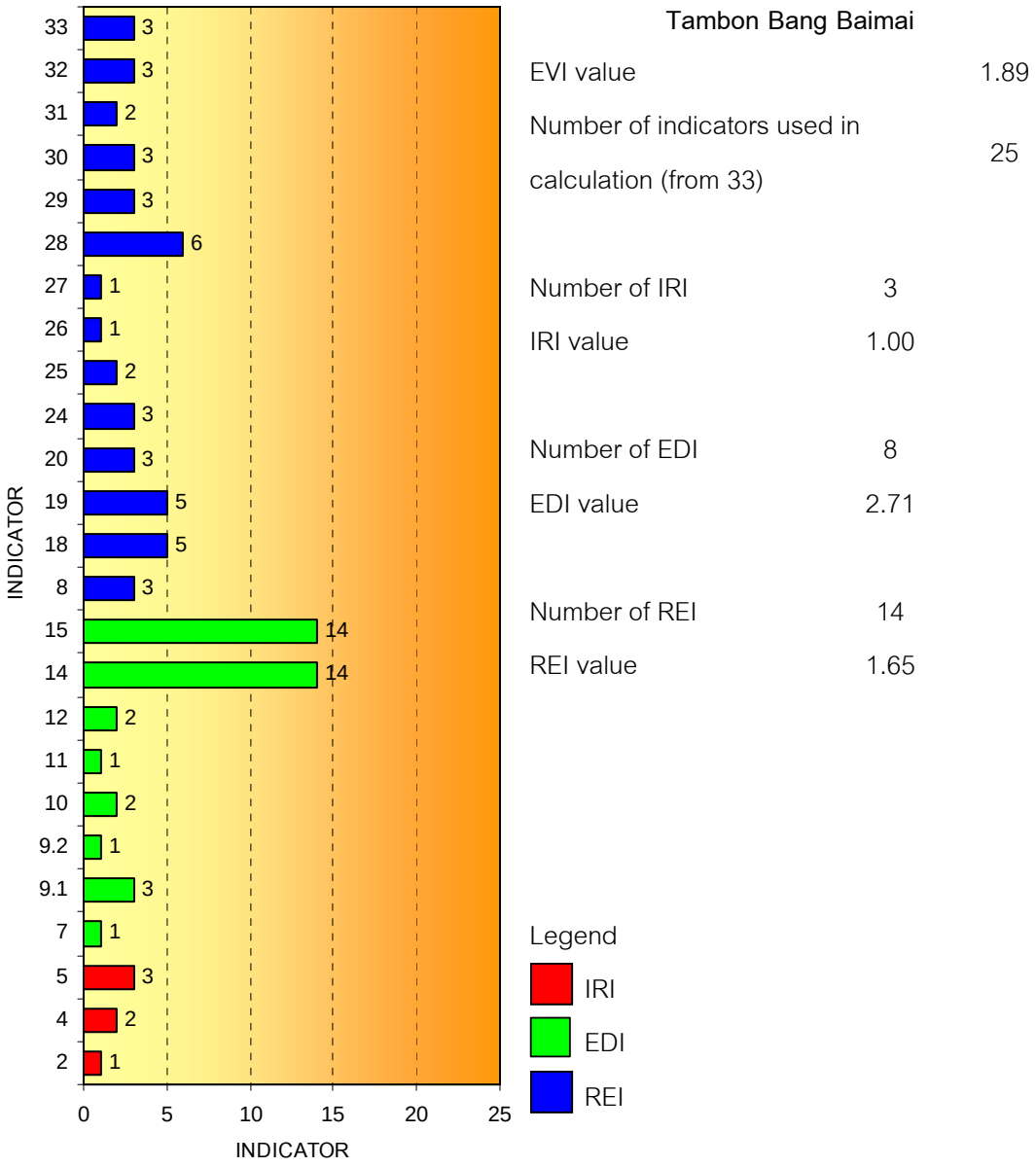


Figure 4.1.18 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Bang Baimai, Amphoe Mueang Surat Thani

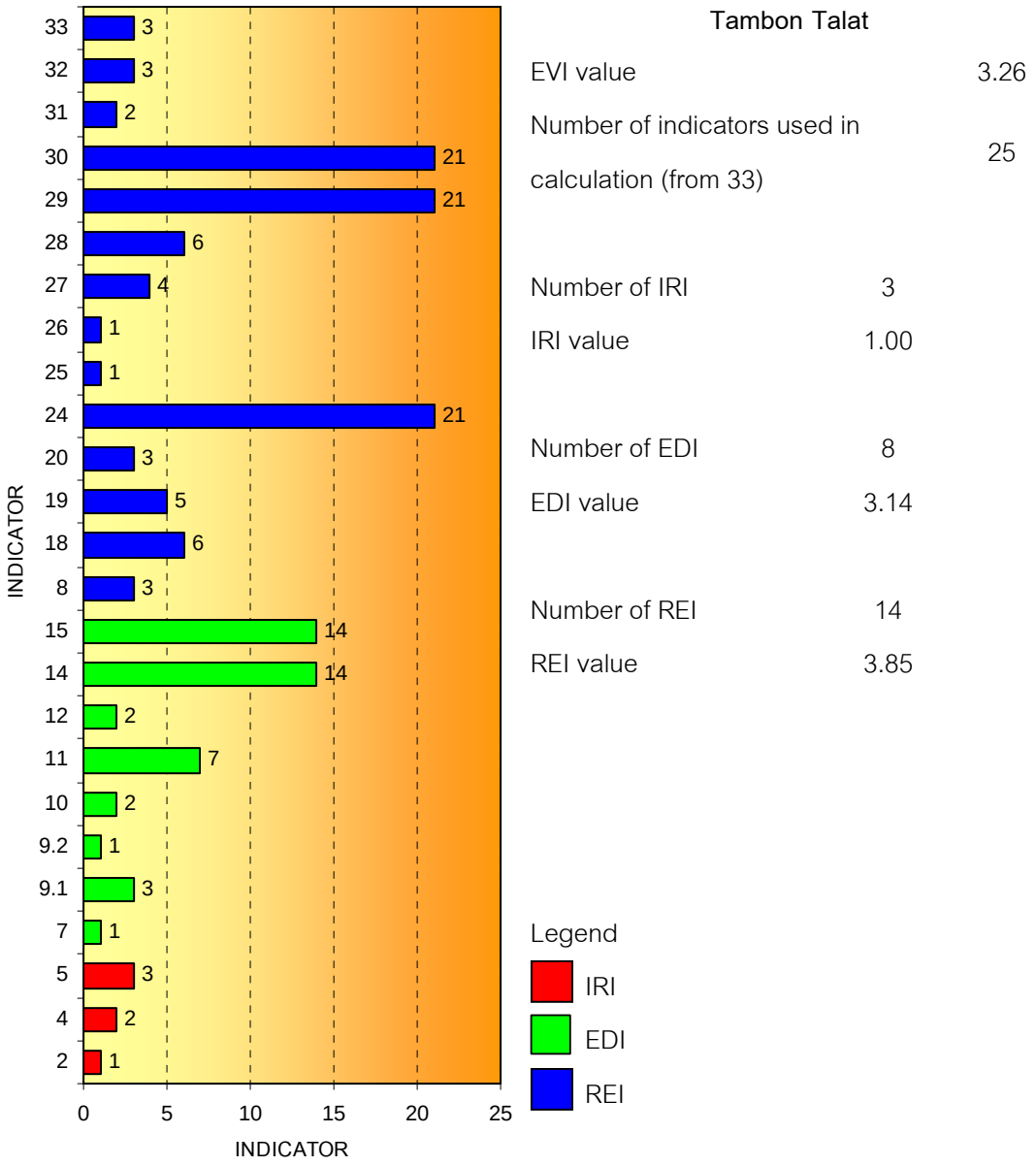


Figure 4.1.19 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Talat, Amphoe Mueang Surat Thani

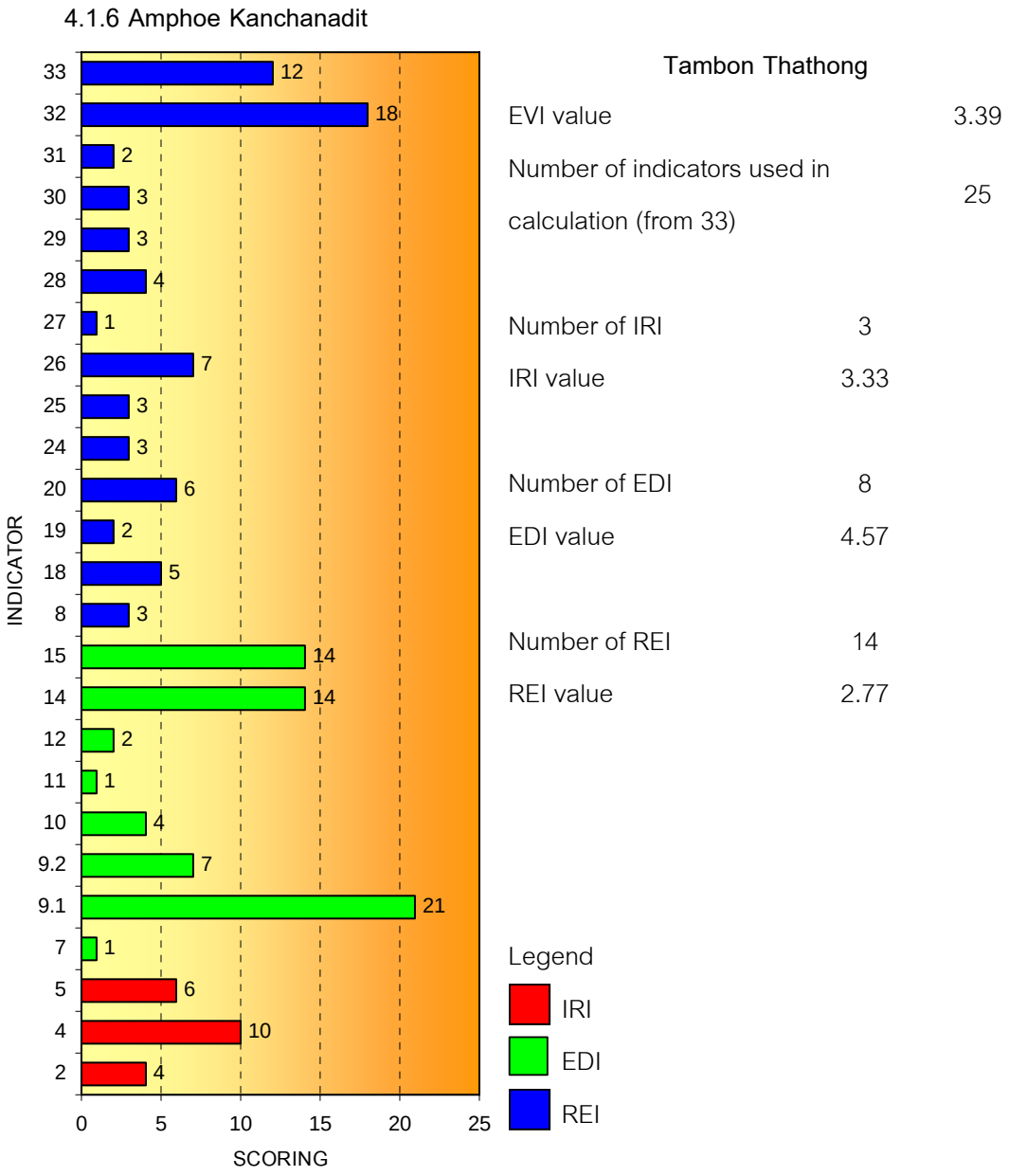


Figure 4.1.20 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Thathong, Amphoe Kanchanadit

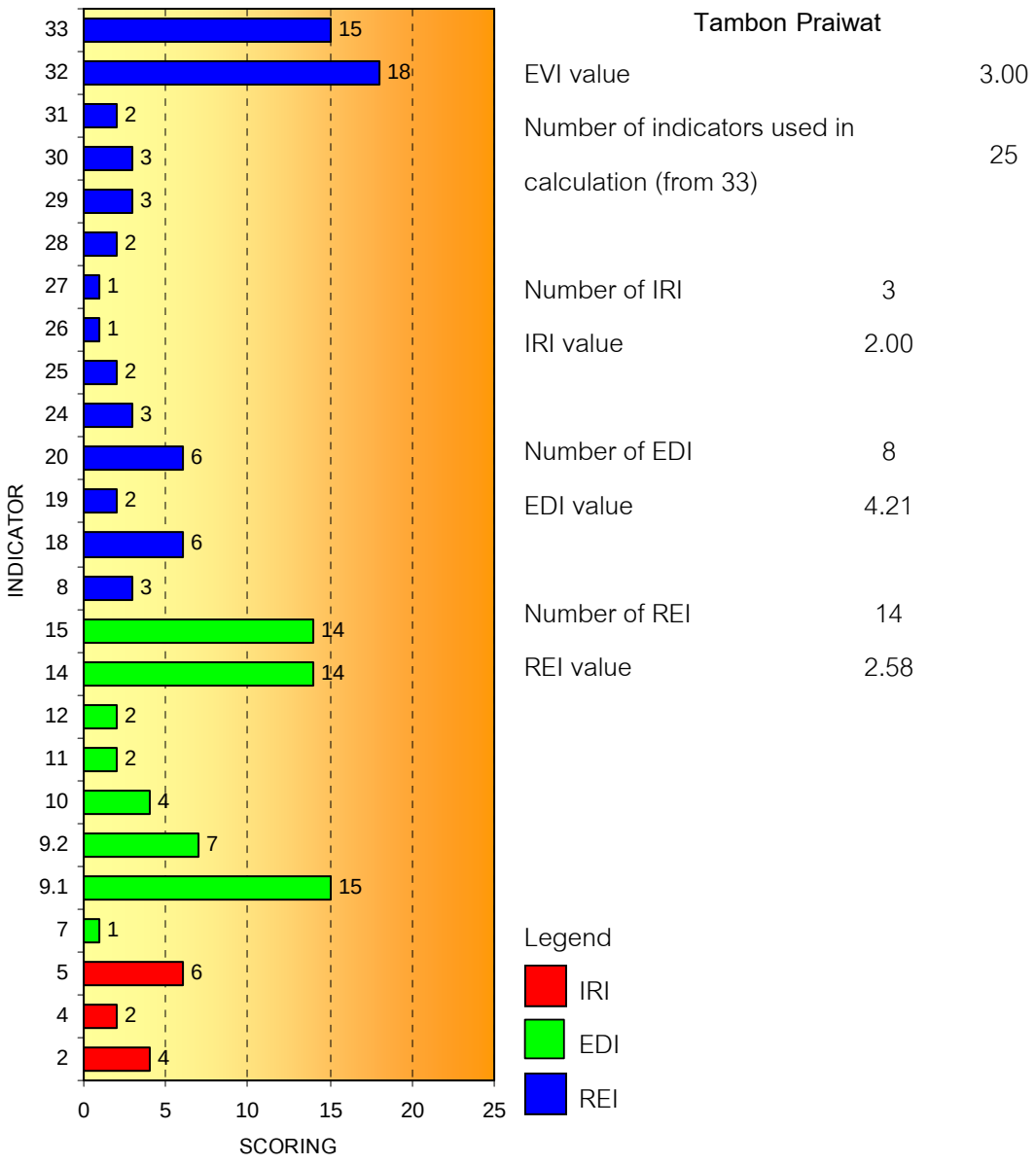


Figure 4.1.21 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Praiwat, Amphoe Kanchanadit

