SCALES OF RELATIVE IMPORTANCE AND DAMAGE SCHEDULES:

A NON-MONETARY VALUATION APPROACH FOR NATURAL RESOURCE MANAGEMENT

by

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Abstract

The damage schedule framework was applied as an analytical protocol to assess communities' valuation of environmental resources. The study was an empirical test of the feasibility of developing damage schedules using two coastal areas of Thailand, Ban Don Bay and Phangnga Bay. The objectives of this research included (a) investigating the ability of people to provide judgments about the relative importance of resources, (b) examining how this information could be used to derive scales of relative importance, and (c) developing the damage schedules based on these importance scales. A questionnaire containing series of paired comparison questions was used as a survey instrument. About 200 people were surveyed for each study area. These included 'formal experts', such as researchers, policy makers and administrators, and 'layexperts', such as resource users, other stakeholders, and people living in the study areas. The first part of the questionnaire presented pairs of resource losses (e.g. damage to coral reefs, loss of mangrove forests), while loss-causing activities (e.g. an oil spill, shrimp farming) were paired in the second part of the questionnaire. For a series of these pairs, respondents were asked to indicate which member within each pair was more important. The results showed a significant agreement in the rankings of importance of resource losses and activities provided by all respondents in each study area. Agreement in the rankings was found between formal experts and layexperts and among layexperts of different occupations. Intransitive responses occurred but did not have a significant effect on the resulting scale values and rankings. Comparison between the damage schedules of the two areas supported the underlying assumption that people could make judgments on the relative importance of different losses and could provide meaningful rankings that reflect community values. The damage schedules can be adjusted over time as losses or activities of different magnitude occur, by interpolating or extrapolating from the initial scale values. Damage schedules, apart from providing predictability and enforceability in the damage payments, can also be developed quickly and at lower cost than current valuation methods.

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CHAPTER 1

Introduction

1.1 Background of the study

Economic valuation is a key aspect of natural resource and environmental management. From 1990 to 1993, about one-third of the articles in the *Journal of Environmental Economics and Management* and *Land Economics* dealt with valuation (Vatn and Bromley, 1994).

There are at least two major roles of economic valuation. One is in guiding policymakers in their decisions concerning natural resource allocation, and the second is in the assessment of environmental damages. In both functions, decision-makers face great difficulties dealing with issues of externalities, common property, and public good characteristics of natural resources and the environment. Unlike other commodities, most goods and services provided by the environment are not traded in the market place. Applications of valuation methods are therefore problematic, as it is not possible to rely on the market system to reveal prices that reflect their economic values.

An example of the problems relating to valuation of environmental resources is the damage assessment procedure under the U.S. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or 'Superfund Act') of 1980. Apart from achieving the expedient and comprehensive cleanup of sites contaminated by hazardous substances, the purpose of CERCLA is to obtain damages for injuries to natural resources caused by such substances (Ward and Duffield, 1992). In accord with CERCLA, financial liability for damages to natural resources is imposed on agents responsible for release of hazardous materials into the environment (Freeman, 1993). This is to ensure that polluters and others responsible for degrading the environment are liable for the costs incurred by their behaviour. The calculation of this liability is, however, disputable. First, identifying the link between the impacting activities and the resources is a complicated task. Secondly, monetary valuation of the damages is difficult, especially for damaged resources and commodities not traded in markets. As Rutherford et al. (1998) note, the research of the past four decades has not provided reliable methods to measure the economic values of most of the nonmarketed environmental assets involved in damage claims and allocation decisions.

The growing concern about environmental degradation heightens the roles of environmental economics and valuation of natural resources as analytical tools to facilitate the development of policies for sustainable management. Given that current valuation methods are not capable of producing acceptable monetary assessments, other non-valuation procedures might usefully be explored. One strategy proposed by Knetsch (1994) is to rely on some form of 'interim damage schedule' to guide resource allocation and assessment of compensation awards.

Rutherford et al. (1998) conducted a study showing that people's judgment of non-pecuniary losses could be effectively used to construct an importance scale, which provided a basis for the development of an interim damage schedule. The study tested the approach, asking graduates of a university resource management programme to answer a questionnaire concerning different environmental losses resulting from oil spills. Although the study found that respondents were able to provide consistent judgments, two main issues remained unexplored by Rutherford et al. (1998). First, they did not determine what proportion of respondents best reflect community assessments of the relative importance of different losses. Secondly, they did not test the relationship between damage schedules developed based on loss scenarios and activity scenarios.

In this study, these issues are addressed more thoroughly than what done by Rutherford et al. (1998). This was accomplished by conducting the study in coastal areas where the approach could be used in the future, and by employing the judgments of people directly familiar with the resources in question.

1.2 Thai coastal areas as study sites

Coastal areas of Thailand were chosen as study sites to construct importance scales. Thailand has extensive coastlines in the eastern and the southern parts of the country. The southern coasts are divided into two sides, the eastern side adjacent to the Gulf of Thailand, connecting with the eastern coast, and the western side in the Andaman Sea (figure 1.1). These coastal areas have certain characteristics that make them suitable for the application of the damage schedule approach. They offer examples of several of the productive and diverse ecosystems found in the tropics, including mangrove forests, seagrass beds, mudflats and coral reefs. Aside from being important as individual ecosystems, the interactions between these ecosystems are complex. For example, mangrove ecosystem is one of the most complicated systems in coastal areas. Ruitenbeek (1994) provided comprehensive examples of uses and environmental functions of mangroves. This includes the production of timber, firewood, charcoal and several fisheries products. Some of the conversion uses are industrial and

Source: The 1997 World Factbook

Figure 1.1 Coastal areas of Thailand

urban land use, aquaculture, salt ponds, rice fields, etc. Mangroves provide other environmental functions, for example, shoreline stabilisation, provision of nursery and breeding grounds for fish, nutrient supply and regeneration, and recreational opportunities. Thus, the degradation and exploitation of mangrove forests can negatively impact other components of the coastal system (Ruitenbeek, 1994).

Coastal resources are generally exploited by various conflicting activities and are under pressure from urban and industrial developments. For example, public access to the beach may be restricted due to the development of hotels and resorts, and small-scale fishers may be in direct competition for fishing grounds with shellfish culturers.

Traditional valuation methods are unlikely to be successfully in the study of Thai coastal resources because of the lack of a comprehensive understanding of coastal ecosystems and a high level of conflict among stakeholders. Moreover, Thailand faces other limitations in terms of availability of information, expertise, financial resources and personnel that are necessary for employing current valuation techniques. Consequently, it seems appropriate to test the novel damage schedule approach on the coastal resources of Thailand. This study provides a practical example of the application of the approach, and one that could easily be adopted and utilised in other environmental resource settings.

Two coastal areas of Thailand were selected for the study: Ban Don Bay on the eastern coast, Gulf of Thailand and Phangnga Bay, on the western coast, Andaman Sea (figure 1.1). One of the main reasons for choosing these areas as study sites is the availability of information on local resources. Ban Don Bay and Phangnga Bay were extensively studied in 1986 by a team of experts in various disciplines under the Association of Southeast

Asian Nations (ASEAN) - United States (US) Coastal Resources Management Project (Paw et al., 1988). Several aspects of coastal areas were included in the coastal environmental profile, including descriptions of the physical setting, land use, population, natural resources, climate, fisheries, aquaculture, tourism and other economic sectors, as well as institutional and legal framework for the management of the coastal areas.

Both of these areas are of high importance to the region in terms of their natural resources and cultural values, yet possess different physical-biological characteristics and economic importance. While Ban Don Bay is an open shallow bay area, with a muddy substrate, Phangnga Bay is a semi-closed area with many small islands. Ban Don Bay has been the center of urban development in the south and was a starting place for the development of the shrimp farming industry in the region. In contrast, Phangnga Bay has been developed as a tourist destination because of its natural beauty, including sandy beaches and coral reefs. It is thus possible to make a comparative study of these two coastal areas, as a means to test the feasibility of the damage schedule approach. A general overview about the coastal resources of Thailand and the detailed description of the two study sites are provided in Chapter 4.

1.3 Objectives of the study

The study is an empirical test of the feasibility of developing damage schedules that successfully reflect community values of environmental resources. Fundamentally, the study (1) investigates the ability of people to provide judgments of the relative importance of resources, (2) examines how well this information could be used to derive scales of relative importance, and (3) shows how the importance scales can be used to construct damage schedules.

In this study, scales of relative importance are derived from responses of 'experts' to a questionnaire containing sets of paired comparisons of various losses and activities causing losses. Experts, in this case, include 'formal experts', such as researchers, policy makers and administrators, and 'layexperts', such as resource users, other stakeholders and people living in the study areas.

Regarding development of damage schedules, this study attempts to answer two key questions. First, can respondents to the survey (formal experts and layexperts) provide consistent scales of relative importance of various resource losses and impacting activities? Second, can these scales be used as a basis for constructing meaningful damage schedules that reflect community values?

In addressing these questions, the study follows these steps.

1) Selecting coastal resources and activities in Ban Don Bay and Phangnga Bay and defining their characteristics for inclusion in the study;
2) Developing a questionnaire and conducting a survey of formal experts (researchers, administrators and policy makers) and layexperts (resource users, stakeholders, and residents of the coastal areas);
3) Deriving scales of relative importance of the selected resource losses and impacting activities;

4) Performing reliability and validity tests on the importance scales and discussing problems associated with the approach;
5) Constructing damage schedules based on these importance scales and showing how they can be used as a tool in policymaking;
6) Recommending future research needs.

This thesis has adopted the damage schedule approach and applied it to study the coastal areas of Thailand. Its definition and application are discussed in Chapter 2. Although the thesis does not deal directly with monetary valuation, I have included Chapter 7 as a comparison between the damage schedule approach and a more traditional approach such as the contingent valuation methods. The primary results obtained from the field surveys were through the co-operation with the Kasetsart University and their procedures concerning data collection were used.