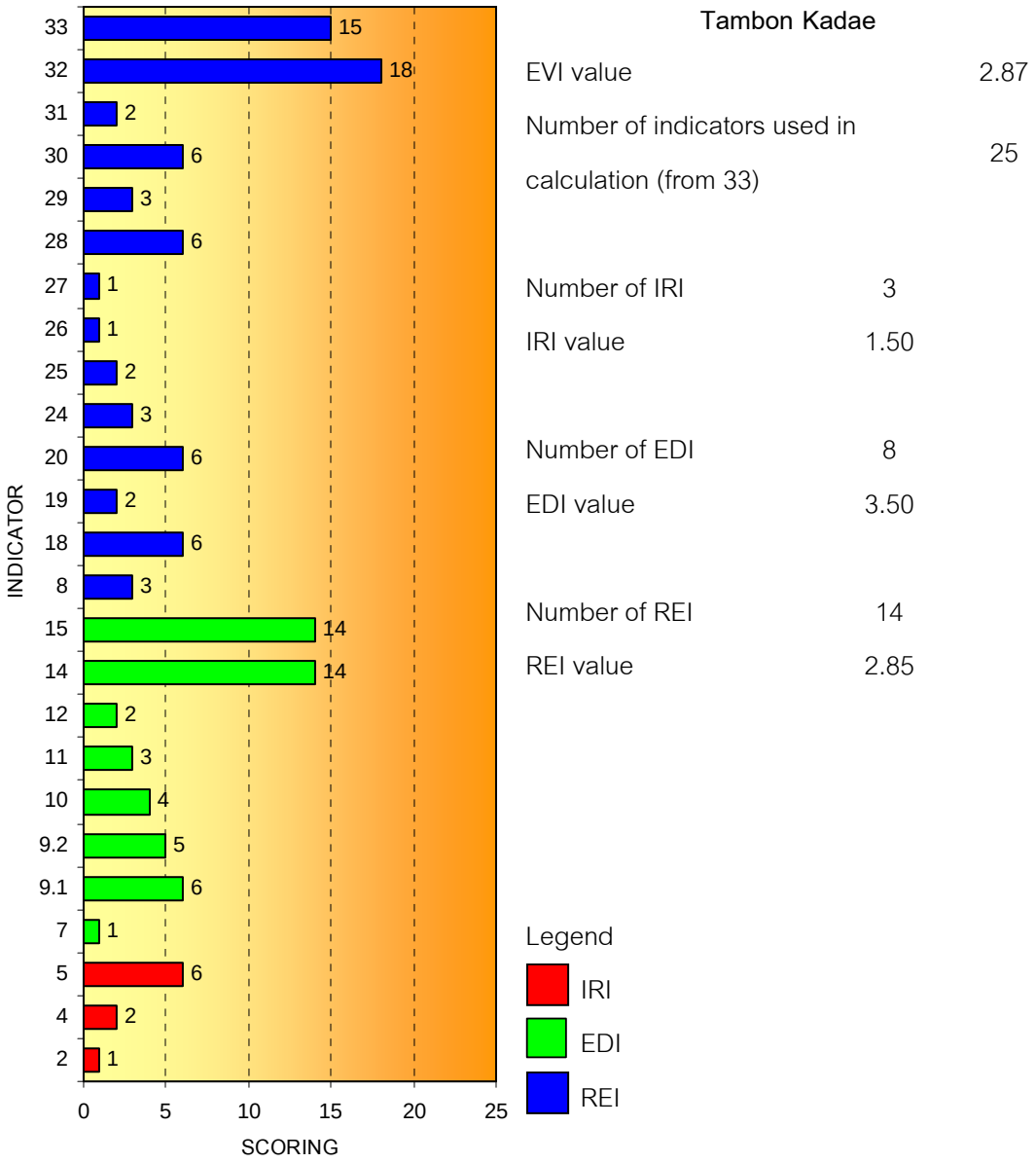


Figure 4.1.22 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Kadae, Amphoe Kanchanadit

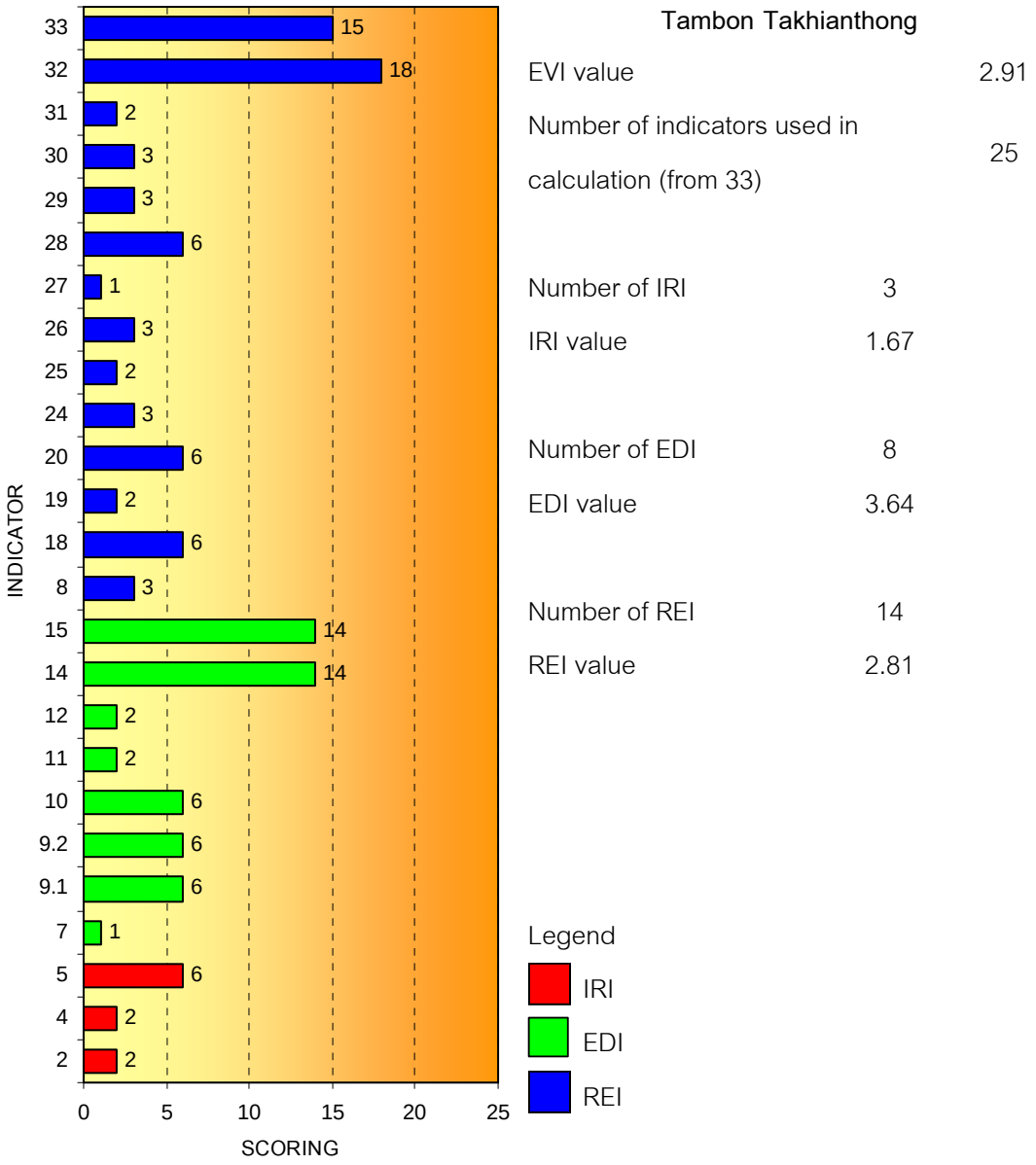


Figure 4.1.23 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Takhianthong, Amphoe Kanchanadit

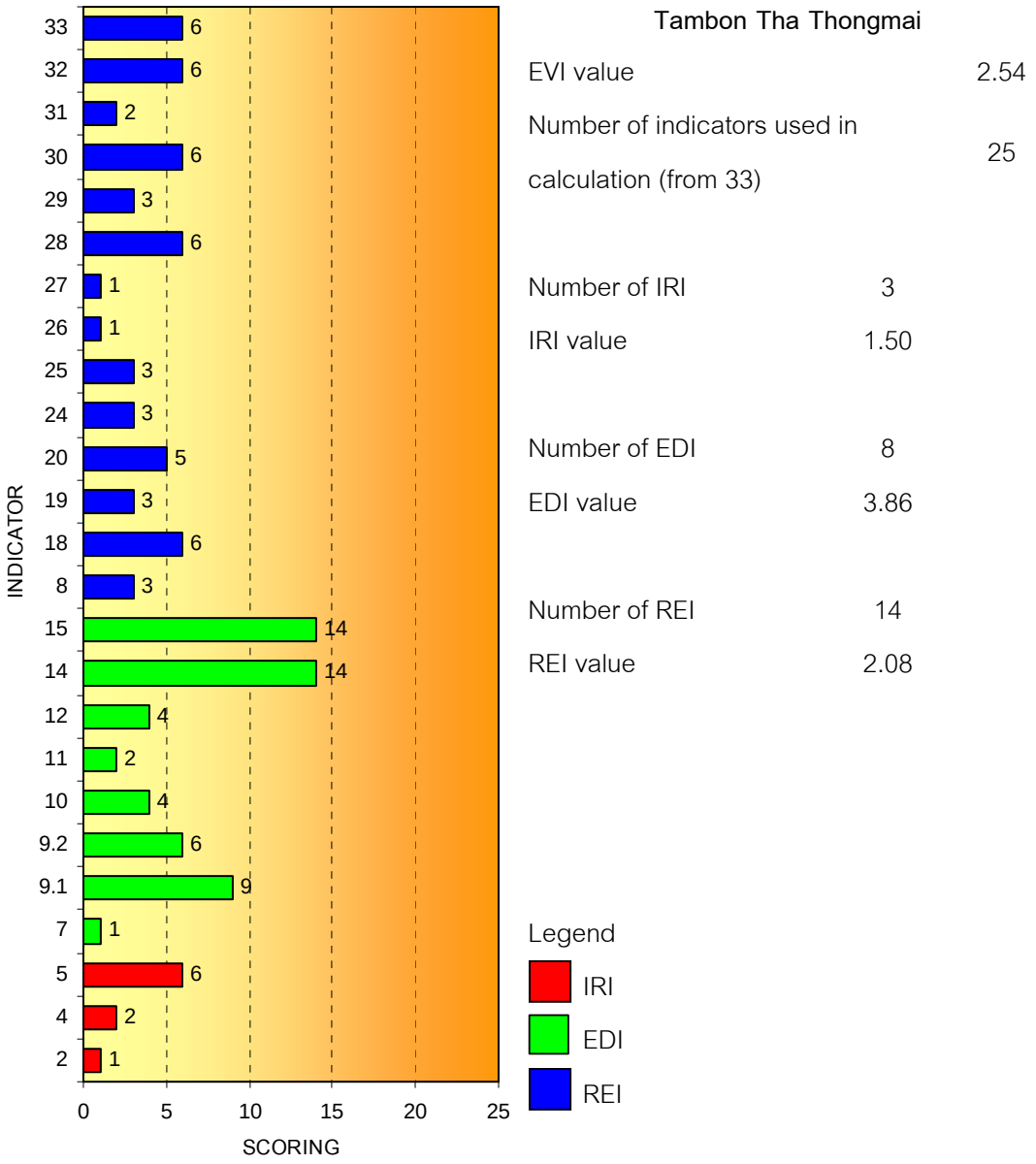


Figure 4.1.24 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for ท่า Tambon Tha Thongmai, Amphoe Kanchanadit

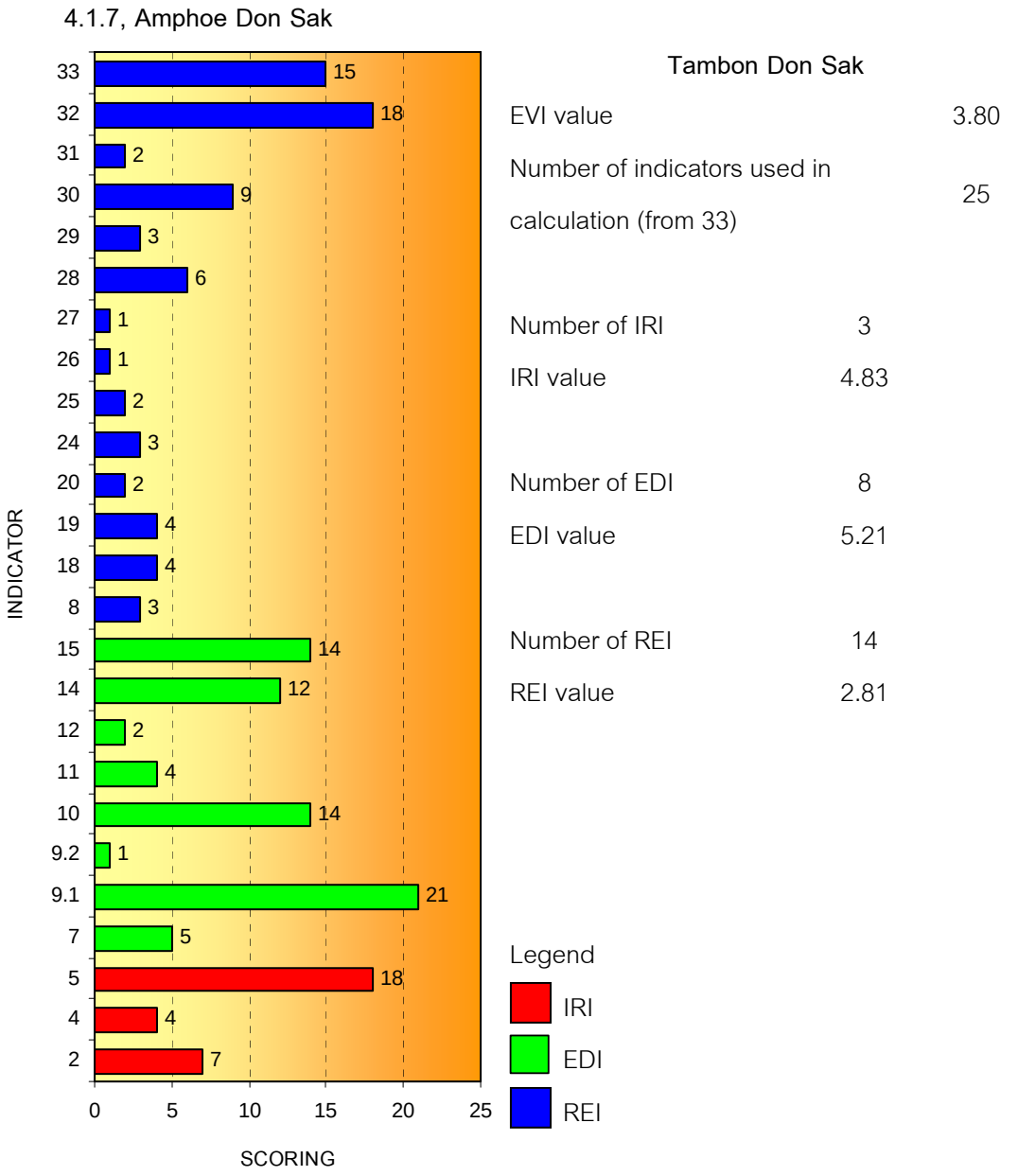


Figure 4.1.25 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Don Sak, Amphoe Don Sak

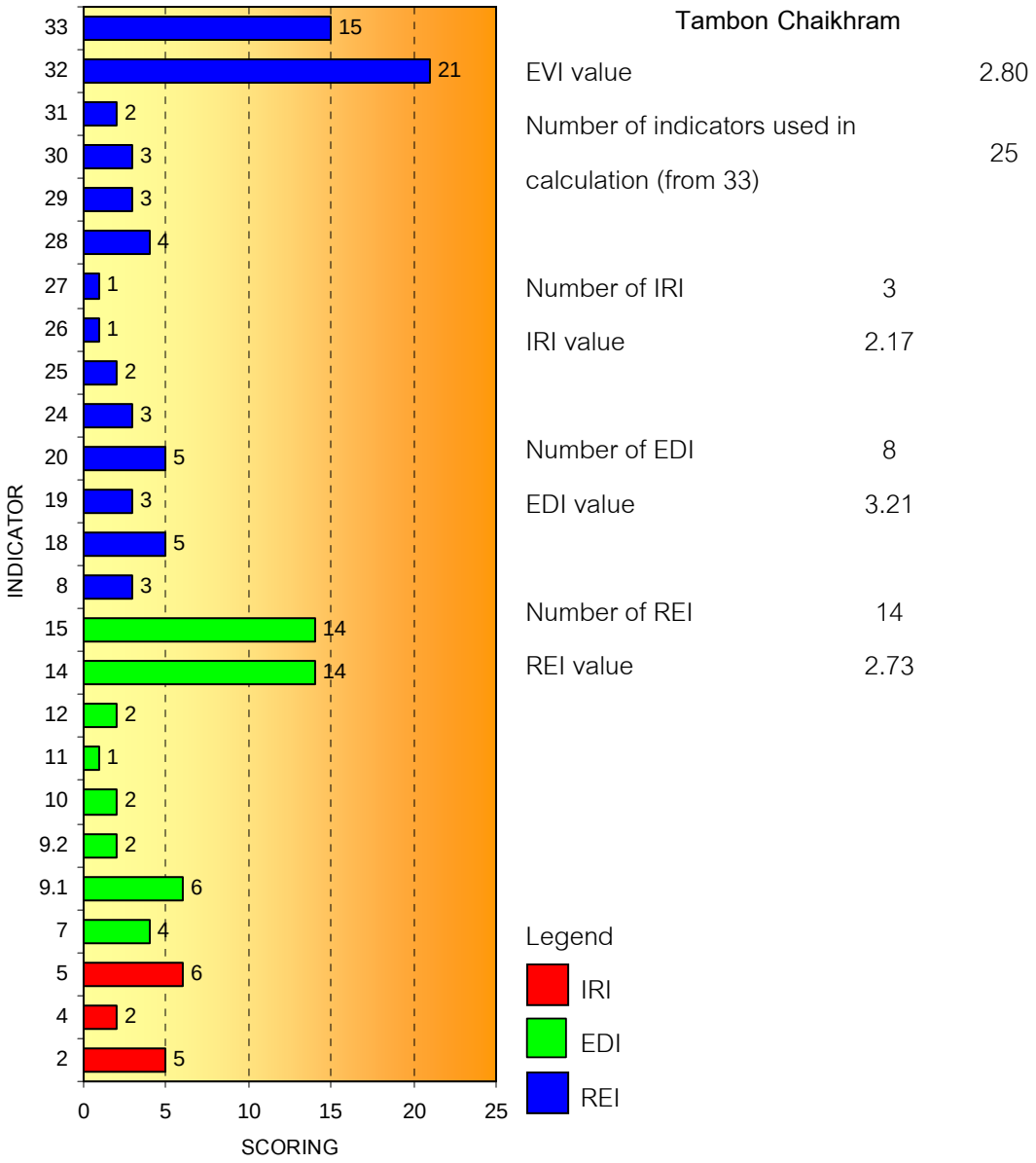


Figure 4.1.26 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Chaikhram, Amphoe Don Sak

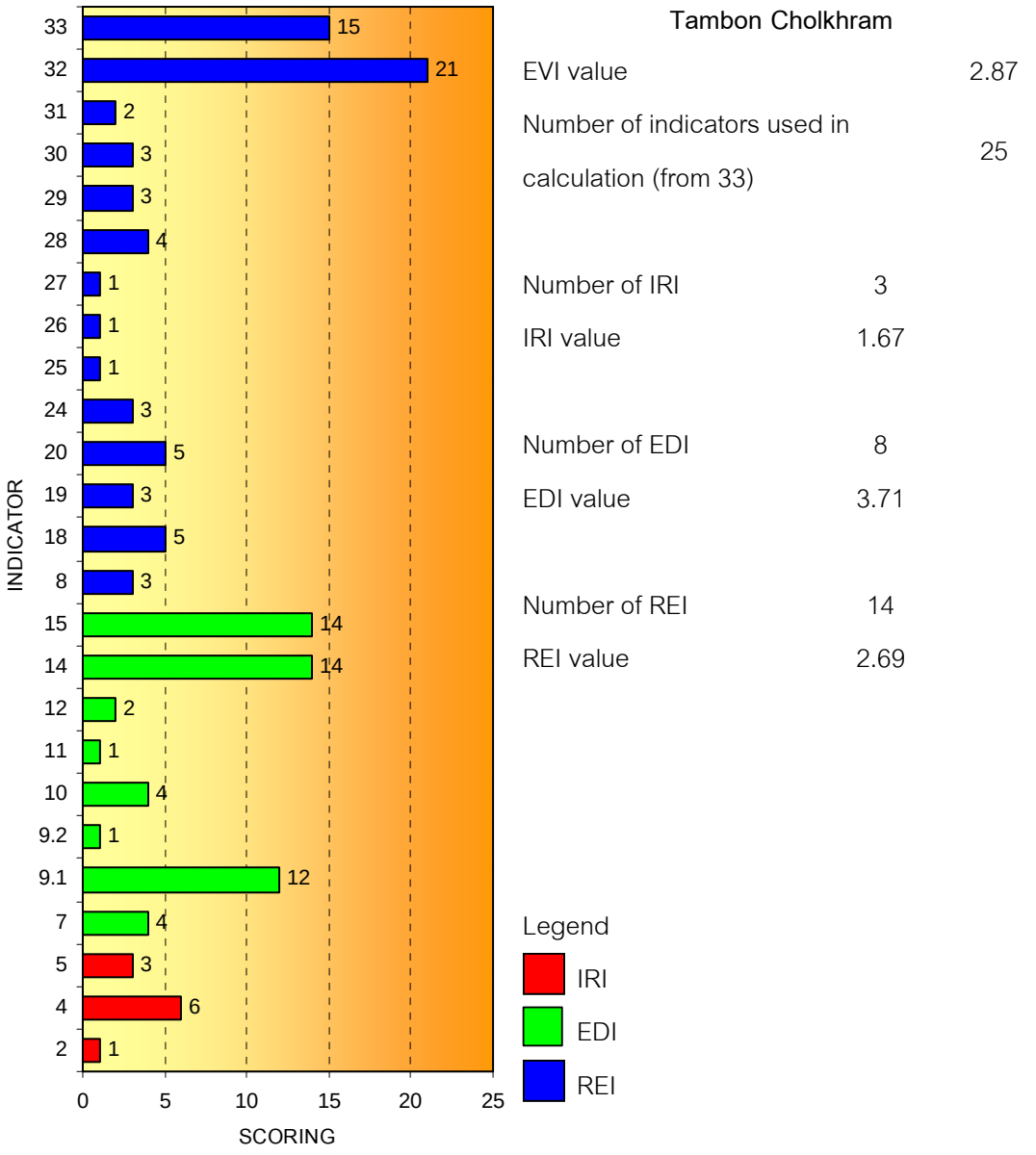


Figure 4.1.27 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Cholkhram, Amphoe Don Sak

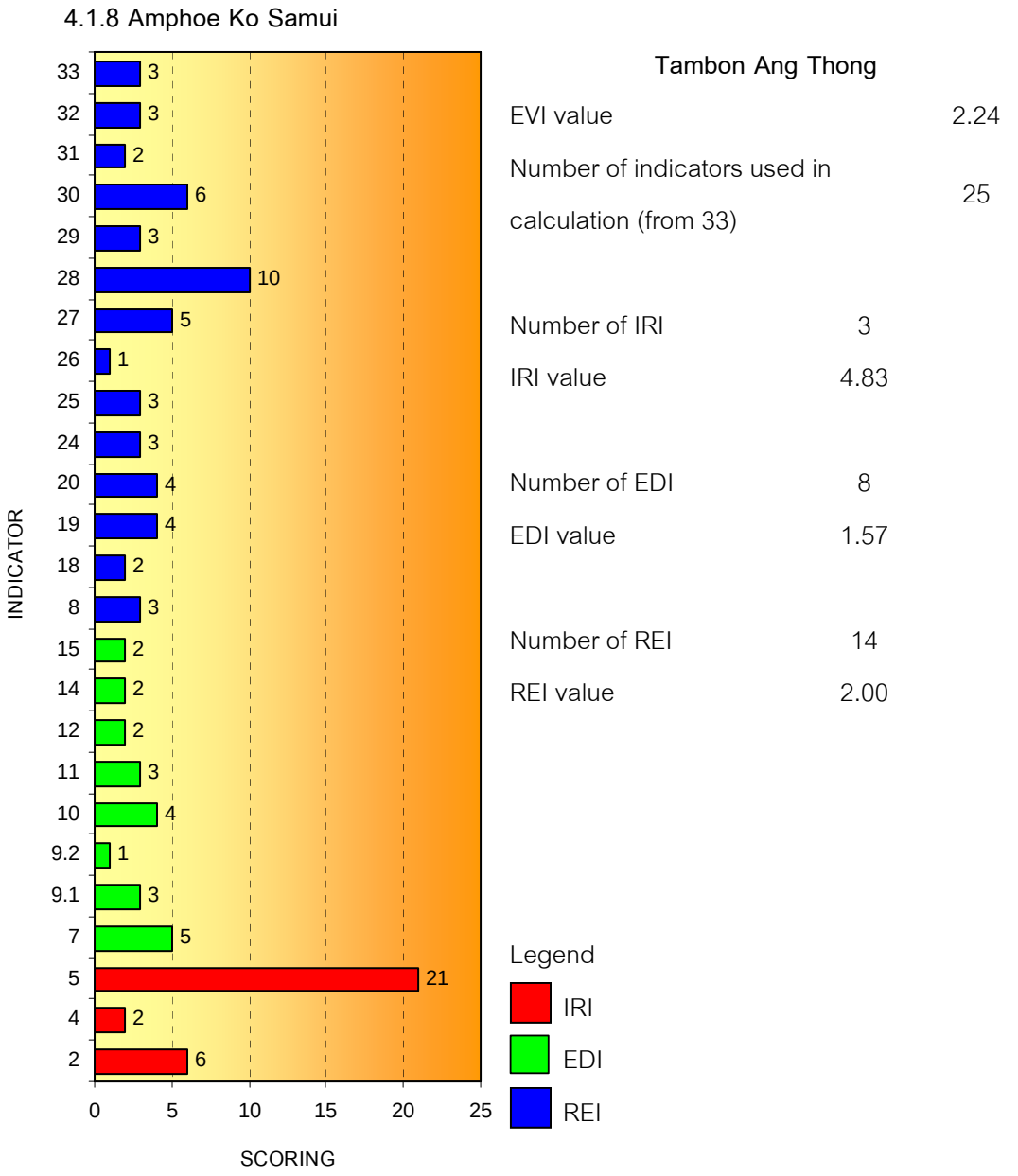


Figure 4.1.28 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Ang Thong, Amphoe Ko Samui

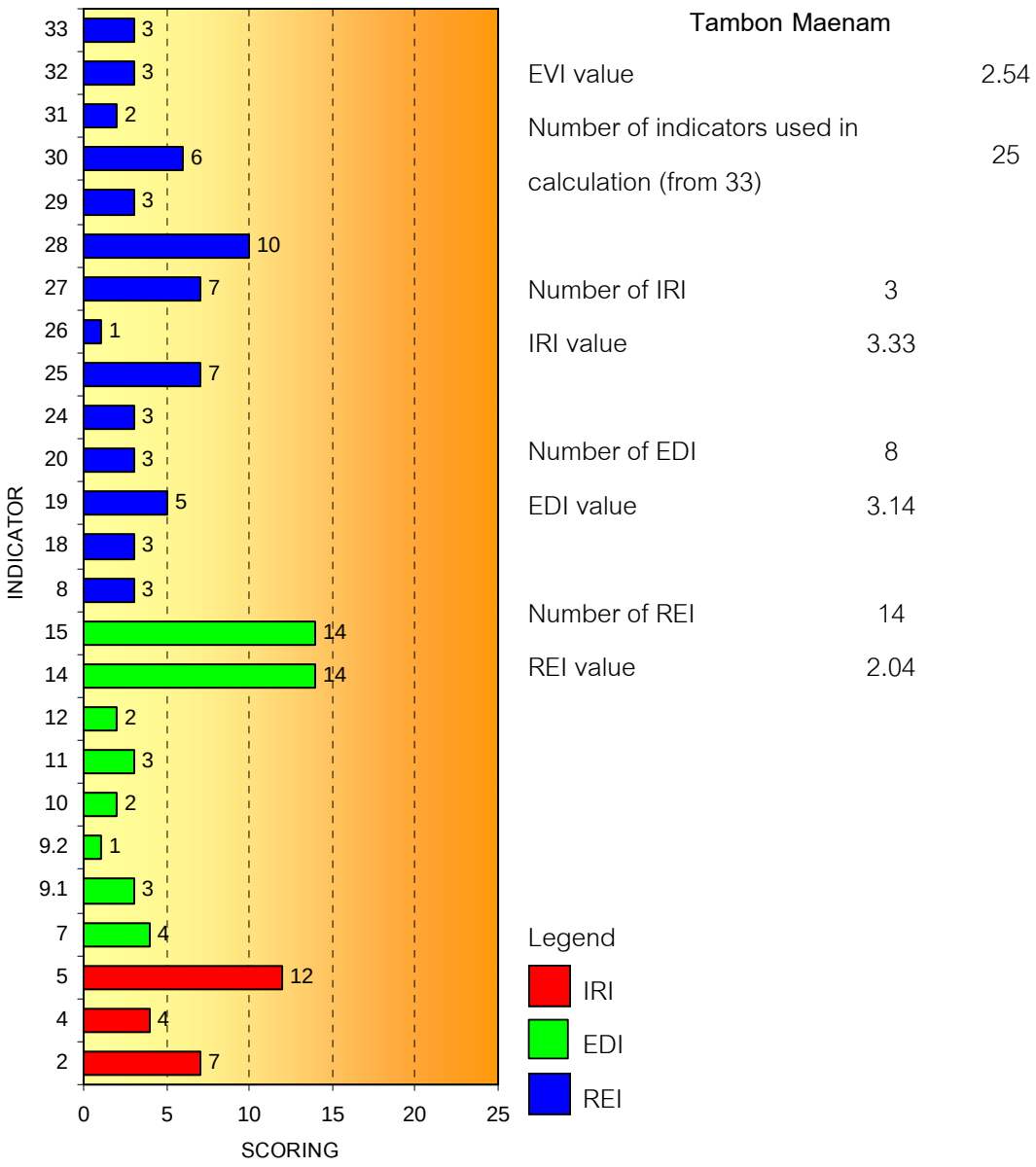


Figure 4.1.29 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Maenam, Amphoe Ko Samui