The outline of this dissertation is as follows. Chapter 2 addresses the issues related to valuation and current practices, as well as discusses the proposed damage schedule approach, its advantages and potential problems. Chapter 3 describes the methodology used to obtain the scales of relative importance and the damage schedules. This chapter provides details of the paired comparison method, the experimental design, and the analysis of paired comparison data. Chapter 4 presents the case studies conducted in the two coastal areas of Thailand as a test on the application of the damage schedule approach in actual situations. Chapter 5 summarises the data analysis and the results of the study. Chapter 6 provides a discussion of the reliability of the resulting scales of importance, the problems relating to the method used, and the damage schedule approach in general. Chapter 7 discusses the issues relating to monetary estimates of the resource losses obtained using the paired comparison method. Chapter 8 gives examples on how to develop damage schedules and how they can be used to aid policy makers in the management of coastal resources of Thailand, as well as other areas, and provides recommendations for future research needs.

CHAPTER 2

Economic Valuation and the Damage Schedule Approach

This chapter provides the framework for this study. The first section describes different types of values of natural resources and environmental assets, and presents examples of the techniques currently used in valuation. The next section introduces the damage schedule as an alternative approach based on scales of relative importance and outlines the theoretical background of the methods used in the study. It also suggests some advantages of the damage schedule approach over existing practices, and potential problems associated with the method.

2.1 Valuation of natural resources and environmental assets

The value of natural resources and environmental assets is commonly separated into three main groups: use value, nonuse value, and option value (figure 2.1) (Barbier 1994, Munasinghe, 1992). Use value represents the values of active use of the resources, either directly or indirectly. Direct use values include consumptive uses, e.g. fuelwood collection, hunting and fishing, and nonconsumptive uses, such as tourism and education. Indirect use values, or functional values, are the indirect support and protection provided by natural functions or environmental services of a resource system (Barbier, 1994). For example, benefits provided by the wetland ecosystem in the form of flood control and storm protection are indirect use values. These values are usually difficult to measure as they are indirectly connected to economic activities.

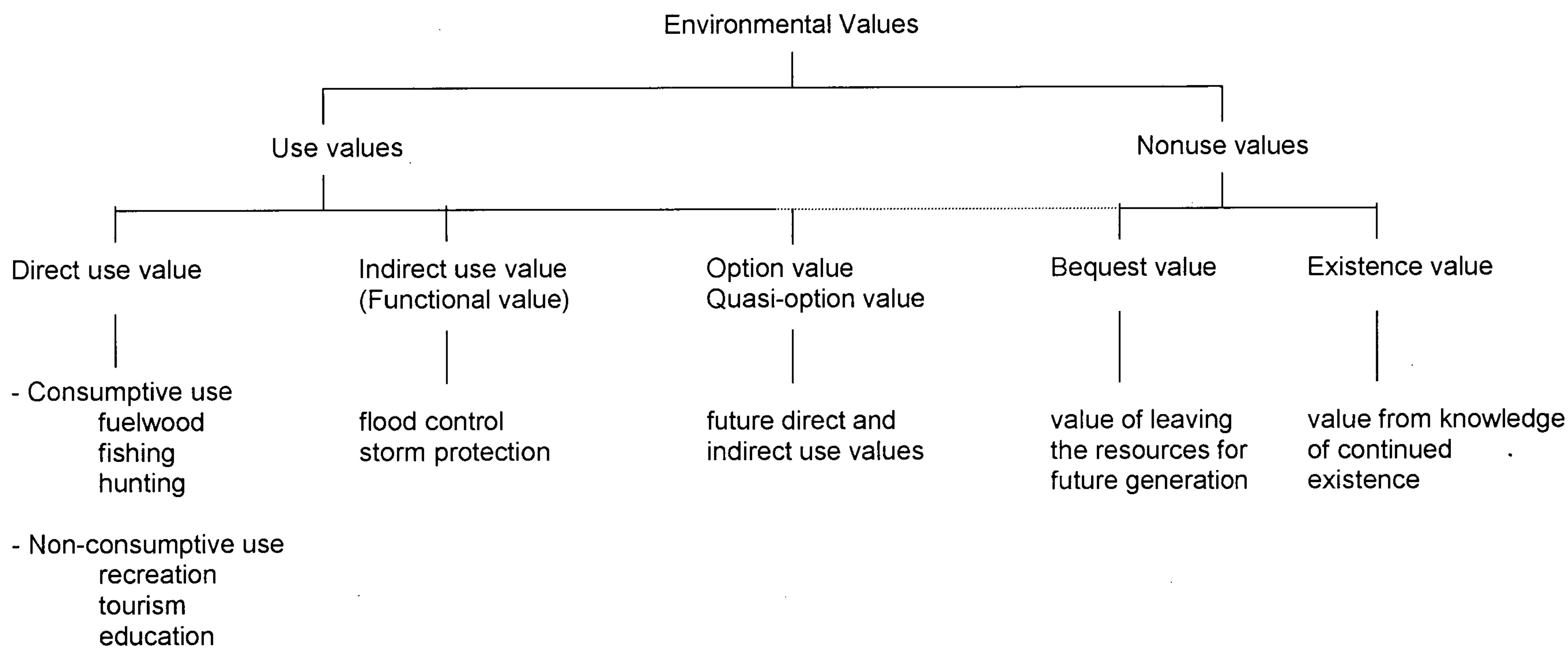


Figure 2.1 Values of natural resources and environmental assets (adapted from Barbier, 1994 and Munasinghe, 1992).

Nonuse value represents the value of the resources in the absence of active use. Two types of values under this category are existence value and bequest value. Existence value refers to the value of knowing that the resources are there and that they continue to exist. Endangered species are good examples of resources that people put existence value on. This form of nonuse value is extremely difficult to measure, as it involves individuals' subjective valuations of things that are unrelated to their own or others' current or future use (Barbier, 1994). The other kind of nonuse value, bequest value, is derived from knowing that the resources remain available for future generations. This value is the same as the preservation value people generally place on habitats and natural areas to ensure that their offspring and others can benefit from them in the future. Similar to existence value, bequest value is difficult to estimate.

Another category of value is option value, which is based on how much people, who are not currently using a resource, are willing to sacrifice today to preserve the option to use that resource in the future (Munasinghe and Lutz, 1993; Wruck, 1994). This value arises from uncertainty about future uses or demand for the resource or its availability. It is sometimes referred to as a type of insurance for access to future benefits from natural ecosystems (de Groot, 1992). Option value could be considered as another form of bequest value when it is placed to ensure future availability of goods and services for future generations (thus, the dotted line between these two types of value in figure 2.1). When exploitation or conversion of resources is believed to be irreversible, a quasi-option value may arise as an expected value of information derived from delaying such activities. Because of uncertainty about the future, it is very difficult to estimate option and quasi-option values of environmental resources and natural ecosystems.

A variety of techniques have been proposed and applied to quantify the different values of natural resources and environmental assets. Such valuation is, however, more complicated than valuation of consumer goods since environmental goods often include those not traded in markets, so that their values are not revealed in market prices. As pointed out by Barbier (1994), the values of marketed products and services of resources, such as wetlands, are easier to measure than the values of their noncommercial and subsistence direct uses.

Resource valuation techniques can be categorised into three main groups, based on the type of market they rely on (Agüero and Flores, 1995; Munasinghe and Lutz, 1993): conventional markets, implicit markets and constructed markets. When changes in productivity or productive capacity are measurable, valuation techniques based on conventional markets, such as the change in productivity method, are useful. Market prices can then be used to indicate the value of goods and services. In cases where there is a lack of such market indicators of value, shadow prices (the social value of one unit of a good) may sometimes be used (Angelsen et al., 1994). These are valuations that could be applied to replace market prices in a cost-benefit analysis (Sugden and Williams, 1978).

When goods and services are not priced, surrogate markets might be created to estimate the implicit value using indirectly the market information. This is done based on prices paid for other related goods that are marketed (Dixon et al., 1988). Techniques under this category include the travel cost method and the hedonic pricing method. The general application of the travel cost method involves using the demand for travel services to indicate willingness to pay for unpriced recreational amenities (Randall, 1987). The hedonic pricing method is normally used in valuation of environmental amenities relating to residential sites. For example, the value of a scenic view might be estimated by the difference in the price of land with and without a view.

In cases where values cannot be estimated by reference to market prices, other means must be used to estimate the values (Green and Tunstall, 1991). Contingent valuation (CV) methods include a variety of techniques used to provide monetary estimates when other methods are not feasible. The change in productivity method, travel cost method and contingent valuation methods are chosen as examples for discussion of the advantages and problems of some of the currently used economic valuation methods.

2.1.1 Change in productivity method.

The application of the change in productivity method is common in valuing environmental impacts resulting from development projects (Dixon et al., 1988). First, physical changes in productivity caused by a particular project are identified. These changes can be expected on site or off site and include all the externalities. The second step is an assessment of the effects on productivity both of proceeding with the project and without. This ensures a proper comparison of actual effects between undertaking the project and not undertaking the project. The next is to value these changes using appropriate market prices for inputs and outputs. These values are then used in the cost-benefit analysis.

The change in productivity technique requires that the cause and effect relationships be known (Dixon et al., 1988). For complex systems such as those of coastal areas, it is not likely that the magnitude of impacts could be determined without considerable speculation and arbitrary assumptions. Thus, the measures of changes in production usually involve great uncertainty. As recognised by Ruitenbeek (1994) in his study of mangrove resources in Indonesia, results of cost-benefit analysis could vary depending on assumptions concerning the nature and degree of linkages among many components of the complex mangrove resources system. These linkages are, unfortunately, not easy to identify.

An example of the application of the change in productivity method was presented in Dixon et al., (1994), which was based largely on the study by Ruitenbeek (1994). Ruitenbeek (1994) provided estimates of the benefits and costs of various management alternatives for mangrove harvesting for woodchip production in the Bintuni Bay area of Irian Jaya, Indonesia. The analysis considered the impacts of harvest activities on other goods and services derived from the mangrove ecosystem, such as local uses (e.g. traditional fishing, hunting, etc.), control of coastal erosion, commercial fisheries and sago production. The change in productivity approach to valuation was chosen despite the speculative relationships between loss of mangrove and direct reduction in fisheries productivity or indirect reduction of agriculture production through erosion (Dixon et al., 1994).