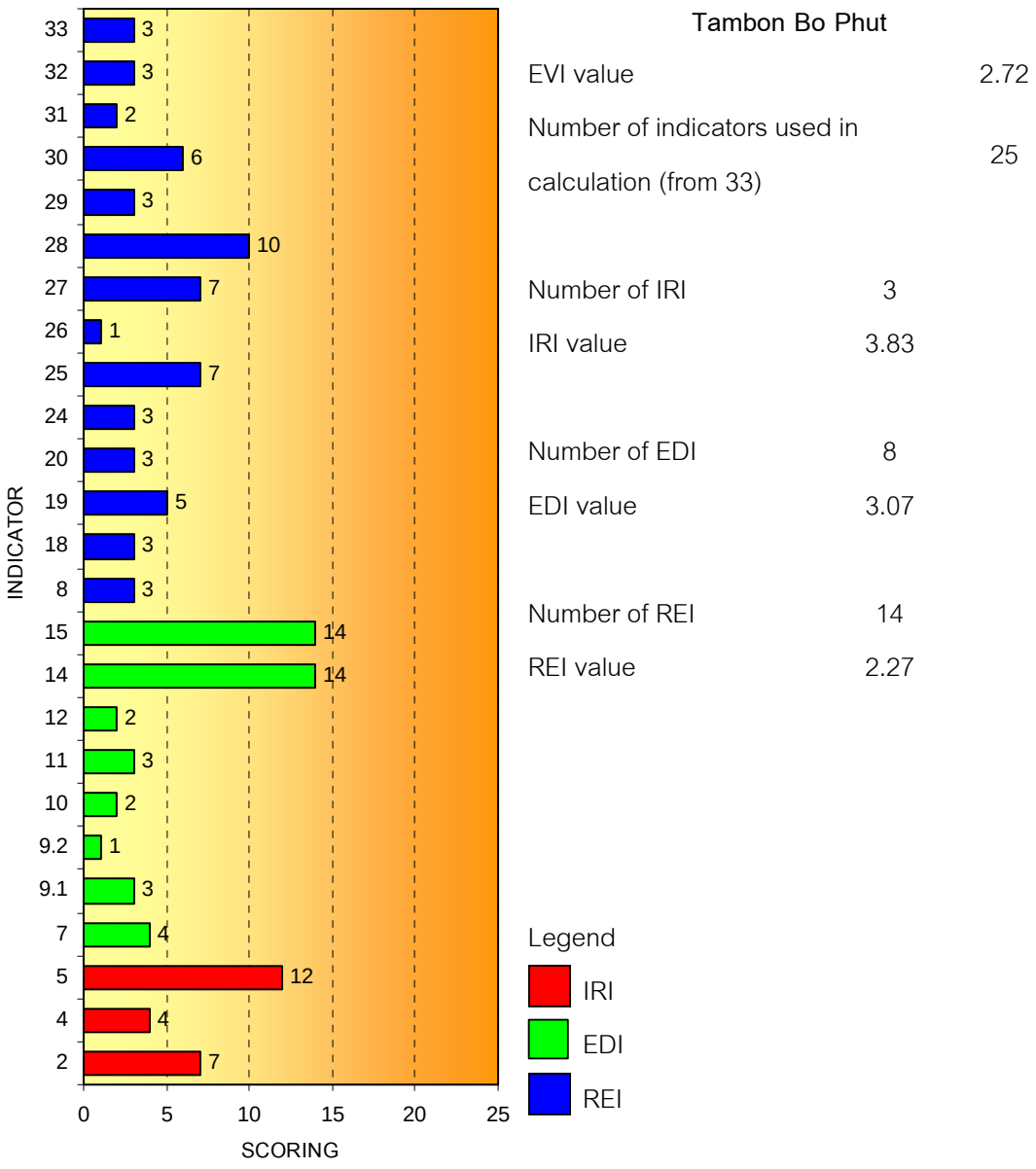


Figure 4.1.30 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Bo Phut, Amphoe Ko Samui

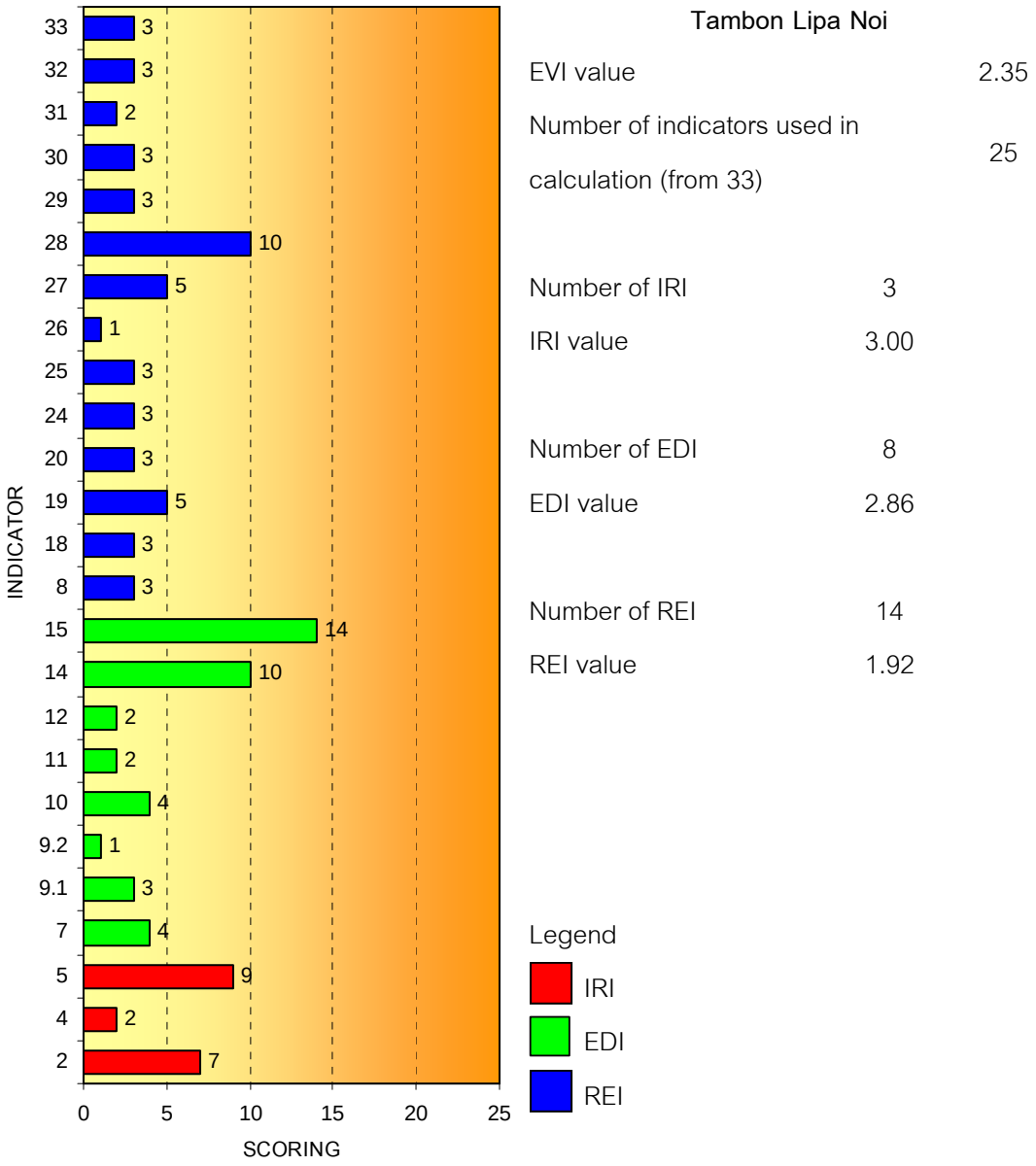


Figure 4.1.31 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Lipa Noi, Amphoe Ko Samui

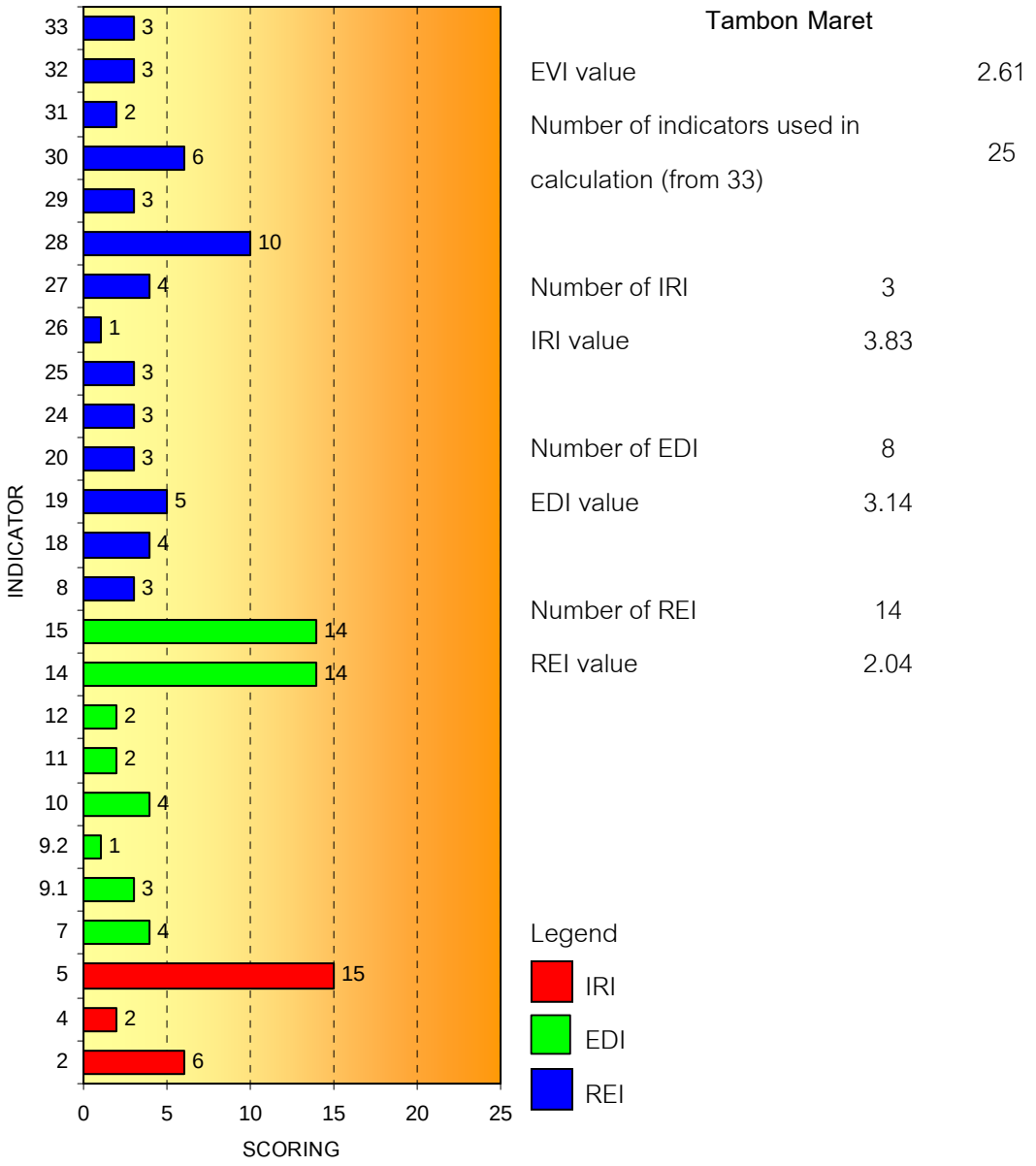


Figure 4.1.32 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Maret, Amphoe Ko Samui

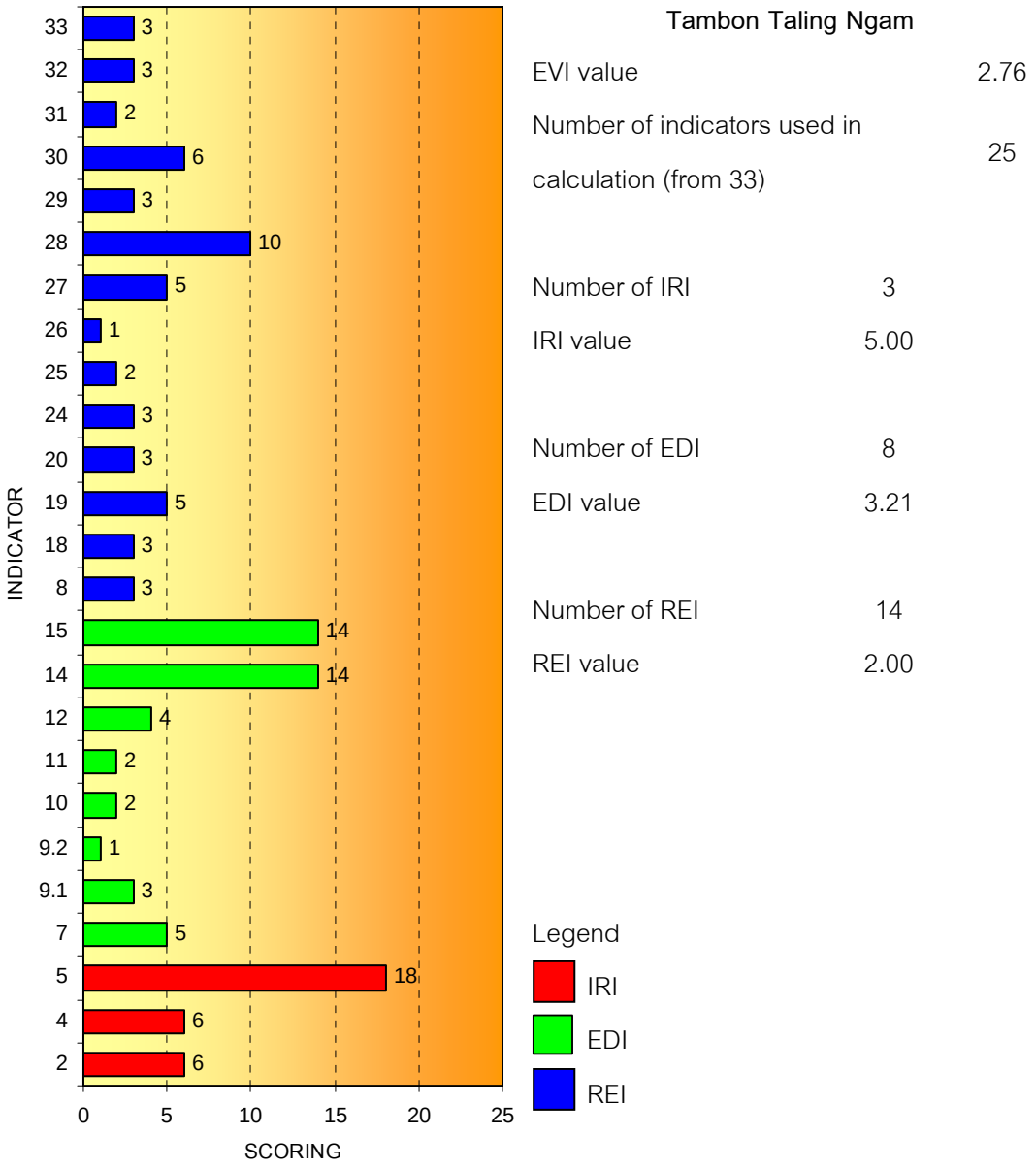


Figure 4.1.33 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Taling Ngam, Amphoe Ko Samui