The valuation technique based on changes in productivity relies on several assumptions. In this example of mangrove valuation in Bintuni Bay, some of the assumptions were the sustainable yields for shrimp fishery, the value of bycatch, and the sustainable level of sago production. Prices of these various products were also assumed to remain constant over the 90-year period covered by the analysis. The study reported the net present values resulting from the benefit-cost analysis for several management options, ranging from a complete cutting ban to complete clear cutting. The results showed that the optimal cutting strategy changed with the effect of linkages between mangrove loss and other economic activities in the area (Ruitenbeek, 1994). These relationships were, unfortunately, difficult to specify, and thus made it less probable that decision-makers could choose a management plan based on this technique.

In summary, the change in productivity method is useful where physical changes in production can be observed and measured. The method is easy to understand and it may be suitable for use in developing countries. It should be recognised, however, that quantification of the predicted resource productivity is problematic. Further limitations become apparent depending on the availability of information on the physical relationship between activities affecting the environment, and outputs, costs or damage (Winpenny, 1991). Moreover, the focus of the method is on the identification and measurement of impacts to the physical environment, and thus, nonuse values are not considered.

2.1.2 Travel cost method

The travel cost method is commonly used for determining values or benefits produced by recreational sites. The approach has been used for almost three decades since it was first suggested by M. Clawson, and further developed by Clawson and Knetsch (1966). The travel cost method aims at deriving the demand for and valuation of a location from variations in the numbers of people going to the site as a function of the costs incurred in travelling to that location from various travel origins.

In this method, a survey of users is conducted at a recreational site to determine the numbers of people visiting from the different points of origin, and visitation rates are calculated accordingly. A statistical analysis is then carried out to empirically estimate the relationship between visitation rates, travel cost and various other determinants of the visit rates. The method implicitly assumes that people would react similarly to increasing travel costs as they would to increased admission charges at the park (Dixon et al., 1988).

A simple travel cost model relating visitation rates to travel costs can be written as in equation 2.1:

$$V = a + b\,T + c\,W, \qquad (2.1)$$

where V is visitation rates, T is travel costs, and W is a measure of socio-economic variables (Mendelsohn and Markstrom, 1988).

Once the relationship has been estimated, the next step is to derive a demand curve for visits to the sites, which measures the consumer surplus of visitors. This consumer surplus represents an estimate of the value of the recreation site in question.

Many studies have applied the travel cost method for valuation of recreation sites. For example, Farber and Costanza (1987) surveyed recreational users of wetland ecosystems in Louisiana and utilised the travel cost method to estimate consumer surplus from the uses of the site. Tobias and Mendelsohn (1991) used this method to measure the value of ecotourism at a tropical rainforest site in Costa Rica.

Although the travel cost method has been used in developing countries to value recreational goods and services (Dixon et al., 1988), its applicability, particularly in assessing environmental values, is rather limited. This is partially due to the cost of conducting the necessary surveys. As well, the measure of travel costs may not be straightforward; travel itself may be part of the pleasure of the visit and travelling by car could be seen as a prestige symbol (Winpenny, 1991).

2.1.3 Contingent valuation method

Contingent valuation (CV) methods are a group of survey-based techniques widely used for determining economic values of natural and environmental resources in the absence of market prices. This technique relies on obtaining information on consumers' preferences by posing direct questions about willingness to pay (or WTP). CV methods are designed to measure both use values and nonuse values. Hanemann (1994) reports 1,600 studies and papers using this method in over 40 countries on topics ranging from transportation to health and the environment, including air, water, land, fish, wilderness area and other wildlife. Other applications of CV methods include their uses in natural resource damage assessment, especially in the case of oil spills (see Binger et al.,1995; Heyde, 1995 and Wruck, 1994 for details).

In a resource valuation study, CV methods use surveys in which people are asked how much they are willing to pay to change the condition of the resource or to prevent natural resource injuries arising from environmental adversity. The typical survey begins by giving some background information to respondents on the resource under discussion, then they are told about the change in the environmental condition to be evaluated. They are also informed about the way money would be collected to finance the change (payment vehicle). Respondents are asked to give a hypothetical amount of how much they would be willing to pay for the change. The questions could be open-ended where respondents are asked to state how much they would pay, or they could be dichotomous-choice questions where respondents are asked if they would pay a stated amount. Another method of stating the amount to pay is to ask individuals to select an amount from payment cards shown to them. Questions about respondents' characteristics, such as age, education, income level, etc., are usually included at the end of the questionnaire (Diamond and Hausman, 1994).

The major concerns for the use of CV methods in resource valuation are structural biases, hypothetical biases and the embedding problem (Angelsen 1994; Dixon et al., 1988; Winpenny 1991; Kahneman and Knetsch, 1992), each of which is discussed below.

Structural biases

Three types of biases related to the structure and design of the CV questionnaire are strategic bias, starting point bias and information bias. Strategic bias reflects what respondents feel will be done with their answers (Dixon et al., 1988). If they feel they may actually have to pay the amount they answer, they may undervalue their true response. On the contrary, environmentalists may feel the need to overstate the amount to bring about the changes in preservation they would like to see.

Starting point bias is directly due to the design of the questionnaire used in the study. Starting point bias, or anchoring bias, refers to the inconsistency of responses when a different sequence of questions is used. For example, starting point bias occurs when the percentage of individuals who are willing to pay $50 for a public good when a higher amount is asked first is greater than that when a lower amount is asked first. This suggests that people anchor their responses on the initial amount proposed to them.

Because respondents to CV questionnaires are not always familiar with the public goods in consideration, detailed and accurate information about the goods is generally provided. The quality and quantity of the information could, however, induce information bias that distorts the WTP responses. As reported by Ajzen et al. (1996), WTP estimates could be affected by the nature of information and subtle contextual cues could seriously bias these estimates under conditions of low personal relevance. Apart from the given information, respondents have their own information set, based on their familiarity and experience with environmental resources, which might also influence the results of CV survey (Cameron and Englin, 1997).

Hypothetical biases

Although contingent valuation methods may be reliable for measuring use values, they may be inappropriate for measuring nonuse values (Agüero and Flores, 1995). This is due in part to the fact that people are unfamiliar with the notion of placing monetary values on non-marketed goods. As the market proposed is hypothetical rather than actual, respondents do not have the same incentives to make the best possible judgment as they would in a real market (Hanley, 1988). Moreover, the amounts indicated by people in response to WTP questions are also hypothetical and may differ from the real payment. As shown by Neill et al. (1994) in their experiment, the median value for the hypothetical willingness to pay for an antique map was $30, while the median value people would actually pay was only $5. According to Angelsen et al. (1994), this hypothetical bias is the most serious problem related to the application of CV methods, particularly in developing countries.

Embedding problem

Kahneman and Knetsch (1992, p. 58) referred to an embedding effect as existing where "*the same good is assigned a lower value if WTP for it is inferred from WTP for a more inclusive good rather than if the particular good is evaluated on its own*". In one of their examples, the WTP of Toronto residents to maintain fish populations in all Ontario lakes was only slightly higher than that to preserve the fish stocks in a small area of the province. Diamond and Hausman (1994) suggested that, because of the embedding effects, variable results of CV studies could be obtained from different surveys, and there was no straightforward way to select the appropriate method.

CV measures of value

Apart from the above problems that cast some doubts on the reliability and validity of the results from CV studies, the fundamental question of whether CV measures truly represent economic values remains an important issue. The argument stems largely from results of several studies suggesting the discrepancy between the valuation of gains obtained from CV surveys using willingness to pay questions and the valuation of losses measured by willingness to accept (see examples in Gregory, 1986; Knetsch, 1994).

In most CV studies, WTP questions are asked instead of willingness to accept (WTA) compensation questions because of three reasons. First, WTP measures seem to correspond more closely to most of the market exchanges people make and thus involve people in a more familiar transaction (Gregory, 1986). Secondly, it is difficult, or impossible, to obtain WTA responses. Respondents are capable of providing WTP measures when they are asked how much they are willing to pay to avoid a specified loss. However, when respondents are faced with a WTA question (i.e. how much they are willing to accept as compensation for such a loss), they often either give a protest response, such as an exceptionally high amount, or they refuse to respond. Finally, the variation between WTA and WTP is considered to be so small that it could be neglected.

Recent research has, however, provided strong evidence suggesting that the assumption of WTP and WTA equivalence is not valid (Knetsch, 1994). Findings from numerous studies show that people commonly value losses much more than they do gains. This discrepancy between valuation of gain and loss is referred to as endowment effect and has been repeatedly reported in the professional literature (see examples in Knetsch 1994). The use of WTP to measure losses will result in their very serious understatement, and should therefore be considered inappropriate (Knetsch, 1994). Gregory (1986) stresses the importance of acknowledging that the disparities in WTP and WTA measures of economic value as evidence of real differences in perception and in behaviour, not something that should be dismissed. Knestch (1994) concluded that the results of CV studies were not comparable to economic values derived from market exchanges and thus provided little or no guide to allocation policies and damage assessments.

2.2 Scale of relative importance and damage schedule

Given the problems associated with existing techniques, the present study explores an alternative approach that could provide an indication of the importance of environmental resources and their values, without the necessity of direct monetary valuation. The approach involves constructing scales of relative importance of environmental resources that are based entirely on people's judgments, and therefore reflect the community values of the resources, and using such scales to construct damage schedules. These schedules can then be used to aid policymakers in their decisions about resource allocation and environmental damage assessment.

A similar approach to the damage schedule has been used to a limited extent for compensation schedules in cases of minor discharge pollution and marine oil spills in the United States. The Florida oil spill compensation schedule set out a formula which took into account several factors such as the type and volume of oil spilled, location of discharge and the habitat impacted (Plant et. al., 1993). The dollar figures developed in these schedules were based on restoration cost and market value-based loss of use. Another example is the state of Washington's compensation schedule which considered the relative sensitivity of the impacting environment and the severity of environmental harm likely to be caused by a particular type of oil (Geselbracht and Logan, undated). The Washington schedule used rankings of ecological importance and sensitivity to provide scores of relative importance to assess damages. However, unlike the study described here, their focus was on the physical and biological aspect, not on the social and community aspect.

The damage schedule approach can be seen as analogous to workers' compensation schemes. Commonly, compensation that employees can recover for workplace injuries is determined, or at least guided, by scheduled sums that vary depending on the severity of the injuries (Rutherford et al., 1998). Based on the damage schedules, all parties would be notified of greater damage payments or more severe sanctions, just as workers are assured of receiving larger damage awards for more serious injuries. Compensation based on the schedules, although not value based, would receive a large measure of acceptance and would serve much of the restitution and deterrence functions that would be possible with a value based compensation award scheme (Rutherford et al., 1998).

2.2.1 Theoretical background

As stated previously, the main objective of the study is to derive scales of relative importance using people's judgments about the importance of resources and impacting activities. These judgments can be taken to reflect the values that people place on resources under consideration. The values obtained in this study are comparable with Brown's definition of 'assigned' value, which is "*the expressed relative importance or worth of an object to an individual or group in a given context*" (Brown, 1984, p.233). This kind of value is relative, not absolute, and thus can only indicate the importance of the object by implicit or explicit comparison (Brown, 1984). The type of values, provided by people in this study, should also be similar to the 'full value' referred to by de Groot (1992), which includes ecological, social and economic values. All these values are captured together, not separately, and are qualitatively described in terms of relative importance.

The concept of value can be expressed as a function of several variables, including utility, environmental conditions and circumstance of the evaluator at time of valuation (Sinden and Worrell, 1979). This concept suggests that people use utility (defined as the satisfaction of a human want or desire) as a criterion in ranking things in order of relative value. Value depends not only on the nature of the thing itself, but also on the environment in which value is being assessed and on different circumstances, such as the personal, emotional, social and political situation, of the people who evaluate it at that time. It is generally assumed that individuals seek to maximise utility subject to constraints such as costs, resource availability, etc. (Randall, 1987).

In complete and ideal markets, where individuals seek to maximise personal utility, economic values of goods and services are determined by their market prices. These measures, however, do not accurately reflect true economic values when markets are not ideal, as in the cases of environmental resources, with their nonexclusive and public good properties. Given the inadequacy of markets to reveal environmental values and to allocate resources, mainstream economics suggests cost-benefit analysis as a routine procedure for evaluating proposed projects (Randall, 1987). Cost-benefit analysis is applied to ensure that society is directed towards improving the economic efficiency of resource allocation. The analysis is based on the concept of potential Pareto improvement, which states that a change is economically desirable if the gain to people gaining is greater than the loss to people losing, and if, in principle, the gainers could compensate the losers. This criterion only requires that compensation be possible, not that it actually occur, and no consent of the involved parties is needed (Randall, 1987).

The scales of relative importance and the damage schedule developed in this study can be used to guide resource allocation decisions in much the same fashion as direct valuation is in cost-benefit analysis. The values obtained from the study, although not necessary leading to maximum economic efficiency or welfare, reflect the choices that people make and should therefore be socially acceptable. Rather than expecting that people would always make a decision that maximises their utility, the study allows for the possibility that an individual's judgment may be a result of intrinsic value, altruistic reason, or ethical duty (Sagoff, 1994).

The construction of the scales of relative importance is based on people's expressed value judgments. As in social choice theory, individuals are presented with a set of alternative social states (in this case, a set of resource losses or activities causing losses). For any individual, a preference ranking or ordering of these alternatives is constructed, and thus individual choice behaviour is determined and indicated in the form of relative importance. Note that preference in this context has a logical syntax that refers to a state of mind, i.e., to psychological meaning (Sagoff, 1994). The concept of social choice theory demands that in order for individual choices to be rational, they must be transitive and anti-symmetric. Choices are transitive and rational if when object *A* is ranked higher than *B* and *B* higher than *C*, it follows that A is ranked higher than *C* (e.g. $A > B$, $B > C$, and $A > C$). Anti-symmetric refers to a condition that if *A* is ranked higher than *B*, *B* cannot be ranked higher than *A*. The representation of the choice mechanism by ordering relations, as attempted in this study, has certain advantages over the more conventional representations in terms of utility functions (Arrow, 1951). As it may not be possible to assign real numbers to the various alternatives to satisfy the usual requirements of a utility function, the direct ordering of the choices is sufficient (Arrow, 1951). The issues concerning rational choice and transitivity are later investigated and discussed.

Rather than asking people to estimate the monetary value of the natural resources and environment, the importance scales are constructed by simply asking people to make a judgment of the relative importance of resource losses and impacting activities presented to them in pairs. There are two main reasons for doing this. First, people are not accustomed to interpreting environmental goods in monetary terms, especially when these goods are not bought or sold in markets. While people may not be able to provide consistent monetary measures of environmental losses (Rutherford et al., 1998), they are faced with a much less difficult task when asked to compare the severity of two losses or two activities. Therefore, they may be able to provide consistent rankings of the relative importance of different resource losses and activities that have adverse impacts on the environment. Even in the case when two losses or events are incommensurable, reasonable choice and ordinal ranking can still be made: "*Options can be incommensurable in this way while still being very much subject to reasonable choice....Indeed, reasonable choices among incommensurable options are the stuff not merely of law, but of everyday life*" (Sunstein, 1994, p. 808).

Another reason for not directly measuring environmental values in monetary terms stems from the belief that pricing or monetary valuing of environmental goods and services is neither necessary nor sufficient to ensure informed, coherent and consistent choices about the environment (Gregory et al., 1993; Vatn and Bromley, 1994). The values implied from the damage schedules are reflective of the choices that the community makes about the importance of environmental resources. In other words, damage schedules are simply indicative of the values that are distilled from a consensus of the value judgments of the individuals that make up the society. It should be noted, however, that these values are not free from the concerning issues of description invariance and procedure invariance, as will be discussed later.

2.2.2 Uses and advantages of the damage schedule approach

The scales of relative importance can be used to derive damage schedules, which can provide useful benchmarks to guide the assessment of specific resources or environmental losses. They can aid policy makers in designing management regulations, in resource allocation decisions and in determining compensation and damage awards (Knetsch, 1994). The damage schedule aims to facilitate decisions made on resource use, especially when confidence in physical measurement and market information is lacking.

The damage schedule approach provides pre-incident information which is more advantageous than post-incident valuation, especially as environmental damages occur abruptly and are not reversible (Arrow et al., 1995). Damage schedules provide predictability and enforceability by specifying in advance the payments that will be required in the event of a loss (Rutherford et al., 1998). Traditionally, economic valuation of resource damage takes place after the incident has occurred and usually involves long processes of collecting information, identifying impacts and calculating costs of restoration or replacement. Hence, not only are value assessments problematic, but the cost of assessing the damages could easily exceed the recovery cost of the resource itself (Rutherford et al., 1998). With the damage schedule, loss assessment could be implemented quickly at low cost. Further, predictable outcomes allow developers and planners to take them into account in considering alternative actions and levels of precaution.

Damage schedules can be developed quickly and can generally be expected to be relatively inexpensive compared to current after-the-fact assessments (Rutherford et al., 1998). The approach is therefore suitable for use in places where it is not feasible to apply other methods that are far more demanding in terms of information, personnel and financial resources. Damage schedules could be easily expanded and fine-tuned over time, when other losses or activities of different form or magnitude occur, by interpolating or extrapolating from the initial scales (Knetsch, 1994). They can also be improved with experience and further knowledge of the resources.

Unlike other methods, data requirements for developing a damage schedule are relatively modest, which makes its application more attractive in cases where knowledge about the resources is limited. Table 2.1 lists the kinds of information needed for this approach and compares it with the information required in using the change in productivity method.

2.2.3. Potential problems with the damage schedule approach

Like any survey study, the damage schedule approach may be subject to certain kinds of bias, in particular information bias. The method relies heavily on what people consider as being important to them. It is assumed that people make judgments based on their knowledge of the resources, their experience and their personal values. Yet, it is possible that people are influenced by the information presented to them in the questionnaire. People's awareness can also be influenced by media, which could result in the judgments that reflect what is 'expected' of them rather than what they really value.

The respondents used in this particular study include both formal experts and layexperts as respondents to the survey. Formal experts are researchers, scientists, policymakers and administrators who have sufficient knowledge about the resources in the study areas or have direct responsibility for management of the resources. Layexperts include resource users, stakeholders, and people who live in the study areas. It is therefore assumed by definition that respondents are familiar with the losses and activities presented to them.

Table 2.1 Information requirement for the changes in productivity method and the damage schedule approach.

Information requirement	**Change in Productivity**	**Damage Schedule**
Level of knowledge about the resources and their uses	Complete understanding is required.	Complete understanding is required.
Ability to quantify resource productivity	Yes, with degree of certainty.	No, only relative importance is needed.
Prediction of changes in production as a result of an activity	Yes, with certain accuracy of magnitude and time.	No, only direction of changes and the relative magnitude is required.
Market prices of inputs and outputs	Yes, some assumptions must be made about costs and prices -- including those for non-market values.	No, not using benefit-cost analysis.

Although such losses and activities are hypothetical, they are realistic and are closely related to the well-being of people in the community. Information provided to the respondents serves to bring everyone to the same reference point. A careful design of the questionnaire and pretests can be used to eliminate, or greatly reduce, information bias and framing effects.

A major issue in the study of choices and preferences is consistency. The traditional revealed preference theory is almost exclusively concerned with transitive preference relations. Sen (1982) suggests, however, that there are good grounds for expecting the preference relation not to be fully transitive. The consistency and transitivity problem will be discussed at length in Chapter 6.

CHAPTER 3

Methodological Framework for Constructing the Scales of Relative Importance

This chapter outlines the methods and procedures that I used to design and implement the scales of relative importance that were fundamental to this study. I designed and developed the questionnaire using the well-established paired comparison method (David, 1988) as guideline. Methods for the analysis of paired comparison data and the statistical analyses were taken from literature. I examined the data and determined the level of intransitivity in the responses. Finally, I developed the scales of relative importance and the damage schedules following methods modified from Rutherford et al. (1998).

In this chapter, the general model is presented first to provide an overview of the procedure. Next, the paired comparison method used to develop the questionnaire for the study is described. Two kinds of analysis of paired comparison data are presented: Thurstone's case V method and Dunn-Rankin's variance stable rank sums method. Several tests of significance and sensitivity analyses of the scale values and the rankings of the resource losses and activities are described. The final section shows how the scales of relative importance are obtained and how they are used to develop the damage schedules.