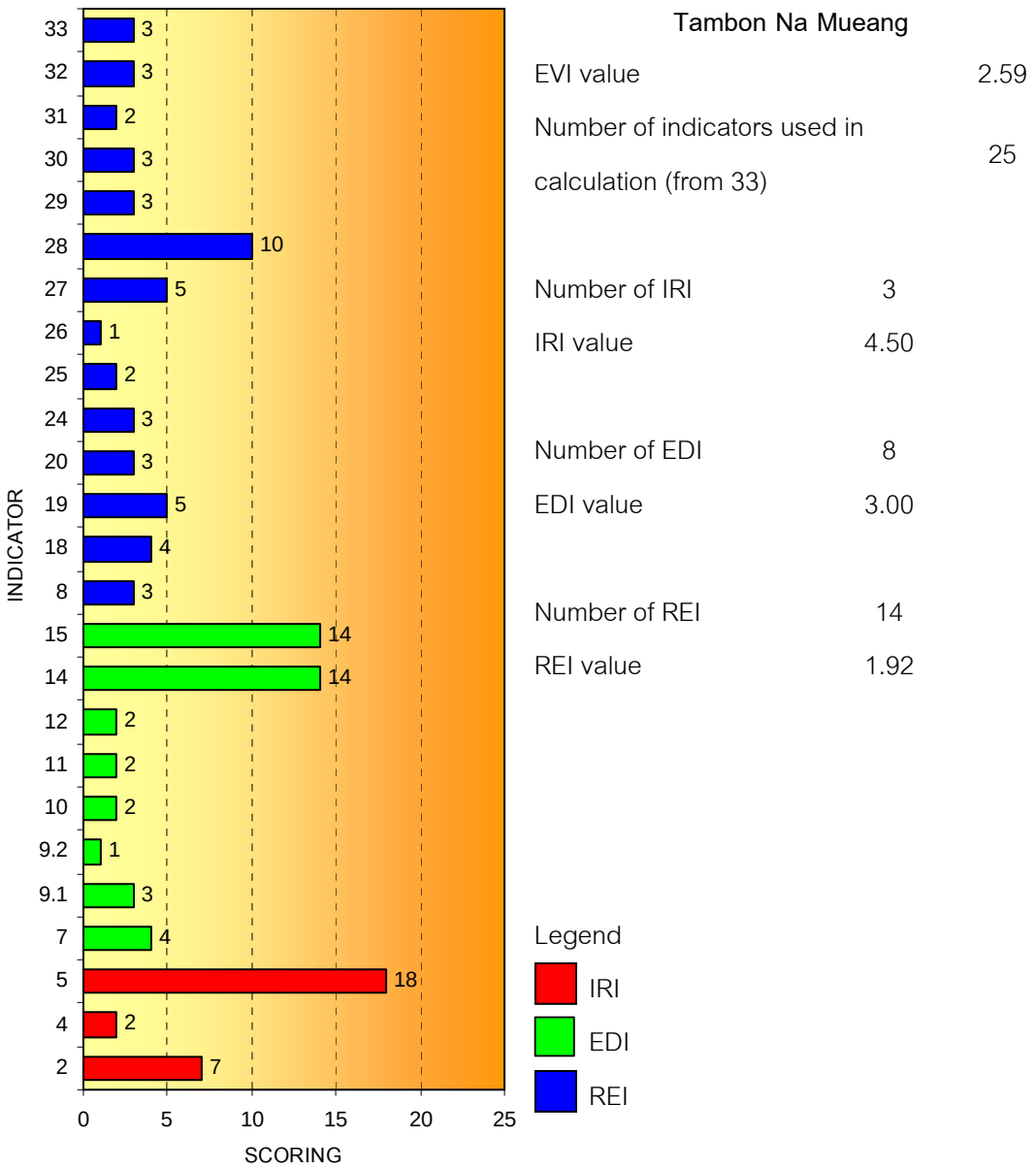


Figure 4.1.34 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Na Mueang, Amphoe Ko Samui

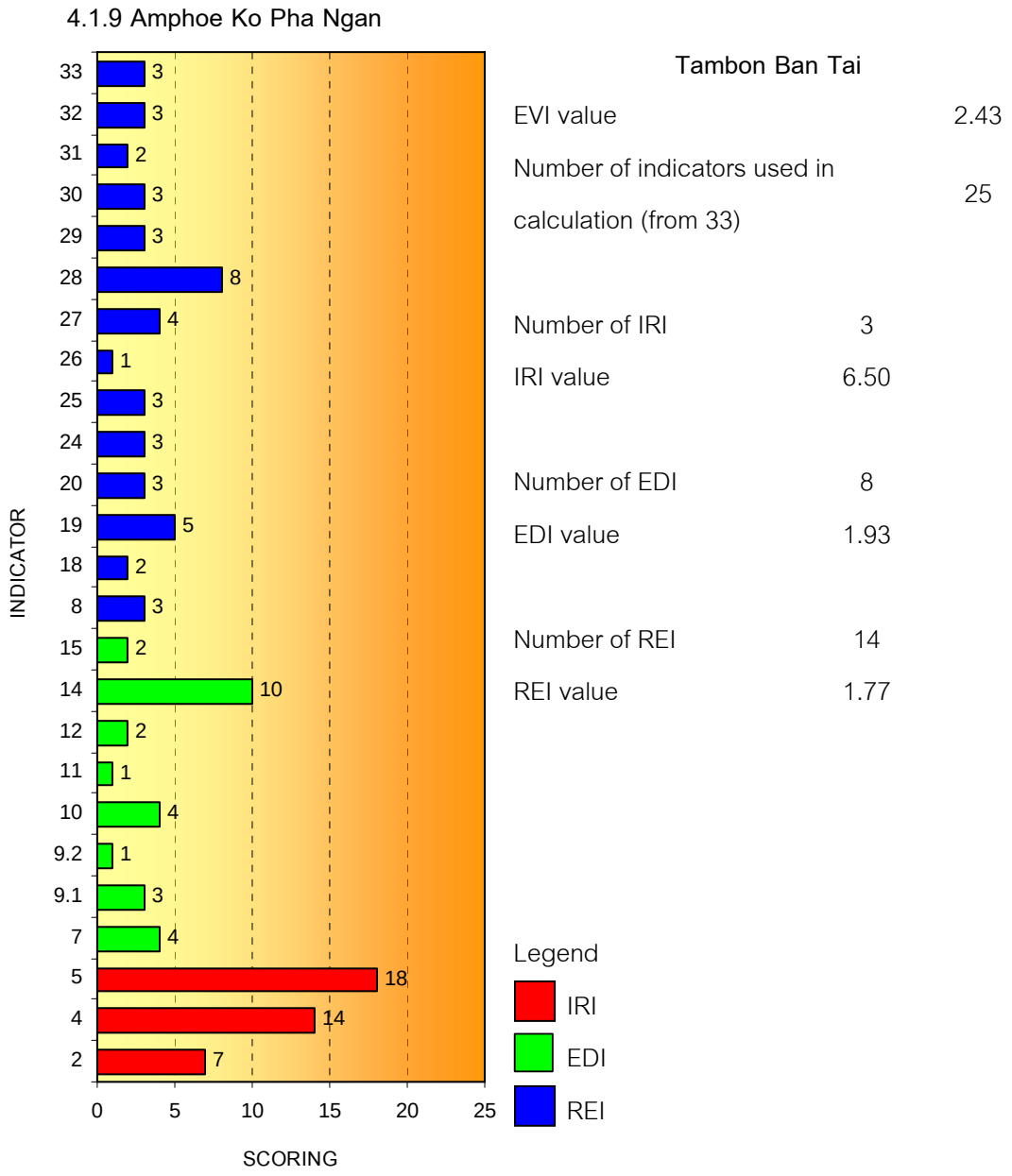


Figure 4.1.35 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Ban Tai, Amphoe Ko Pha Ngan

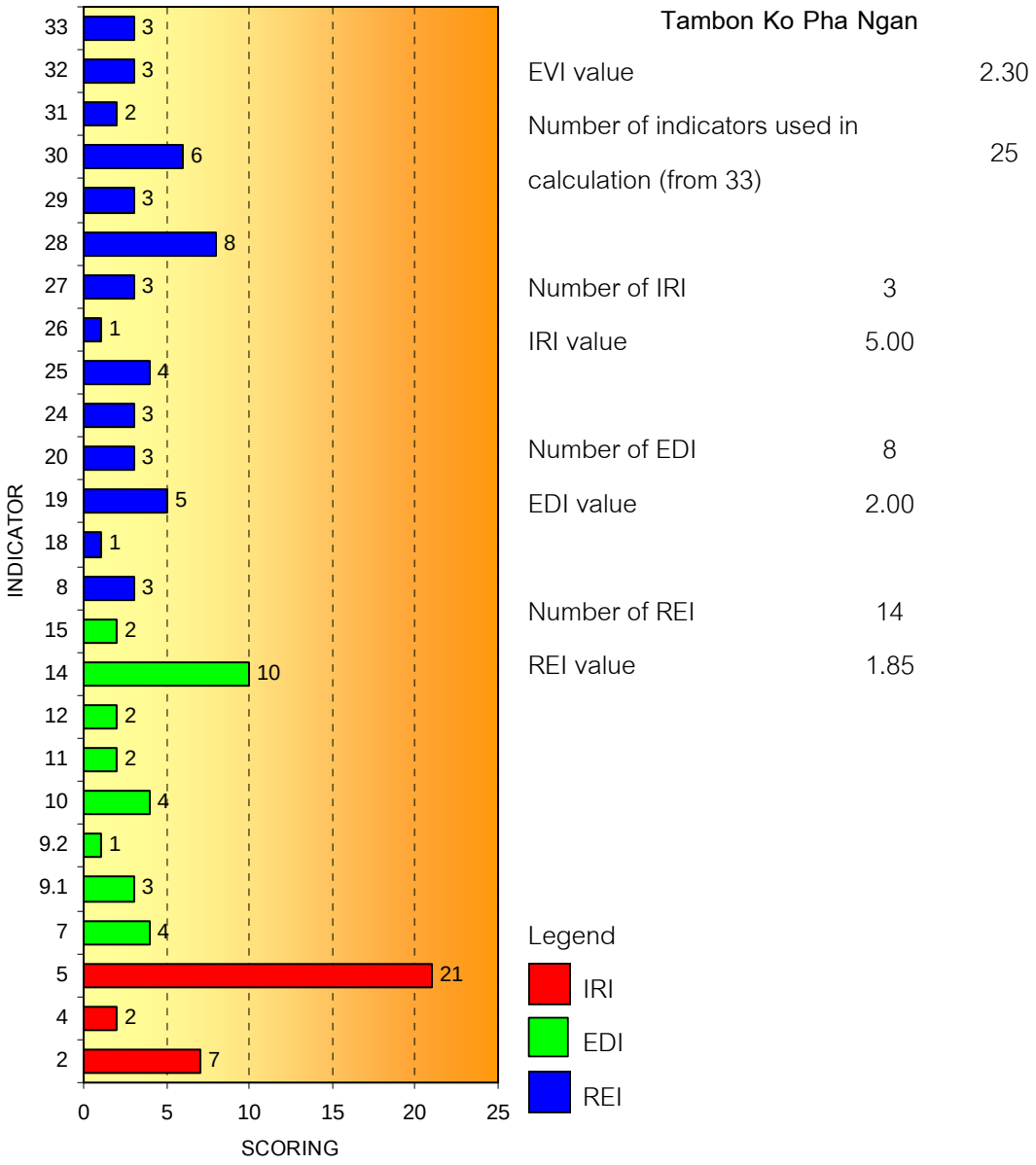


Figure 4.1.36 Study results of each indicator and the calculation of IRI, EDI, REI and EVI values for Tambon Ko Pha Ngan, Amphoe Ko Pha Ngan

Table 4.1.1 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Tha Chana

No	Sub-Index	Weight (W)	Factor	T.Khan Thuli		T.Tha Chana		T.Wang	
				S	S x W	S	S x W	S	S x W
2	IRI	1	Vertical relief	5	5	5	5	5	5
4	IRI	2	Coastal erosion	4	8	3	6	1	2
5	IRI	3	Habitats diversity	1	3	1	3	1	3
	Sum	6	Sum	10	16	9	14	7	10
			IRI		**2.67**		**2.33**		**1.67**

No	Sub-Index	W	Factor	T.Khan Thuli		T.Tha Chana		T.Wang	
				S	S x W	S	S x W	S	S x W
7	EDI	1	Endangered species	4	4	4	4	4	4
9.1	EDI	3	Landbase Coastal Aquaculture	1	3	1	3	3	9
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1	1	1
10	EDI	2	Fisheries	2	4	2	4	2	4
11	EDI	1	Water resources	2	2	2	2	1	1
12	EDI	2	Open surface area and mining	7	14	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	6	12	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14	7	14
	Sum	14	Sum	30	54	25	44	26	49
			EDI		**3.86**		**3.14**		**3.50**

No	Sub-Index	W	Factor	T.Khan Thuli		T.Tha Chana		T.Wang	
				S	S x W	S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3	3	3
18	REI	1	High winds	7	7	4	4	3	3
19	REI	1	Dry periods	2	2	3	3	3	3
20	REI	1	Wet periods	6	6	5	5	5	5
24	REI	3	Human population density	1	3	1	3	1	3
25	REI	1	Human population growth rate	2	2	1	1	1	1
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1	1	1
27	REI	1	Tourists guest rooms	1	1	1	1	1	1
28	REI	2	Tourism area life cycle	2	4	3	6	2	4
29	REI	3	Waste waters	1	3	1	3	1	3
30	REI	3	Solid waste	2	6	2	6	1	3
31	REI	2	Oil spills	1	2	1	2	1	2
32	REI	3	Fertilizers	6	18	5	15	5	15
33	REI	3	Pesticides	5	15	4	12	4	12
	Sum	26	Sum	37	73	35	65	32	59
			REI		**2.81**		**2.50**		**2.27**
Sum		**46**	**EVI**		**3.11**		**2.67**		**2.57**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.2 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Tha Chana

No	Sub-Index	Weight (W)	Factor	T.Takrob		T.Thung		T.Chaiya	
				S	S x W	S	S x W	S	S x W
2	IRI	1	Vertical relief	1	1	2	2	1	1
4	IRI	2	Coastal erosion	3	6	1	2	1	2
5	IRI	3	Habitats diversity	2	6	2	6	1	3
	Sum	6	Sum	6	13	5	10	3	6
			IRI		2.17		1.67		1.00

No	Sub-Index	W	Factor	T.Takrob		T.Thung		T.Chaiya	
				S	S x W	S	S x W	S	S x W
7	EDI	1	Endangered species	5	5	1	1	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	2	6	1	3	1	3
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1	1	1
10	EDI	2	Fisheries	2	4	1	2	1	2
11	EDI	1	Water resources	1	1	1	1	2	2
12	EDI	2	Open surface area and mining	1	2	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14	7	14
	Sum	14	Sum	26	47	20	38	21	39
			EDI		3.36		2.71		2.79