3.1 General model for constructing the scale of relative importance

The present study employed a simple and straightforward model to develop the scales of relative importance (figure 3.1). First, a survey was conducted using a questionnaire containing a series of paired comparison questions. Two comparable approaches could be

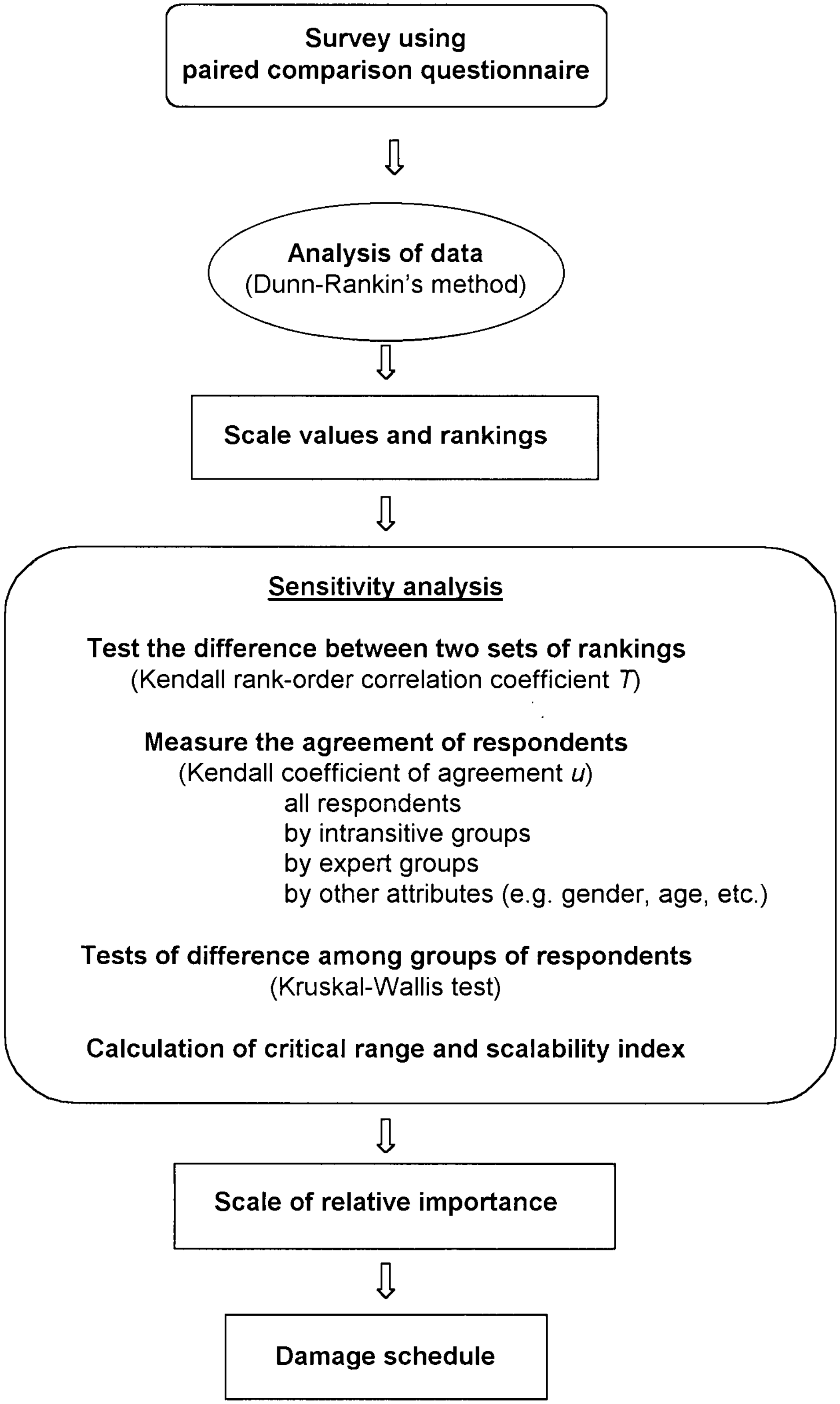


Figure 3.1 General model for constructing the damage schedule.

used to analyse paired comparison data: Thurstone's case V method and Dunn-Rankin's variance stable rank sums method. The latter was chosen in this study because of its ease in the application and in the interpretation of data. The results of the analysis of paired comparison data were the interval scale values and the rankings of the relative importance of resource losses and activities causing the losses. Several nonparametric statistical tests and sensitivity analyses were performed on the scale values and the rankings. These included (1) tests of difference between pairs of rankings (Kendall rank-order correlation coefficient *T*); (2) measures of agreement in the rankings obtained from various groups of respondents (determined by Kendall coefficient of agreement *u*); and (3) tests of difference in the scale values obtained from different groups of respondents (Kruskal-Wallis test). Moreover, critical range analysis was conducted and the scalability index was calculated to determine if the losses and activities included for comparisons were distinguishable. Once the tests were completed, the scales of relative importance were constructed and the damage schedules were developed based on these importance scales.

3.2 Paired comparison method – theory and application

3.2.1 Theoretical background

The method of paired comparisons is a well-established psychometric method, used mostly in the study of preference and choice (David, 1988). The method involves presentation of objects in pairs to one or more judges, who are asked to express a preference ordering among the elements of a choice set, by choosing one member of each pair.

The basic model employs all possible paired comparisons of *n* objects by a number of judges (*k*). For each judge, the total number of possible pairs (*P*) for comparison can be calculated by:

$$P = n\,(n - 1)\,/\,2 \tag{3.1}$$

where *n* is the number of objects. Based on this equation, the total number of pairs is 3 for three objects, 6 for four objects, etc. The total number of pairs for all *k* judges is therefore (*k* * *P*).

As each object is paired an equal number of times, it has the same probability of being selected. For example, for any three objects, *x*, *y* and *z*, there are three possible paired comparisons: *(x y)*, *(x z),* and *(y z).* Each subject in this case is presented twice in the total number of three pairs given to each judge.

According to the transitivity condition, which is the most basic principle in choice theory (Tversky, 1969), if *x* is preferred to *y* and *y* is preferred to *z*, then *x* has to be preferred to *z*. When instead *z* is preferred to *x*, a 'circular triad' occurs, viz.

$$x \rightarrow y,\quad y \rightarrow z,\quad z \rightarrow x \quad ,$$

where the arrow ' $\rightarrow$ ' means 'is preferred to'. A circular triad is a form of intransitivity, indicating inconsistency in the choices of the judge. The simplest explanation for a circular triad is that the judge may be partially guessing when declaring his/her preferences because the choices are too similar (David, 1988), or the judge is incompetent or simply makes mistakes (Peterson and Brown, in press).

Individuals are not always perfectly consistent in their choices. If one is checking the list of pairs of several choices or alternatives, it is possible that the particular alternative, *n*, would on some occasions seem to him/her a little more preferable than ordinarily, while on other occasions (s)he would judge *n* to be less preferable (Thurstone, 1927a). Thus it is not uncommon for intransitivity to occur, especially when the choices are multidimensional, meaning that they vary along several attributes or dimensions that are relevant to choice (Tversky, 1969). If choice *x* differs from choice *y* only in one dimension, even a small difference on this dimension may produce strict preference. However, when concerning multidimensional choices or alternatives, the offsetting differences on several dimensions may give rise to indifference areas that lead to intransitive choices (Fishburn, 1970).

To account for these inconsistencies, Tversky (1969) suggested that preference be defined in a probabilistic fashion, as follows.

Let the probability of choosing *x* in a choice between *x* and *y* be $P(x,y)$ and the choice of choosing *y* be $P(y,x)$, where $P(x,y) + P(y,x) = 1$. Preference can now be defined by

$$x \geq y \quad \text{if and only if} \quad P(x,y) \geq \tfrac{1}{2}.$$

The ' $\geq$ ' denotes the preference or indifference relation. The preference relation expressed above incorporates the inconsistency of the choices as x is said to be preferred to y only when it is chosen over y more than half the time. The transitivity axiom in terms of this definition yields

$$P(x,y) \geq ½ \text{ and } P(y,z) \geq ½ \text{, imply } P(x,z) \geq ½ .$$

This condition is called weak stochastic transitivity and is the most general probabilistic form of transitivity (Tversky, 1969). This condition also leads to a clear-cut ordering of all choices or alternatives in the paired comparisons, and thus allows the choices to be represented by points on a straight line (David, 1988).

3.2.2 Application of paired comparison method

The paired comparison method is used primarily in cases where the objects to be compared can be judged only subjectively (David, 1988), such as in taste testing, color comparisons, and personnel evaluation. Paired comparison method is preferable to other ranking methods when the number of objects to be compared is large and the differences between objects are not apparent (David, 1988).

The method of paired comparison is also used to define a measurement scale for dependent variables in conjoint analysis. Conjoint analysis refers to models and techniques that emphasise the transformation of subjective responses into estimated parameters (Green and Srinivasan, 1978), by decomposing value sets of individual evaluations, or discrete choices, from a designed set of multiattribute alternatives (Louviere, 1988). Conjoint analysis has been extensively used in marketing research and transportation, with applications to natural resource valuations including tourism, hunting and fishing (Rosenberger and Peterson, unpublished). The paired comparison method is less preferred to the rank-order approach in conjoint analysis since it is less efficient in terms of information obtained per unit time (Green and Srinivasan, 1978). Nonetheless, the method is acknowledged as being advantageous in its ability to test for intransitivities in the respondent's expressed preferences.

Two recent studies showed that the method of paired comparison could be successfully applied to public goods such as natural resources and environmental assets. Rutherford et al. (1998) used the method of paired comparison in their study of the ability of individuals to choose between pairs of environmental losses as a result of oil spills. Six pairs of losses were presented to respondents who then chose the loss in each pair for which the greater amount of compensation should be paid. The study found that consistent choices were obtained using the method of paired comparison to elicit people's judgments about non-pecuniary environmental losses.

Peterson and Brown (1998) used the same methodology in their study of valuation of public and private goods. The choice set included six public goods, such as a wildlife refuge or public eating area, four familiar market goods with suggested retail prices and eleven sums of money. The method of paired comparison was found to be useful for valuing public goods in this study, even with a large number of pairs (155) and a mixture of different kinds of goods in the choice set.

The present study used the method of paired comparison to present ‘objects’ to many individual judges (or respondents), in three different parts of the questionnaire. Objects in this case differed from one part of the questionnaire to the next. In Part I, the objects included resource losses or damages, such as losses of mangrove forests, damages to coral reefs and damages to sandy beaches. The objects in another part of the questionnaire (Part III) were activities or events causing such losses. Some examples are shrimp farming, housing development and oil spills. In these two parts of the questionnaire, the comparisons were between similar items, i.e. between any two resource losses or between any two activities.

The objects in these two parts of the questionnaire involved multidimensional attributes. For each of the resource losses, the attributes included the kind of resources (e.g. mangrove forests, sandy beaches, coral reefs, etc), the level of losses (e.g. severe or partial), the level of productivity affected by such losses, and the recovery period. For impacting activities, the attributes included the kind of activity, the size of the operation, and in some cases, the extent of clear-cutting of mangrove forests involved in such activities. Only eight objects were included in each part in order to keep the number of pairs small. This was done to avoid imposing a demanding task on the respondents, especially since the choices were not familiar market commodities or psychological objects. Certain degrees of inconsistency in the choices were expected and their impacts on the scale of relative importance and the development of the damage schedules are discussed in Chapter 6.

In Part II of the questionnaire, the paired comparison questions took a slightly different form. The objects in this part were four resource losses (selected from those used in Part I) and losses of four amounts of money. Thus, rather than comparing any two resource losses (already done in Part I), or any two monetary losses for which the preferred choice is obvious, the comparisons were between a resource loss and a loss of money. The details of this type of paired comparison and its analysis are presented in Chapter 7.

3.3 Analysis of paired comparison data

As stated earlier, with the paired comparison method, objects are arranged in pairs so that every one of them is compared with every other one. When a pair of objects (e.g. a pair of resource losses, or a pair of impacting activities) is presented to a respondent (i.e. an expert), (s)he has to indicate his/her preference by choosing the member of the pair that is more important. For example, when presented with two resource losses, as in Part I of the questionnaire, the respondent has to choose one of the two losses that is considered to be more important or more severe. When presented with a pair of coastal activities (as in Part III), s(he) has to choose the activity that is considered to be more important or to have a greater impact on the coastal ecosystem. No ties are allowed in this study. That is, respondents have to select one of the two choices, even if they feel that they are of equal importance.

Suppose there are four objects, *A*, *B*, *C* and *D*, presented to one judge for paired comparisons. The total number of pairs in all possible comparisons, calculated by equation

3.1, is six. The following list gives hypothetical results of these six comparisons by the judge, with the underlined object being the preferred one.

Pair number	1:	*A* vs *B*
	2:	*A* vs *C*
	3:	*A* vs *D*
	4:	*B* vs *C*
	5:	*B* vs *D*
	6:	*C* vs *D*

These results can be tabulated into a square matrix of 4 x 4, as in table 3.1 where the four objects are presented both in columns and in rows. This matrix contains frequency counts indicating preferences of the four objects being compared. The matrix of 16 cells can be divided diagonally in two reciprocal parts. For any one judge, only two values, '1' or '0', are entered in the matrix. '1' indicates that the column object is preferred to the row object, where as '0' indicates that the row object is preferred to the column object. In other words, if a cell takes on a value of '1', its corresponding cell on the other side of the diagonal line would be '0', and vice versa. No value is entered for the cells on the diagonal line, as the objects are not being compared to themselves.

Using the above example, for pair number 1, object *A* is preferred to object *B*, thus '1' is assigned for the column object *A* and the row object *B*. The corresponding cell of column object *B* and row object *A* takes a value of '0'. Similarly for pair number 2, '1' is put for column object *A* and row object *C* to indicate that object *A* is preferred to object *C*, and '0' is put for the corresponding column object *C* and row object *A*.

Table 3.1 Example of a matrix of paired comparison responses (or frequency matrix) of one judge comparing four objects.

	A	*B*	*C*	*D*
A	-	0	0	0
B	1	-	0	0
C	1	1	-	0
D	1	1	1	-
Sum	3	2	1	0

Column totals obtained for each of the four objects are the sum of frequency counts indicating ‘preference ordering’ of these objects. According to table 3.1, the preference ordering, from the object that is most preferred to the object that is least preferred, is *A*, *B*, *C*, *D*, with frequency counts or ‘preference scores’ of 3, 2, 1 and 0, respectively.

For each individual judge, the responses to paired comparison questions are recorded in the frequency matrix as in table 3.1, and preference scores are obtained. When there is more than one judge to the survey, the frequency counts of all judges can be aggregated and entered in a similar matrix, as shown in table 3.2.

Using table 3.2 as an example of 10 judges, the frequency count of ‘7’ for column object *A* and row object *B* means that 7 out of 10 judges state that they prefer *A* to *B*. The reciprocal cell (column object *B* and row object *A*) has a corresponding count of ‘3’ to indicate that the other three judges prefer *B* to *A*. The maximum frequency count that each cell can have is 10 and the minimum is 0. The column totals show the preference ordering and the aggregated preference scores of all four objects based on the 10 judges. In this example, the ordering is the same as in table 3.1 (*A*, *B*, *C*, and *D*, in the order of most preferred to least preferred) and the aggregated preference scores are 20, 17, 16 and 7, respectively.

Once the responses are recorded in the frequency matrix, the analysis of the data can be performed to obtain the scale values indicating the importance of the objects. There are two commonly used methods for the analysis of paired comparison data. One is Thurstone’s case V method (Thurstone, 1927b) and the other is Dunn-Rankin’s variance

Table 3.2 Example of a frequency matrix of paired comparison responses of 10 judges, each comparing four objects.

	A	*B*	*C*	*D*
A	-	3	4	3
B	7	-	4	2
C	6	6	-	2
D	7	8	8	-
Sum	20	17	16	7

stable rank sums method (Dunn-Rankin, 1983). The details of each procedure are summarised in the following sections.

3.3.1. Thurstone's case V method

Thurstone (1927b) used the law of comparative judgment to provide a rationale for ordering objects on a scale of attribute called the psychological continuum. This law applies to judgments of many kinds of stimuli, ranging from physical stimulus intensities to psychological values such as a series of opinions on disputed public issues. The psychological continuum is constructed based on the frequencies of the discriminal processes (or reactions) for any given objects that form a normal distribution on the psychological scale. The scale values for two objects compared (S_1 and S_2) occupy the same positions as the most frequent reactions, or the modes, which are also equivalent to the means. The distance between these two scale values is:

$$S_1 - S_2 = x_{12} \sqrt{[\sigma_1^2 + \sigma_2^2 - (2 r \sigma_1 \sigma_2)]} \qquad (3.2)$$

where

x_{12} = the standard normal deviate corresponding to the proportion of judgments that object 1 is selected over object 2;

σ_1 and σ_2 = standard deviation of the distribution of reactions for each object;

r = correlation.

Case V is the simplest form of the law of comparative judgment, with the assumption that the correlation is zero and that standard deviations are equal for all objects (Thurstone, 1927b). Equation 3.2 is thus reduced to

$$S_1 - S_2 = x_{12} \qquad (3.3)$$

There are five main steps in applying Thurstone's case V method to paired comparison data. Table 3.3 illustrates this procedure using the hypothetical frequencies in table 3.2.

The first step is to count the frequencies of judgments and develop a frequency matrix for the 10 judges as in table 3.2. These frequencies (f) are then converted to proportions (p) (step 2) by dividing f by the number of respondents (k). For example, the frequency count of 7 for the column object *A* and row object *B* corresponds to a proportion of 7/10 or 0.7. The proportion of the reciprocal cell is then 3/10 or 0.3. A proportion matrix is thus developed, as shown in table 3.3 (b). The proportion on the diagonal line is 0.5, based on the assumption of complete indifference when choosing between perfect substitutes.

The next step (step 3) is to translate these observed proportions into normal deviates (z) by reference to the normal distribution (Dunn-Rankin, 1983). The value of z is positive when the proportion is greater than 0.5, negative when the proportion is less than 0.5, and zero when the proportion is 0.5. For example, in table 3.3 (c), the z values under the diagonal line are all positive since the proportions of these cells are greater than 0.5.

Once the normal deviate matrix is constructed, the z values are summed and averaged by the number of objects (n) (step 4), and the scale values are obtained (step 5). In order to

Table 3.3 Analysis of paired comparison data using Thurstone's Case V method (based on hypothetical responses of 10 judges on 4 objects).

(a) Frequency matrix (*f* = frequency count in each cell)

Objects	*A*	*B*	*C*	*D*
A	-	3	4	3
B	7	-	4	2
C	6	6	-	2
D	7	8	8	-
Sum	20	17	16	7

(b) Proportion matrix ($p = f / k$, where k = number of judges)

Objects	*A*	*B*	*C*	*D*
A	0.5	0.3	0.4	0.3
B	0.7	0.5	0.4	0.2
C	0.6	0.6	0.5	0.2
D	0.7	0.8	0.8	0.5
Sum	2.5	2.2	2.1	1.2

(c) Normal deviate matrix, z

Objects	*A*	*B*	*C*	*D*
A	0.0	-0.524	-0.253	-0.524
B	0.524	0.0	-0.253	-0.842
C	0.253	0.253	0.0	-0.842
D	0.524	0.842	0.842	0.0
Sum	1.301	0.571	0.336	-2.208
n	4	4	4	4
Mean	0.325	0.143	0.084	-0.552
Scale value	0.877	0.695	0.636	0.0

make all scale values positive, an arbitrary origin is located at the object that is least preferred (Thurstone, 1927a). In this example, *D* has a scale value of 0.0 since it has the smallest aggregated preference score of 7. The values of the other three objects are scaled from *D*, based on the absolute distance from the mean normal deviate of *D*. For example, the absolute distance between *C* and *D* is 0.084 plus 0.552 equals 0.636, which is the scale value of *C*. The scale values of *A* and *B* are obtained in a similar manner.