No	Sub-Index	W	Factor	T.Takrob		T.Thung		T.Chaiya	
				S	S x W	S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3	3	3
18	REI	1	High winds	2	2	2	2	3	3
19	REI	1	Dry periods	2	2	2	2	3	3
20	REI	1	Wet periods	6	6	6	6	6	6
24	REI	3	Human population density	1	3	1	3	1	3
25	REI	1	Human population growth rate	2	2	2	2	1	1
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1	1	1
27	REI	1	Tourists guest rooms	1	1	1	1	1	1
28	REI	2	Tourism area life cycle	2	4	2	4	2	4
29	REI	3	Waste waters	1	3	1	3	1	3
30	REI	3	Solid waste	1	3	1	3	1	3
31	REI	2	Oil spills	1	2	1	2	1	2
32	REI	3	Fertilizers	2	6	7	21	7	21
33	REI	3	Pesticides	2	6	5	15	7	21
	Sum	26	Sum	24	44	35	68	38	75
			REI		1.69		2.62		2.88
Sum		46	EVI		2.26		2.52		2.61

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.2… (Continued)

No	Sub-Index	Weight (W)	Factor	T.Phum Riang		T.Lamed	
				S	S x W	S	S x W
2	IRI	1	Vertical relief	1	1	3	3
4	IRI	2	Coastal erosion	3	6	1	2
5	IRI	3	Habitats diversity	6	18	2	6
	Sum	6	Sum	10	25	6	11
			IRI		**4.17**		**1.83**

No	Sub-Index	W	Factor	T.Phum Riang		T.Lamed	
				S	S x W	S	S x W
7	EDI	1	Endangered species	5	5	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	2	6	2	6
9.2	EDI	1	Seabase Coastal Aquaculture	2	2	1	1
10	EDI	2	Fisheries	2	4	1	2
11	EDI	1	Water resources	2	2	1	1
12	EDI	2	Open surface area and mining	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14
	Sum	14	Sum	28	49	21	41
			EDI		**3.50**		**2.93**

No	Sub-Index	W	Factor	T.Phum Riang		T.Lamed	
				S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3
18	REI	1	High winds	3	3	3	3
19	REI	1	Dry periods	1	1	3	3
20	REI	1	Wet periods	5	5	7	7
24	REI	3	Human population density	1	3	1	3
25	REI	1	Human population growth rate	2	2	2	2
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1
27	REI	1	Tourists guest rooms	1	1	1	1
28	REI	2	Tourism area life cycle	3	6	2	4
29	REI	3	Waste waters	1	3	1	3
30	REI	3	Solid waste	2	6	1	3
31	REI	2	Oil spills	1	2	1	2
32	REI	3	Fertilizers	1	3	7	21
33	REI	3	Pesticides	1	3	7	21
	Sum	26	Sum	26	42	40	77
			REI		**1.62**		**2.96**
Sum		**46**	**EVI**		**2.52**		**2.80**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.3 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Tha Chang

No	Sub-Index	Weight (W)	Factor	T.Khao Than		T.Tha Khoei		T.Tha Chang	
				S	S x W	S	S x W	S	S x W
2	IRI	1	Vertical relief	3	3	2	2	1	1
4	IRI	2	Coastal erosion	1	2	1	2	1	2
5	IRI	3	Habitats diversity	2	6	2	6	2	6
	Sum	6	Sum	6	11	5	10	4	9
			IRI		**1.83**		**1.67**		**1.50**

No	Sub-Index	W	Factor	T.Khao Than		T.Tha Khoei		T.Tha Chang	
				S	S x W	S	S x W	S	S x W
7	EDI	1	Endangered species	1	1	1	1	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	2	6	4	12	2	6
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1	1	1
10	EDI	2	Fisheries	1	2	2	4	2	4
11	EDI	1	Water resources	1	1	1	1	2	2
12	EDI	2	Open surface area and mining	1	2	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14	7	14
	Sum	14	Sum	21	41	24	49	23	44
			EDI		**2.93**		**3.50**		**3.14**

No	Sub-Index	W	Factor	T.Khao Than		T.Tha Khoei		T.Tha Chang	
				S	S x W	S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3	3	3
18	REI	1	High winds	3	3	4	4	4	4
19	REI	1	Dry periods	4	4	7	7	5	5
20	REI	1	Wet periods	4	4	1	1	3	3
24	REI	3	Human population density	1	3	1	3	1	3
25	REI	1	Human population growth rate	1	1	2	2	1	1
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1	1	1
27	REI	1	Tourists guest rooms	1	1	1	1	1	1
28	REI	2	Tourism area life cycle	2	4	2	4	2	4
29	REI	3	Waste waters	1	3	1	3	1	3
30	REI	3	Solid waste	1	3	1	3	1	3
31	REI	2	Oil spills	1	2	1	2	1	2
32	REI	3	Fertilizers	6	18	7	21	7	21
33	REI	3	Pesticides	5	15	6	18	6	18
	Sum	26	Sum	31	65	38	73	37	72
			REI		**2.50**		**2.81**		**2.77**
Sum		**46**	**EVI**		**2.54**		**2.87**		**2.72**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.4 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Phunphin

No	Sub-Index	Weight (W)	Factor	T.Liled	
				S	S x W
2	IRI	1	Vertical relief	1	1
4	IRI	2	Coastal erosion	1	2
5	IRI	3	Habitats diversity	2	6
	Sum	6	Sum	4	9
			IRI		1.50

No.	Sub-Index	W	Factor	T.Liled	
				S	S x W
7	EDI	1	Endangered species	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	6	18
9.2	EDI	1	Seabase Coastal Aquaculture	3	3
10	EDI	2	Fisheries	2	4
11	EDI	1	Water resources	1	1
12	EDI	2	Open surface area and mining	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14
15	EDI	2	Marine reserves	7	14
	Sum	14	Sum	28	57
			EDI		4.07

No.	Sub-Index	W	Factor	T.Liled	
				S	S x W
8	REI	1	Migrating species	3	3
18	REI	1	High winds	5	5
19	REI	1	Dry periods	5	5
20	REI	1	Wet periods	3	3
24	REI	3	Human population density	1	3
25	REI	1	Human population growth rate	1	1
26	REI	1	Rate of loss of natural cover/vegetation	1	1
27	REI	1	Tourists guest rooms	1	1
28	REI	2	Tourism area life cycle	3	6
29	REI	3	Waste waters	1	3
30	REI	3	Solid waste	1	3
31	REI	2	Oil spills	1	2
32	REI	3	Fertilizers	3	9
33	REI	3	Pesticides	2	6
	Sum	26	Sum	28	51
			REI		1.96
Sum		46	EVI		2.54

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.5 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Mueang

No	Sub-Index	Weight (W)	Factor	T.Bang Chana		T.Bang Sai	
				S	S x W	S	S x W
2	IRI	1	Vertical relief	1	1	1	1
4	IRI	2	Coastal erosion	1	2	1	2
5	IRI	3	Habitats diversity	2	6	2	6
	Sum	6	Sum	4	9	4	9
			IRI		1.50		1.50

No	Sub-Index	W	Factor	T.Bang Chana		T.Bang Sai	
				S	S x W	S	S x W
7	EDI	1	Endangered species	1	1	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	1	3	1	3
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1
10	EDI	2	Fisheries	2	4	3	6
11	EDI	1	Water resources	1	1	1	1
12	EDI	2	Open surface area and mining	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14
	Sum	14	Sum	21	40	22	42
			EDI		2.86		3.00

No.	Sub-Index	W	Factor	T.Bang Chana		T.Bang Sai	
				S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3
18	REI	1	High winds	5	5	5	5
19	REI	1	Dry periods	4	4	4	4
20	REI	1	Wet periods	4	4	4	4
24	REI	3	Human population density	1	3	1	3
25	REI	1	Human population growth rate	2	2	3	3
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1
27	REI	1	Tourists guest rooms	1	1	1	1
28	REI	2	Tourism area life cycle	3	6	2	4
29	REI	3	Waste waters	1	3	1	3
30	REI	3	Solid waste	1	3	1	3
31	REI	2	Oil spills	1	2	1	2
32	REI	3	Fertilizers	1	3	3	9
33	REI	3	Pesticides	1	3	2	6
	Sum	26	Sum	26	43	32	51
			REI		1.65		1.96
Sum		46	EVI		2.00		2.22

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.5… (Continued)

No	Sub-Index	Weight (W)	Factor	T.Khlong Chanak		T.Bang Pho	
				S	S x W	S	S x W
2	IRI	1	Vertical relief	1	1	1	1
4	IRI	2	Coastal erosion	1	2	1	2
5	IRI	3	Habitats diversity	3	9	2	6
	Sum	6	Sum	5	12	4	9
			IRI		2.00		1.50

ลำดับ	Sub-Index	W	Factor	T.Khlong Chanak		T.Bang Pho	
				S	S x W	S	S x W
7	EDI	1	Endangered species	1	1	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	2	6	1	3
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1
10	EDI	2	Fisheries		0	1	2
11	EDI	1	Water resources	1	1	1	1
12	EDI	2	Open surface area and mining	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14
	Sum	14	Sum	20	39	20	38
			EDI		2.79		2.71

No	Sub-Index	W	Factor	T.Khlong Chanak		T.Bang Pho	
				S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3
18	REI	1	High winds	5	5	5	5
19	REI	1	Dry periods	3	3	5	5
20	REI	1	Wet periods	5	5	3	3
24	REI	3	Human population density	1	3	1	3
25	REI	1	Human population growth rate	1	1	2	2
26	REI	1	Rate of loss of natural cover/vegetation	2	2	1	1
27	REI	1	Tourists guest rooms	1	1	1	1
28	REI	2	Tourism area life cycle	3	6	2	4
29	REI	3	Waste waters	1	3	1	3
30	REI	3	Solid waste	1	3	1	3
31	REI	2	Oil spills	1	2	1	2
32	REI	3	Fertilizers	1	3	1	3
33	REI	3	Pesticides	1	3	1	3
	Sum	26	Sum	29	43	28	41
			REI		1.65		1.58
Sum		46	EVI		2.04		1.91

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.5… (Continue)

No	Sub-Index	Weight (W)	Factor	T.Bang Kung		T.Bang Baimai		T.Talat	
				S	S x W	S	S x W	S	S x W
2	IRI	1	Vertical relief	2	2	1	1	1	1
4	IRI	2	Coastal erosion	1	2	1	2	1	2
5	IRI	3	Habitats diversity	2	6	1	3	1	3
	Sum	6	Sum	5	10	3	6	3	6
			IRI		**1.67**		**1.00**		**1.00**

No	Sub-Index	W	Factor	T.Bang Kung		T.Bang Baimai		T.Talat	
				S	S x W	S	S x W	S	S x W
7	EDI	1	Endangered species	1	1	1	1	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	2	6	1	3	1	3
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1	1	1
10	EDI	2	Fisheries	2	4	1	2	1	2
11	EDI	1	Water resources	5	5	1	1	7	7
12	EDI	2	Open surface area and mining	1	2	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14	7	14
	Sum	14	Sum	26	47	20	38	26	44
			EDI		**3.36**		**2.71**		**3.14**

No	Sub-Index	W	Factor	T.Bang Kung		T.Bang Baimai		T.Talat	
				S	S x W	S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3	3	3
18	REI	1	High winds	6	6	5	5	6	6
19	REI	1	Dry periods	3	3	5	5	5	5
20	REI	1	Wet periods	5	5	3	3	3	3
24	REI	3	Human population density	2	6	1	3	7	21
25	REI	1	Human population growth rate	3	3	2	2	1	1
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1	1	1
27	REI	1	Tourists guest rooms	2	2	1	1	4	4
28	REI	2	Tourism area life cycle	3	6	3	6	3	6
29	REI	3	Waste waters	2	6	1	3	7	21
30	REI	3	Solid waste	5	15	1	3	7	21
31	REI	2	Oil spills	1	2	1	2	1	2
32	REI	3	Fertilizers	1	3	1	3	1	3
33	REI	3	Pesticides	1	3	1	3	1	3
	Sum	26	Sum	38	64	29	43	50	100
			REI		**2.46**		**1.65**		**3.85**
Sum		**46**	**EVI**		**2.63**		**1.89**		**3.26**

Remark: W = Weighting factor

S = Score of each indicator

S x W = Score x Weighting factor

Table 4.1.6 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Kanchanadit

No	Sub-Index	Weight (W)	Factor	T.Thathong		T.Plaiwat		T.Kadae	
				S	S x W	S	S x W	S	S x W
2	IRI	1	Vertical relief	4	4	4	4	1	1
4	IRI	2	Coastal erosion	5	10	1	2	1	2
5	IRI	3	Habitats diversity	2	6	2	6	2	6
	Sum	6	Sum	11	20	7	12	4	9
			IRI		3.33		2.00		1.50

No	Sub-Index	W	Factor	T.Thathong		T.Plaiwat		T.Kadae	
				S	S x W	S	S x W	S	S x W
7	EDI	1	Endangered species	1	1	1	1	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	7	21	5	15	2	6
9.2	EDI	1	Seabase Coastal Aquaculture	7	7	7	7	5	5
10	EDI	2	Fisheries	2	4	2	4	2	4
11	EDI	1	Water resources	1	1	2	2	3	3
12	EDI	2	Open surface area and mining	1	2	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14	7	14
	Sum	14	Sum	33	64	32	59	28	49
			EDI		4.57		4.21		3.50

No	Sub-Index	W	Factor	T.Thathong		T.Plaiwat		T.Kadae	
				S	S x W	S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3	3	3
18	REI	1	High winds	5	5	6	6	6	6
19	REI	1	Dry periods	2	2	2	2	2	2
20	REI	1	Wet periods	6	6	6	6	6	6
24	REI	3	Human population density	1	3	1	3	1	3
25	REI	1	Human population growth rate	3	3	2	2	2	2
26	REI	1	Rate of loss of natural cover/vegetation	7	7	1	1	1	1
27	REI	1	Tourists guest rooms	1	1	1	1	1	1
28	REI	2	Tourism area life cycle	2	4	1	2	3	6
29	REI	3	Waste waters	1	3	1	3	1	3
30	REI	3	Solid waste	1	3	1	3	2	6
31	REI	2	Oil spills	1	2	1	2	1	2
32	REI	3	Fertilizers	6	18	6	18	6	18
33	REI	3	Pesticides	4	12	5	15	5	15
	Sum	26	Sum	40	72	37	67	40	74
			REI		2.77		2.58		2.85
Sum		46	EVI		3.39		3.00		2.87

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.6 ... (Continued)

No	Sub-Index	Weight (W)	Factor	T.Takhianthong		T.Tha Thongmai	
				S	S x W	S	S x W
2	IRI	1	Vertical relief	2	2	1	1
4	IRI	2	Coastal erosion	1	2	1	2
5	IRI	3	Habitats diversity	2	6	2	6
	Sum	6	Sum	5	10	4	9
			IRI		**1.67**		**1.50**

No	Sub-Index	W	Factor	T.Takhianthong		T.Tha Thongmai	
				S	S x W	S	S x W
7	EDI	1	Endangered species	1	1	1	1
9.1	EDI	3	Landbase Coastal Aquaculture	2	6	3	9
9.2	EDI	1	Seabase Coastal Aquaculture	6	6	6	6
10	EDI	2	Fisheries	3	6	2	4
11	EDI	1	Water resources	2	2	2	2
12	EDI	2	Open surface area and mining	1	2	2	4
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14
	Sum	14	Sum	29	51	30	54
			EDI		**3.64**		**3.86**