3.3.2 Dunn-Rankin's variance stable rank sums method

The variance stable rank method of scaling is an adaptation of a two-way analysis of variance by ranks (Dunn-Rankin, 1983). As in Thurstone's method, this method is applicable to psychological objects presented as choices to a group of judges, using the paired comparison procedure. The analysis of paired comparison data using Dunn-Rankin's method follows a simple procedure. First, the responses of each individual are recorded in a frequency matrix and the preference scores of the objects are obtained, as shown in table 3.1. Using the same example of four objects *A, B, C, D*, the preference scores of these four objects based on the responses of one judge are 3, 2, 1, 0 respectively.

Next, the individual preference scores of all the judges are transferred to a table, as shown in table 3.4. This table is based on the same hypothetical data as in table 3.2, used to illustrate Thurstone's method. The scores are aggregated across the 10 judges and summed at the bottom of the table as rank sums (R_k), which are identical to the aggregated preference scores for the four objects in table 3.2. The minimum possible score of zero represents the case where an object is never preferred to other objects,

Table 3.4 Analysis of paired comparison data using Dunn-Rankin's variance stable rank sums method (based on hypothetical responses of 10 judges on 4 objects). Each row of data represents preference scores given by each judge.

Judges	Min	*D*	*C*	*B*	*A*	Max
1	0	1	0	2	3	3
2	0	0	1	3	2	3
3	0	0	2	3	1	3
4	0	1	2	3	0	3
5*	0	1	1	1	3	3
6	0	2	1	0	3	3
7*	0	0	2	2	2	3
8	0	0	3	1	2	3
9	0	2	3	0	1	3
10	0	0	1	2	3	3
Rank sum (R_k)	0	7	16	17	20	30
Scale value	0	23.33	53.33	56.67	66.67	100

Notes:

1. * indicates the circular triads in the choices of the judges;
2. Maximum score $(R_{max}) = k\ (n-1)$, where k = number of judges and n = number of objects;
3. Scale value $(SV) = (R_k / R_{max}) \times 100$.

while the maximum possible score refers to the case where the object is always preferred to all other objects. The maximum score for each judge simply equals $(n - 1)$, where n = number of objects. In this example, with 10 judges and four objects, the maximum score for each individual judge is 3 and for all judges is therefore 30. The objects are rearranged from the smallest aggregated preference score to the highest score (i.e. *D, C, B* and *A*, respectively).

Once the preference scores are aggregated, the scale values can be calculated. The basic assumption in this procedure is that the scale values obtained from the choices made by the judges are proportional to the sum of the ranks assigned by them to each of the objects (Dunn-Rankin, 1983). This implies that, using the maximum and minimum possible rank totals, of 100 and 0, as a convenient and interpretative frame of reference, the objects can be linearly scaled based on the rank sum (R_k). The scale value (*SV*) of each object is thus:

$$SV = (R_k / R_{max}) \times 100 \tag{3.4}$$

where R_k = aggregated preference score of each object;

R_{max} = maximum total possible score;

= $n(k - 1)$, where n is the number of object and k is the number of judges.

According to Dunn-Rankin (1983), the scale values obtained by this simplified rank sums method are isomorphic with values obtained under Thurstone's case V method. Dunn-Rankin's method was thus chosen in this study to analyse the paired comparison data since it was easier to perform.

3.4 Nonparametric statistical tests of the rankings and the scale values

Scale values indicate the ranking of the objects that are judged in the paired comparison study. Rankings can be manually assigned to the object such that '1' refers to the object with largest scale value and '8' refers to the object with smallest scale value. Alternatively, each individual preference score from paired comparisons can be converted into rankings, and mean ranks can be obtained. Nonparametric tests, such as measures of agreement and rank correlation analysis, can be performed to determine if the two sets of rankings or the two sets of scale values are related and, if so, to what degree. Nonparametric tests were used in this study instead of parametric technique since they are most suitable application to ordinal data (Siegel and Castellan, 1988). Furthermore, nonparametric tests can be used without any assumption about the population being normally distributed and of equal variances.

Two measures of rank association are presented in this section: the Kendall rank-order correlation coefficient T and the Kendall coefficient of agreement u. The first measure involves converting the preference scores from paired comparison data to rankings while the latter deals directly with paired comparison data. Each of these measures is briefly described in the following sections. Details of the methodology, including the treatment of tied observations and the test of significance, can be found in most nonparametric statistics texts.

3.4.1 Kendall rank-order correlation coefficient *T* (Kendall *T*)

Kendall *T* is a measure of association or correlation between two variables that are measured on at least an ordinal scale (Siegel and Castellan, 1988). Although in this study the use of Kendall *T* is limited to two sets of rankings or two judges, the method was adapted to use as part of the sensitivity analysis of the results.

The basic model can be explained by the use of table 3.4, taking only the first two judges, ranking four objects (*A* to *D*). The individual preference scores of judge 1 and 2, based on the hypothetical data in table 3.4, are

Objects:	*A*	*B*	*C*	*D*
Judge #1:	3	2	0	1
Judge #2:	2	3	1	0

The ranking of preference could be assigned to these scores, assigning rank '1' for the highest score and rank '4' for the lowest score. The rankings of the four objects for these two judges are:

Objects:	*A*	*B*	*C*	*D*
Judge #1:	1	2	4	3
Judge #2:	2	1	3	4

Arranging the order of the objects in the natural order based on the ranking of Judge 1, the rankings become:

Objects:	*A*	*B*	*D*	*C*
Judge #1:	1	2	3	4
Judge #2:	2	1	4	3

The number of agreements and disagreements in the ordering are counted and Kendall T is calculated using equation 3.5.

$$T = 2S / n(n-1) \qquad (3.5)$$

where T = Kendall rank-order correlation coefficient;

S = number of agreements – number of disagreements;

n = number of objects.

This coefficient T determines the degree of correspondence between the two sets of rankings. To obtain S, consider the ranking of Judge 2 in relation to the natural rank order provided by Judge 1. If the ranking of the first element in the rank set of Judge 2 is in the natural order to the second element, then there is an agreement between the two judges. On the contrary, if the ranking is not in the natural order, there is a disagreement. In the above example, Judge 2 ranked the first element 2 and the second element 1. This first pair of comparison shows a disagreement, and thus is entered as (-1) in the calculation of S. The next element is ranked 4 by Judge 2, which is in the natural order, the value (+1) is entered. The same is found in the ranking of the next pair ($A > C$). By doing this to all possible pairs, S is obtained and used to calculate T. In this example, T = + 0.33 is a measure of the agreement between the ranks assigned to the objects by the two judges. If the two rankings are in perfect agreement, *T* would equal +1, but if they are in perfect disagreement, *T* would equal -1. Increasing values from –1 to 1 thus correspond to increasing agreement between the two sets of ranks (Kendall and Gibbons, 1990).

The test of significance of the value of rank correlation used in this study indicates if the two sets of ranks are unrelated. When the null hypothesis is rejected, it can be concluded that the two ranks are related at a certain level of significance.

3.4.2 Kendall coefficient of agreement *u* (Kendall *u*)

Kendall *u* measures the degree of agreement among individuals in their preferences. It is most suitable for data from paired comparisons. If the paired comparisons for each judge are consistent (i.e. a ranking of the *n* objects could be consistently done), Kendall *u* would be equal to the average Kendall *T* among several judges (Siegel and Castellan, 1988). Therefore, Kendall *T* can be calculated for each pair of judges, and the average of all of the *T's* would be equal to *u*.

The preference matrix is first constructed as in table 3.1 for each judge and aggregated across all judges as in table 3.2. Based on the preference scores for the four objects, *A*, *B*, *C*, and *D* of the first four judges in table 3.4, the aggregated preference matrix is:

	A	*B*	*C*	*D*
A	-	3	2	1
B	1	-	0	0
C	2	4	-	1
D	3	4	3	-
Sum	6	11	5	2

The number in each cell (a_{ij}) indicates the number of times the column object is selected over (or preferred to) the row object. The coefficient of agreement u among the judges can be calculated using equation 3.6:

$$u = [\, 8\,(\Sigma a^2_{ij} - k\,\Sigma a_{ij}\,) \,/\, k\,(k - 1)\,n\,(n - 1)\,] + 1 \qquad (3.6)$$

where the summation is taken over the a_{ij}'s either below or above the diagonal, k is the number of judges and n is the number of objects in the paired comparisons. Based on these hypothetical data, u is calculated to be 0.2778.

The test of significance of u is based on the null hypothesis that there is no agreement among the judges; and the alternative is that the degree of agreement is greater than what one would expect had the paired comparisons been done at random (Siegel and Castellan, 1988). When sample size is small (number of judges less than 7 and number of objects less than 9), the test of significance of u can be done by comparing the calculated *u* with the critical *u* in a probability table. For four judges responding randomly in paired comparisons involving four objects, the probability that the observed value of *u* is greater than or equal to 0.2778 is 0.0877. Based on this example, the null hypothesis cannot be rejected at a probability level of 0.05 and thus it cannot be concluded that there is significant agreement among the judges.

For larger sample size, equation 3.7 can be used to test the significance of *u* based on the same null hypothesis as above, that there is no agreement among the judges.

$$X^2 = [\, n\,(n-1)\,\{1 + u\,(k-1)\}\,]\,/\,2 \qquad (3.7)$$

This test statistic X^2 is asymptotically distributed as chi-square with a degree of freedom equal to [$n\,(n-1)\,/\,2$]. The null hypothesis is rejected if the calculated X^2 is greater than chi-square at a certain level of significance.

When there is complete agreement among the judges, Kendall *u* will be equal to one. The minimum value of u is [$-1\,/\,(k-1)$] when k is even and [$-1\,/\,k$] when k is odd.

3.4.3 Other tests of the scale values

Apart from the measures of association, Dunn-Rankin (1983) suggests other tests that can be performed once the scale values are calculated. First, to ensure the possibility of the *n* objects being significantly different, a certain number of judges (*k*) is needed. Dunn-Rankin provided a table of sample size necessary at the .01, .05, and .10 probability levels (see table 5.2, Dunn-Rankin, 1983, p. 58). In general, when the comparisons involve a large number of objects, the number of judges would have to be large enough to provide normal approximation to the distribution of the differences between the rank sums. For example, only 19 judges are needed for the comparisons of four objects, in order to assure that these objects are significantly different at 0.5 probability level. In case of eight objects, however, at least 111 judges are needed.