No	Sub-Index	W	Factor	T.Takhianthong		T.Tha Thongmai	
				S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3
18	REI	1	High winds	6	6	6	6
19	REI	1	Dry periods	2	2	3	3
20	REI	1	Wet periods	6	6	5	5
24	REI	3	Human population density	1	3	1	3
25	REI	1	Human population growth rate	2	2	3	3
26	REI	1	Rate of loss of natural cover/vegetation	3	3	1	1
27	REI	1	Tourists guest rooms	1	1	1	1
28	REI	2	Tourism area life cycle	3	6	3	6
29	REI	3	Waste waters	1	3	1	3
30	REI	3	Solid waste	1	3	2	6
31	REI	2	Oil spills	1	2	1	2
32	REI	3	Fertilizers	6	18	2	6
33	REI	3	Pesticides	5	15	2	6
	Sum	26	Sum	41	73	34	54
			REI		**2.81**		**2.08**
Sum		**46**	**EVI**		**2.91**		**2.54**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.7 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Don Sak

No	Sub-Index	Weight (W)	Factor	T.Don Sak		T.Chaikhram		T.Chonkhram	
				S	S x W	S	S x W	S	S x W
2	IRI	1	Vertical relief	7	7	5	5	1	1
4	IRI	2	Coastal erosion	2	4	1	2	3	6
5	IRI	3	Habitats diversity	6	18	2	6	1	3
	Sum	6	Sum	15	29	8	13	5	10
			IRI		**4.83**		**2.17**		**1.67**

No	Sub-Index	W	Factor	T.Don Sak		T.Chaikhram		T.Chonkhram	
				S	S x W	S	S x W	S	S x W
7	EDI	1	Endangered species	5	5	4	4	4	4
9.1	EDI	3	Landbase Coastal Aquaculture	7	21	2	6	4	12
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	2	2	1	1
10	EDI	2	Fisheries	7	14	1	2	2	4
11	EDI	1	Water resources	4	4	1	1	1	1
12	EDI	2	Open surface area and mining	1	2	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	6	12	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14	7	14
	Sum	14	Sum	38	73	25	45	27	52
			EDI		**5.21**		**3.21**		**3.71**

No	Sub-Index	W	Factor	T.Don Sak		T.Chaikhram		T.Chonkhram	
				S	S x W	S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3	3	3
18	REI	1	High winds	4	4	5	5	5	5
19	REI	1	Dry periods	4	4	3	3	3	3
20	REI	1	Wet periods	2	2	5	5	5	5
24	REI	3	Human population density	1	3	1	3	1	3
25	REI	1	Human population growth rate	2	2	2	2	1	1
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1	1	1
27	REI	1	Tourists guest rooms	1	1	1	1	1	1
28	REI	2	Tourism area life cycle	3	6	2	4	2	4
29	REI	3	Waste waters	1	3	1	3	1	3
30	REI	3	Solid waste	3	9	1	3	1	3
31	REI	2	Oil spills	1	2	1	2	1	2
32	REI	3	Fertilizers	6	18	7	21	7	21
33	REI	3	Pesticides	5	15	5	15	5	15
	Sum	26	Sum	34	73	38	71	37	70
			REI		**2.81**		**2.73**		**2.69**
Sum		**46**	**EVI**		**3.80**		**2.80**		**2.87**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.8 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Ko Samui

No	Sub-Index	Weight (W)	Factor	T.Ang Thong		T.Maenam		T.Bo phut	
				S	S x W	S	S x W	S	S x W
2	IRI	1	Vertical relief	6	6	6	6	7	7
4	IRI	2	Coastal erosion	1	2	1	2	2	4
5	IRI	3	Habitats diversity	7	21	4	12	4	12
	Sum	6	Sum	14	29	11	20	13	23
			IRI		**4.83**		**3.33**		**3.83**

No	Sub-Index	W	Factor	T.Ang Thong		T.Maenam		T.Bo phut	
				S	S x W	S	S x W	S	S x W
7	EDI	1	Endangered species	5	5	4	4	4	4
9.1	EDI	3	Landbase Coastal Aquaculture	1	3	1	3	1	3
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1	1	1
10	EDI	2	Fisheries	2	4	2	4	1	2
11	EDI	1	Water resources	3	3	2	2	3	3
12	EDI	2	Open surface area and mining	1	2	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	1	2	7	14	7	14
15	EDI	2	Marine reserves	1	2	7	14	7	14
	Sum	14	Sum	15	22	25	44	25	43
			EDI		**1.57**		**3.14**		**3.07**

No	Sub-Index	W	Factor	T.Ang Thong		T.Maenam		T.Bo phut	
				S	S x W	S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3	3	3
18	REI	1	High winds	2	2	3	3	3	3
19	REI	1	Dry periods	4	4	5	5	5	5
20	REI	1	Wet periods	4	4	3	3	3	3
24	REI	3	Human population density	1	3	1	3	1	3
25	REI	1	Human population growth rate	3	3	3	3	7	7
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1	1	1
27	REI	1	Tourists guest rooms	5	5	5	5	7	7
28	REI	2	Tourism area life cycle	5	10	5	10	5	10
29	REI	3	Waste waters	1	3	1	3	1	3
30	REI	3	Solid waste	2	6	2	6	2	6
31	REI	2	Oil spills	1	2	1	2	1	2
32	REI	3	Fertilizers	1	3	1	3	1	3
33	REI	3	Pesticides	1	3	1	3	1	3
	Sum	26	Sum	31	52	35	53	41	59
			REI		**2.00**		**2.04**		**2.27**
Sum		**46**	**EVI**		**2.24**		**2.54**		**2.72**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.8... (Continued)

No	Sub-Index	Weight (W)	Factor	T.Lipa Noi		T.Maret	
				S	S x W	S	S x W
2	IRI	1	Vertical relief	7	7	6	6
4	IRI	2	Coastal erosion	1	2	1	2
5	IRI	3	Habitats diversity	3	9	5	15
	Sum	6	Sum	11	18	12	23
			IRI		**3.00**		**3.83**

No	Sub-Index	W	Factor	T.Lipa Noi		T.Maret	
				S	S x W	S	S x W
7	EDI	1	Endangered species	4	4	4	4
9.1	EDI	3	Landbase Coastal Aquaculture	1	3	1	3
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1
10	EDI	2	Fisheries	2	4	2	4
11	EDI	1	Water resources	2	2	2	2
12	EDI	2	Open surface area and mining	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	5	10	7	14
15	EDI	2	Marine reserves	7	14	7	14
	Sum	14	Sum	23	40	25	44
			EDI		**2.86**		**3.14**

No	Sub-Index	W	Factor	T.Lipa Noi		T.Maret	
				S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3
18	REI	1	High winds	3	3	4	4
19	REI	1	Dry periods	5	5	5	5
20	REI	1	Wet periods	3	3	3	3
24	REI	3	Human population density	1	3	1	3
25	REI	1	Human population growth rate	3	3	3	3
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1
27	REI	1	Tourists guest rooms	5	5	4	4
28	REI	2	Tourism area life cycle	5	10	5	10
29	REI	3	Waste waters	1	3	1	3
30	REI	3	Solid waste	1	3	2	6
31	REI	2	Oil spills	1	2	1	2
32	REI	3	Fertilizers	1	3	1	3
33	REI	3	Pesticides	1	3	1	3
	Sum	26	Sum	34	50	35	53
			REI		**1.92**		**2.04**
Sum		**46**	**EVI**		**2.35**		**2.61**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.8... (Continued)

No	Sub-Index	Weight (W)	Factor	T.Taling Ngam		T.Na Mueang	
				S	S x W	S	S x W
2	IRI	1	Vertical relief	6	6	7	7
4	IRI	2	Coastal erosion	3	6	1	2
5	IRI	3	Habitats diversity	6	18	6	18
	Sum	6	Sum	15	30	14	27
			IRI		**5.00**		**4.50**

No	Sub-Index	W	Factor	T.Taling Ngam		T.Na Mueang	
				S	S x W	S	S x W
7	EDI	1	Endangered species	5	5	4	4
9.1	EDI	3	Landbase Coastal Aquaculture	1	3	1	3
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1
10	EDI	2	Fisheries	1	2	1	2
11	EDI	1	Water resources	2	2	2	2
12	EDI	2	Open surface area and mining	2	4	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	7	14	7	14
15	EDI	2	Marine reserves	7	14	7	14
	Sum	14	Sum	26	45	24	42
			EDI		**3.21**		**3.00**

No	Sub-Index	W	Factor	T.Taling Ngam		T.Na Mueang	
				S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3
18	REI	1	High winds	3	3	4	4
19	REI	1	Dry periods	5	5	5	5
20	REI	1	Wet periods	3	3	3	3
24	REI	3	Human population density	1	3	1	3
25	REI	1	Human population growth rate	2	2	2	2
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1
27	REI	1	Tourists guest rooms	5	5	5	5
28	REI	2	Tourism area life cycle	5	10	5	10
29	REI	3	Waste waters	1	3	1	3
30	REI	3	Solid waste	2	6	1	3
31	REI	2	Oil spills	1	2	1	2
32	REI	3	Fertilizers	1	3	1	3
33	REI	3	Pesticides	1	3	1	3
	Sum	26	Sum	34	52	34	50
			REI		**2.00**		**1.92**
Sum		**46**	**EVI**		**2.76**		**2.59**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

Table 4.1.9 The calculation of IRI, EDI, REI and EVI values of Tambon, Amphoe Ko Pha Ngan

No	Sub-Index	Weight (W)	Factor	T.Ban Tai		T.Ko Pha Ngan	
				S	S x W	S	S x W
2	IRI	1	Vertical relief	7	7	7	7
4	IRI	2	Coastal erosion	7	14	1	2
5	IRI	3	Habitats diversity	6	18	7	21
	Sum	6	Sum	20	39	15	30
			IRI		**6.50**		**5.00**

No	Sub-Index	W	Factor	T.Ban Tai		T.Ko Pha Ngan	
				S	S x W	S	S x W
7	EDI	1	Endangered species	4	4	4	4
9.1	EDI	3	Landbase Coastal Aquaculture	1	3	1	3
9.2	EDI	1	Seabase Coastal Aquaculture	1	1	1	1
10	EDI	2	Fisheries	2	4	2	4
11	EDI	1	Water resources	1	1	2	2
12	EDI	2	Open surface area and mining	1	2	1	2
14	EDI	2	Terrestrial reserves and environmental protected areas	5	10	5	10
15	EDI	2	Marine reserves	1	2	1	2
	Sum	14	Sum	16	27	17	28
			EDI		**1.93**		**2.00**

No	Sub-Index	W	Factor	T.Ban Tai		T.Ko Pha Ngan	
				S	S x W	S	S x W
8	REI	1	Migrating species	3	3	3	3
18	REI	1	High winds	2	2	1	1
19	REI	1	Dry periods	5	5	5	5
20	REI	1	Wet periods	3	3	3	3
24	REI	3	Human population density	1	3	1	3
25	REI	1	Human population growth rate	3	3	4	4
26	REI	1	Rate of loss of natural cover/vegetation	1	1	1	1
27	REI	1	Tourists guest rooms	4	4	3	3
28	REI	2	Tourism area life cycle	4	8	4	8
29	REI	3	Waste waters	1	3	1	3
30	REI	3	Solid waste	1	3	2	6
31	REI	2	Oil spills	1	2	1	2
32	REI	3	Fertilizers	1	3	1	3
33	REI	3	Pesticides	1	3	1	3
	Sum	26	Sum	28	46	31	48
			REI		**1.77**		**1.85**
Sum		**46**	**EVI**		**2.43**		**2.30**

Remark: W = Weighting factor
S = Score of each indicator
S x W = Score x Weighting factor

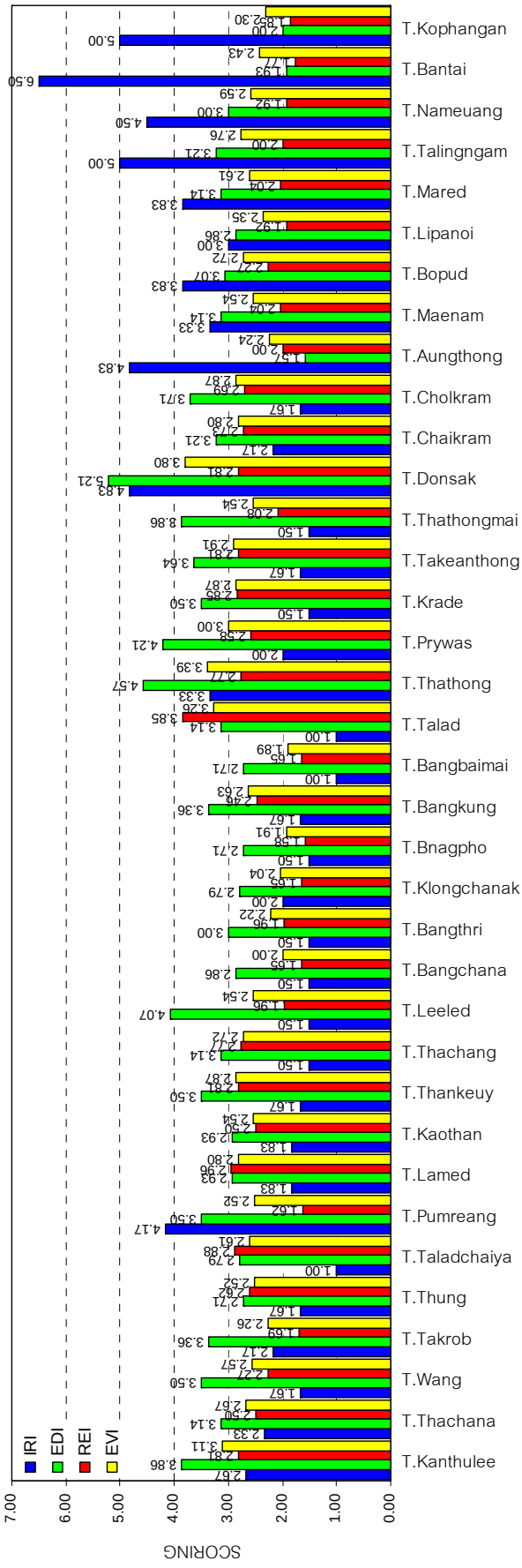


Figure 4.1.37 Comparison of IRI, EDI, REI and EVI values of Ban Don Bay and its islands

Consider IRI of the Ban Don Bay (Figure 4.1.37), T.Ban Tai, T.Ko Pha Ngan (A.Ko Pha Ngan), T.Taling Ngam, T.Na Mueang (A.Ko Samui), T.Don Sak (A.Don Sak), and T.Phum Riang (A.Chaiya) are high resistant or vulnerable to natural disasters and human activities. And then, T.Khan Thuli, T.Tha Chana (A.Tha Chana), T.Takrob (A.Chaiya), T.Thathong (A.Kanchanadit, T.Chaikhram (A.Don Sak), T.Maenam, T.Bo Phut, T.Lipa Noi, T.Maret (A.Ko Samui) are moderate resistant or vulnerable to natural disasters and human activities. These IRIs are low since these areas have various elevation levels. There are diverse habitats and are source of mangrove forest, seagrass beds and endangered species

The loss in natural system of T.Liled (A.Phunphin), T.Thathong, T.Plaiwat (A.Kanchanadit), T.Don Sak (A.Don Sak) are high (EDI > 4). These high EDIs are results of many fisheries and coastal aquaculture activities. T.Aungthong (A.Ko Samui, T.Ban Tai, T.Ko Pha Ngan (A.Ko Pha Ngan) are high resistance to damages. Others are moderate are moderate resistance to damages.

All tambon of A.Tha Chana, A.Tha Chang, A.Kanchanadit, A.Don Sak are moderate risk (2 < REI < 4.01). And all tambon of A.Phunphin, A.Pha Ngan are low risk. 2.00 and 1.95, respectively. This is because there are few environmental threats including drought, acute flood and high use of pesticide.

The EVI of T.Bang Chana, T.Bang Pho, T.Bang Baimai (A.Mueang Surat Thani) are lower than 2.01. This means the vulnerability is low and stable. Anothers Tambon is moderate vulnerability. Even though these areas have low and moderate EVI values, conservation measures should be clearly undertaken to protect mangrove forests, coral reefs, seagrass beds, and endangered species. Moreover, high attention should be paid to pesticide utilization in agricultural activities and natural disaster prevention and preparedness.

4.2 AREA INFORMATION AND ITS VULNERABILITY

The area information and analysis results of environmental vulnerability of each coastal unit in Ban Don Bay and its islands are shown as follows:

4.2.1 Amphoe Tha Chana

4.2.1.1 Tambon Khan Thuli

General description

The main geographical feature of this area is the hilly ares and mountain on west. The east part is coastal area and hill. The area is 176.33 Km^2. The main river is Khlong kunthulee. There are Khan Thuli swamp, mangrove, seagrass and coral.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 2.67) as well as the state of environmental degradation (EDI = 3.86).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.81).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 3.11). There are no pressing environmental issues. Two major aspects of concern for BB01 are the protection of natural ecosystems (mangroves, shoreline) and the growing problem of aquaculture.

4.2.1.2 Tambon Tha Chana

General description

The main geographical feature of this area is a coastal plain engulfing. The east part is coastal area and hill. The area is 36.74 Km^2. The main river is Khlong Tha Chana, Khlong Thakrachay, and Khlong Thalingthao, etc. Coastal erosion has been occured.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 2.33) as well as the state of environmental degradation (EDI = 3.14).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.50).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.67). There are no pressing environmental issues.

4.2.1.3 Tambon Wang

General description

The main geographical feature of this area is a coastal plain engulfing. The main geographical feature of this area is a coastal plain engulfing. The east part is coastal area and hill. The area is 37.76 Km^2. The main river is Khlong Tha Chana, Khlong Thamuang, Khlong Wang, and Khlong Pakkew, etc. Coastal erosion has been occured. The main resources are terrestrial forest and mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.67), while state of environmental degradation is moderate (EDI = 3.50).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.27).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.57). There are no pressing environmental issues.

4.2.2 Amphoe Chaiya

4.2.2.1 Tambon Takrob

General description

The main geographical feature of this area is a coastal plain engulfing. The area is 36.71 Km^2. The main river is Khlong Bangpakkrad. Coastal erosion has been occured. The main resource is mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 2.17) as well as the state of environmental degradation (EDI = 3.36).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.69).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.26). There are no pressing environmental issues.

4.2.2.2 Tambon Thung

General description

The main geographical feature of this area is plain. This area disconnect to coastal area. The area is 43.94 Km^2. The main river is Khlong Thachean, Khlong Hlong, and Khlong Chaiya, etc. The main resource is mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.67), while state of environmental degradation is moderate (EDI = 2.71).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.62).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.52). There are no pressing environmental issues.

4.2.2.3 Tambon Chaiya

General description

The main geographical feature of this area is plain. This area disconnect to coastal area. The area is 11.50 Km^2. The main river is Khlong Thachean, Khlong Thateen, Khlong Thapho, and Khlong Chaiya, etc.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.00), while state of environmental degradation is moderate (EDI = 2.79).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.88).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.61). There are no pressing environmental issues.

4.2.2.4 Tambon Phum Riang

General description

The main geographical feature of this area is a coastal plain engulfing. The area is 38.00 Km^2. The main river is Khlong Yaipumreang, Khlong Pumreang, Khlong Thakean, Khlong Kunthung, etc. Coastal erosion has been occured. The main resource are mangrove, seagrass and rare species such doogong.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is high (IRI = 4.17), while state of environmental degradation is moderate (EDI = 3.50).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.62).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.52). There are no pressing environmental issues.

4.2.2.5 Tambon Lamet

General description

The main geographical feature of this area is the hilly ares on the west. The east part is coastal area and plain. The area is 38.09 Km^2. The main river is Khlong Takean, Khlong Thapho, Khlong Chaiya, Khlong Thapun, etc. The main resource is mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.83), while state of environmental degradation is moderate (EDI = 2.93).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.96).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.80). There are no pressing environmental issues.

4.2.3 Amphoe Tha Chang

4.2.3.1 Tambon Khao Than

General description

The main geographical feature of this area is the hilly ares on the west. The east part is coastal area and plain. The area is 54.05 Km^2. The main river is Khlong Thachang. The main resources are terrestrial forest and mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.83), while state of environmental degradation is moderate (EDI = 2.93).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.50).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.54). There are no pressing environmental issues.

4.2.3.2 Tambon Tha Chang

General description

The main geographical feature of this area is plain.. The area is 34.35 Km^2. The main river is Khlong Thachangand Khlong Thakeuy. The main resource is mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.50), while state of environmental degradation is moderate (EDI = 3.14).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.77).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.72). There are no pressing environmental issues.

4.2.3.3 Tambon Tha Khoei

General description

The main geographical feature of this area is the hilly area. The middle area is plain. And the east part is coastal area. The area is 88.74 Km^2. The main river is Khlong Tha Khoei, Khlong Bangpid, Khlong Khud, Khlong Wangnaw, etc. The main resource is mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.67), while state of environmental degradation is moderate (EDI = 3.50).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.81).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.87). There are no pressing environmental issues.

4.2.4 Amphoe Phunphin

4.2.4.1 Tambon Liled

General description

The main geographical feature of this area is plain. The area is 41.14 Km^2. The main river is Khlong Phunphin, Khlong Rangm, Khlong Ko, Khlong Liled and Khlong Banghuayso. The main resource is mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.50), while state of environmental degradation is high (EDI = 4.07).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.96).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.54). There are no pressing environmental issues.

4.2.5 Amphoe Mueang Surat Thani

4.2.5.1 Tambon Bang Pho

General description

The main geographical feature of this area is plain. The area is 22.03 Km^2. The main river is Khlong Phunphin and Khlong Bnag Kruay. There is small area of mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.50), while state of environmental degradation is moderate (EDI = 2.71).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.58).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 1.91). There are no pressing environmental issues.

4.2.5.2 Tambon Bang Sai

General description

The main geographical feature of this area is plain. The area is 9.09 Km^2. The main river is Khlong Phunphin, Khlong Suk, Khlong Bangperd, Khlong Bangkruay, etc. There is small area of mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.50), while state of environmental degradation is moderate (EDI = 3.00).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.96).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.22). There are no pressing environmental issues.

4.2.5.3 Tambon Bang Chana

General description

The main geographical feature of this area is plain. The area is 18.34 Km^2. The main river is Khlong Phunphin, Khlong Suk, Khlong Rew, Khlong Chanak, etc. The main resource is mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.50), while state of environmental degradation is moderate (EDI = 3.86).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.65).

Recommendations

The environmental vulnerability is estimated to be low (EVI = 2.00). There are no pressing environmental issues.

4.2.5.4 Tambon Bang Baimai

General description

The main geographical feature of this area is plain. The area is 14.28 Km^2. The main river is Khlong Thapi, Khlong Bangbaimai, etc.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.00), while state of environmental degradation is moderate (EDI = 2.71).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.58).

Recommendations

The environmental vulnerability is estimated to be low (EVI = 1.91). There are no pressing environmental issues.

4.2.5.5 Tambon Khlong Chanak

General description

The main geographical feature of this area is plain. The area is 22.06 Km^2. The main river is Tapi River, Khlong Chanak, Khlong Rew, Khlong Thonglang, Khlong Sabayoy, etc. The main resource is mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 2.00), while state of environmental degradation is moderate (EDI = 2.79).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.65).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.04). There are no pressing environmental issues.

4.2.5.6 Tambon Talat

General description

The main geographical feature of this plain. The area is 3.08 Km^2. The main river is Tapi River.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.00), while state of environmental degradation is moderate (EDI = 3.14).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 3.85).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 3.26). There are no pressing environmental issues.

4.2.5.7 Tambon Bang Kung

General description

The main geographical feature of this area is plain. The area is 21.91 Km^2. The main river is Khlong Bangkung, Khlong Thathong, etc. The are clump of mangrove.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.67), while state of environmental degradation is moderate (EDI = 3.36).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.46).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.63). There are no pressing environmental issues.

4.2.6 Amphoe Kanchanadit

4.2.6.1 Tambon Tha Thongmai

General description

The main geographical feature of this area is coastal plain. The area is 18.23 Km^2. The main river is Tapi River, Khlong Thathong, Khlong Chimwang, etc. There is mangrove along coastal line.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.50), while state of environmental degradation is moderate (EDI = 3.86).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.08).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.54). There are no pressing environmental issues.

4.2.6.2 Tambon Takhianthong

General description

The main geographical feature of this area is coastal plain. The area is 23.32 Km^2. The main river is Khlong Chengcha. There are mangroves along coastal line.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.67), while state of environmental degradation is moderate (EDI = 3.64).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.81).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.91). There are no pressing environmental issues.

4.2.6.3 Tambon Kadae

General description

The main geographical feature of this area is coastal plain. The area is 19.15 Km^2. The main river is khlong Kadae, Khlong Chengcha. The mangrove can be found along coastal of Ban Don Bay.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.50), while state of environmental degradation is moderate (EDI = 3.50).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.85).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.87). There are no pressing environmental issues.

4.2.6.4 Tambon Plaiwat

General description

The main geographical feature of this area is plain and coastal plain. The main river is Khlong Krade, Khlong Ram, Khlong Thathong, etc. The mangrove area can be found along the coast of Ban Don Bay.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 2.00), while state of environmental degradation is high (EDI = 4.21).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.58).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 3.00). There are no pressing environmental issues.

4.2.6.7 Tambon Thathong

General description

The main geographical feature of this area is plain and coastal plain. The area is 65.86 Km^2. The main river is Khlong Thathong, Khlong Phun, Khlong Klang, etc. There are mangrove and terrestrial forest.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 3.33), while state of environmental degradation is high (EDI = 4.57).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.77).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 3.39). There are no pressing environmental issues.

4.2.7 Amphoe Don Sak

4.2.7.1 Tambon Cholkhram

General description

The main geographical feature of this area is coastal plain. The area is 26.33 Km^2. The main river is Khlong Kwam. There is small area of mangrove. Serious coastal erosion has been occured.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is low (IRI = 1.67), while state of environmental degradation is moderate (EDI = 3.71).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.69).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.87). There are no pressing environmental issues.

4.2.7.2 Tambon Chaikhram

General description

The main geographical feature of this area is hilly on south sloping down to north. The area is 36.36 Km^2. The main river is Khlong Kwam. Serious coastal erosion has been occured.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 2.17) as well as the state of environmental degradation (EDI = 3.21).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.73).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.80). There are no pressing environmental issues.

4.2.7.3 Tambon Don Sak

General description

The main geographical feature of this area is high plain sloping down along north coast. South part and east part is mountain. There are small islands with 150.74 Km^2 of area. The main river is Khlong Don Sak, Khlong Bangsom, Khlong Thalamphu, Khlong Banhuay, Khlong Bangtangheeb, etc, Coastal erosion has been occured. There are various resources such as terrestrial forest, mangrove, seagrass and coral reef.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is high (IRI = 4.83) as well as the state of environmental degradation (EDI = 5.21).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.81).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 3.80). There are no pressing environmental issues.

4.2.8 Amphoe Ko Samui

4.2.8.1 Tambon Ang Thong

General description

The main geographical feature of this area is islands compose of Ang Thong islands and some part of Ko Samui. There are 45 islands. The coral reefs on the north part of island are abundance. But the coral reefs on south part of island have been broken down. The main resources are composed of seagrass and coral reef.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is high (IRI = 4.83), while state of environmental degradation is low (EDI = 1.57).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.00).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.24). There are no pressing environmental issues.

4.2.8.2 Tambon Maenam

General description

The main geographical feature of this area is coastal plain and mountain. The tourism resources are coral reef and beach such as Bangpo beach, Maenam Beach.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 3.33) as well as the state of environmental degradation (EDI = 3.14).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.04).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.54). There are no pressing environmental issues.

4.2.8.3 Tambon Bo Phut

General description

The main geographical feature of this area is high mountain and coastal plain. The tourism resources are coral reef and beach such as Bophud beach, Pangrak Beach, Banpraylam beach, Cheungmon Beach, Chawang beach. Coastal erosion has been occured.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 3.83) as well as the state of environmental degradation (EDI = 3.07).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.27).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.72). There are no pressing environmental issues.

4.2.8.4 Tambon Maret

General description

The main geographical feature of this area is high mountain and coastal plain. The tourism resources are coral reef and beach such as Lamai beach. Seagrass can be found at Bannakay and Namjeud Bay.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 3.83) as well as the state of environmental degradation (EDI = 3.14).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be moderate (REI = 2.04).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.61). There are no pressing environmental issues.

4.2.8.5 Tambon Na Mueang

General description

The main geographical feature of this area is high mountain and coastal plain. There are coral reef and seagrass along coastal area.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is high (IRI = 4.50), while state of environmental degradation is moderate (EDI = 3.00).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.92).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.59). There are no pressing environmental issues.

4.2.8.6 Tambon Taling Ngam

General description

The main geographical feature of this area is high mountain and coastal plain and islands such as Ko Tan, Ko Muddang, Ko Mudkong, Ko Wangnai, Ko Wangnok, Ko Rab, Ko Thalu, Ko Din, Ko Jetmun, Ko Maetub, Ko Malangpong. Coral reef and seagrass can be foune around Hinlad Bay, Pangka Bay, Taling Ngam Bay.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is high (IRI = 5.00), while state of environmental degradation is moderate (EDI = 3.21).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 2.00).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.76). There are no pressing environmental issues.

4.2.8.7 Tambon Lipa Noi

General description

The main geographical feature of this area is High Mountain and coastal plain. The tourism resource is Lipanoi beach and coral reef at Lam Jonkrame.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is moderate (IRI = 3.00) as well as the state of environmental degradation (EDI = 2.86).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.92).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.35). There are no pressing environmental issues.

4.2.9 Amphoe Ko Pha Ngan

4.2.9.1 Tambon Ko Pha Ngan

General description

The main geographical feature of this area is high mountain and coastal plain. This area composes of Ko Ma, Ko Kongnui, Ko Kongkreng, Ko Tanai, Ko Tanok. Seagrass can be found on northwest of island. And coral reef can be found along coastal area and island.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is high (IRI = 5.00), while state of environmental degradation is low (EDI = 2.00).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.85).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.30). There are no pressing environmental issues.

4.2.9.2 Tambon Ban Tai

General description

The main geographical feature of this area is high mountain and coastal plain and island such as Ko Kongtansaded, Ko Kongrin. Seagrass can be found at south part of island there are coral reef along coastal line and around island.

Sensibility

In this area, its sensibility or resistance to either the natural and anthropogenic disturbance or intrinsic resilience is high (IRI = 6.50), while state of environmental degradation is low (EDI = 1.93).

Risk factors

The area is not much prone to high degree and frequency of natural and man-made risks. The Risk Exposure Index is ranked to be low (REI = 1.77).

Recommendations

The environmental vulnerability is estimated to be moderate (EVI = 2.43). There are no pressing environmental issues.

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