Critical range (*CR*) can be calculated to determine the significant difference of these rank sums at a certain probability level using equation 3.8:

$$CR = E(S) \cdot Q_a \tag{3.8}$$

where $E(S) = \sqrt{[\{k(n)(n+1)\}/12]}$, ($n$ = no. of objects; k = no. of judges)

Q_a = W/S is the studentised range for n objects and infinite degrees of freedom (Dunn-Rankin, 1983).

The rank sums are significantly different at a certain probability level if they are greater than the critical range at that level. This test of significance helps to determine if the two objects come from the same population of stimuli (Dunn-Rankin, 1983). Furthermore, a scalability index (*SI*) can also be obtained as follows:

$$SI = \text{No. of Significantly Different Pairs} / [\,n\,(n-1)/2\,] \tag{3.9}$$

This index can be used to quantify the ability of different groups of people to distinguish between objects (Dunn-Rankin, 1983).

3.5 Sensitivity analysis

Apart from the tests of significance, other sensitivity analyses should be performed on the scale values and the rankings. These analyses can help determining what groups of respondents the scales of relative importance could be derived from and the number of scales that should be constructed to represent the losses or activities in question.

3.5.1 Tests for intransitivity effects

When a judge is presented with a task of ranking several objects, a unique rank is given to each object. The method of paired comparisons, however, allows the judges to be inconsistent in their choices, which in turn affects their rankings. Although an attempt is made to avoid inconsistent preferences, it should be noted that they may occur more frequently than one might suppose (Siegel and Castellan, 1988).

Two methods are used in this study to determine the degree of intransitivity in the responses. First, the number of circular triads (c) is calculated, based on the preference scores ($s_1, s_2, \ldots, s_n$), using equation 3.10 (David, 1988):

$$c = n / 24\,(n^2 - 1) - \tfrac{1}{2} N \qquad (3.10)$$

where n = number of objects

$N = \Sigma\ (s_i - s_a)^2$;

$s_a = \Sigma s_i / n = \tfrac{1}{2}(n - 1)$.

The number of circular triads obtained using the above equation is the highest level of intransitivity that takes place, when all n objects are compared to each other, and there is no prior ordering of the preference of these objects. In this study, however, prior ordering existed because of the inclusion of the obvious pairs. For example, it was assumed that the severe damage to coral reefs would always be considered to be more important than the partial damage to coral reefs. Thus, respondents did not have to answer this pair. Although these obvious pairs were excluded from the comparisons, they were included in the computation of the number of circular triads. The number of circular triads therefore provides an upper bound for the number of intransitive responses that exists in the paired comparisons.

An interpretation of the number of circular triads is that one set of judgments may be regarded as more consistent than another set if it includes fewer circular triads (David, 1988). The maximum number of circular triads and the mean number of circular triads can be determined using the following equations (Dunn-Rankin, 1983):

$$Max\ c = (n^3 - n)/24 \qquad \text{for odd } n \qquad (3.11)$$

$$Max\ c = (n^3 - 4n)/24 \qquad \text{for even } n \qquad (3.12)$$

$$Mean\ c = [n(n-1)(n-2)]/24 \qquad (3.13)$$

The coefficient of consistence (z) can be calculated, based on the number of circular triads, by:

$$z = 1 - [\,24\,c\,/\,n\,(n^2 - 1)\,] \quad \text{for odd } n \tag{3.14}$$

$$z = 1 - [\,24\,c\,/\,n\,(n^2 - 4)\,] \quad \text{for even } n \tag{3.15}$$

If the coefficient of consistence is 1, there are no inconsistencies in the configuration of preferences. The choices can therefore be expressed as a ranking (David, 1988). As the coefficient of consistence decreases to zero, the inconsistency increases.

The second method used to determine the degree of intransitivity in the responses is by observation of the preference scores. This method is a simple means to provide a lower bound for the number of intransitive responses. If there is no intransitivity in the choices, preference scores of an individual judge will contain all integers from 0 to $n - 1$, where n is the number of objects for comparison. If some integers appear more than once while others disappear, there are some intransitive responses. For example, based on the hypothetical data in table 3.4, judges 5 and 7 provided intransitive responses. Once intransitivity is indicated, the responses from all paired comparisons are manually checked to determine which pairs cause the intransitivity to occur. The number of intransitive responses can be determined as the minimum number of pairs whose choices need to be switched in order to create a fully transitive set of responses. In this study, up to two intransitive responses were detected for each respondent, although they may have been more. The procedure was too laborious to perform manually for a higher level of intransitivity.

3.5.2 Tests of significant difference among groups of respondents

Instead of considering all respondents as one sample, scale values and rankings can be obtained for different groups of respondents. For example, comparisons can be made between formal experts and layexperts as one group, and between formal experts and four groups of layexperts who differ in their occupation. Moreover, respondents could be grouped according to other attributes, such as age, gender, education, etc.

To assess the possible differences in the scales of relative importance that result from the rankings obtained from different groups of respondents, a test of significant difference is performed on the scale values indicated by these groups. While rank correlation tests the agreement among the rankings of respondents in any subgroup, it does not provide any indication of whether there are any differences among these groups. For instance, Kendall u measures might indicate that there is a high agreement among a group of formal experts, and also among a group of fishers. However, the test does not determine if that group of formal experts differs significantly in their rankings from the fishers.

The Kruskal-Wallis test is a nonparametric test used in this study to test the differences among three or more groups of samples. The method is useful when the samples are drawn independently from the population and each group of samples are not of equal size (Siegel and Castellan, 1988). The Kruskal-Wallis test provides the same probability of occurrence of the null hypothesis as the Mann-Whitney test in case of two independent samples.

To compute the Kruskal-Wallis (*KW*) statistic, all individual scores from all of the j groups of respondents are combined and ranked. The average of the ranks for each group is used to calculate *KW*:

$$KW = [\{12/X(X+1)\}\Sigma x_i R_a^2] - 3(X+1) \qquad (3.16)$$

where j = number of groups;

x_i = number of cases in the *ith* sample;

X = total number cases (sum of the x_i's);

R_a = average of the ranks in each group;

and the summation is across the j groups.

For large samples, the sampling distribution of *KW* can be approximated by the chi-square distribution with $j - 1$ degrees of freedom.

Similar to its equivalent parametric test, the one-way analysis of variance, the Kruskal-Wallis technique tests the null hypothesis that j groups come from the same population or from identical populations with the same median. When the alternative hypothesis is true, it can be concluded that at least one group has a different median from at least one other group (Siegel and Castellan, 1988). In the case where the null hypothesis cannot be rejected, it does not necessary mean that there are no differences between the groups. This is because the sample size may be too small and/or the variability in the sample so large that the true differences cannot be detected. The scale values obtained for each group of respondents are used to corroborate the results before accepting the null hypothesis.

When the null hypothesis is rejected, a simple procedure is used to determine which pairs of the groups are different. First, the difference in the average rank (ΔR_{12}) is found for each pair of groups. These differences are then tested for significance by using the following inequality. If

$$\Delta R_{12} \geq z_{\alpha / j (j-1)} \sqrt{[\{ X (X + 1) / 12 \} (1/x_1 + 1/x_2)]} \qquad (3.17)$$

it can be concluded that the medians of the two groups are different. The value of $z_{\alpha / j (j-1)}$ is the abscissa value from the unit normal distribution above which lies $\alpha / j (j-1)$ percent of the distribution (Siegel and Castellan, 1988).

3.6 Construction of the scale of relative importance and the damage schedule

The results from the tests of significance and the sensitivity analysis determine if only one scale of relative importance is needed to represent all respondents, or if it is more desirable to construct scales of relative importance for different group of respondents. In either case, the scale values obtained from the Dunn-Rankin's method of the analysis of paired comparison data are taken directly to construct the scale of relative importance. These scale values are easy to interpret because they have been linearly transformed into a scale with endpoints of zero and 100. For example, the scale of relative importance for the four objects, *A, B, C,* and *D* in table 3.4, would consist of the scale values of 66.67; 56.67; 53.33; and 23.33, respectively.

Although scale values are relative, the ranking is informative and useful. A damage schedule can be developed based on these scales to indicate relative importance of the resources, by mapping different policy responses onto the importance scales. The importance scale of resource losses and the importance scale of impacting activities are independently derived, using the responses from Part I and Part III of the questionnaire, respectively. These result in two kinds of damage schedules that could be developed. A schedule for consequences or losses (loss schedule) is constructed using the important scale of resource losses, and a schedule for events or activities (activity schedule) is based on the importance scale of impacting activities.

The loss schedule could be used to assess sanctions of payments for specific losses or damages, measured after the occurrence of a particular event (Rutherford et al, 1998). For example, the loss schedule in this study incorporates four different resources, each with two levels of losses. When an event occurs, on-site measurement of the losses is required to determine what resource is damaged or lost and the severity of the losses. The application of remedies can then be specified based on these findings, using the loss schedule. It is possible that more than one resource is damaged as a result of such event. The loss schedule would determine which resource loss is more important and thus should receive greater attention.

With the activity schedule, damage payments could be assessed without having to measure the specific losses resulting from any particular activity. This is because the activity schedule has already incorporated the information via experts' *ex ante* judgments of the most likely consequences of particular activities and their relative significance. Therefore, when an event occurs, there is no need to measure the losses following such an event. Instead, the event would be assessed the standard payment, or other sanction, specified by the activity schedule.

The current study is the first to develop both types of damage schedules in the same setting. The study examines the advantages and disadvantages of each schedule, as well as the association between them. That is, the study observes the extent to which the activity that is considered to be most damaging is related to the most important resource loss.

CHAPTER 4

Empirical Application on Coastal Areas of Thailand

The first part of this chapter provides an overview of coastal resources of Thailand, followed by detailed information about the two study areas, Ban Don Bay and Phangnga Bay. The next section generally describes the fieldwork that was conducted in Thailand. This is followed by information on the coastal resources and activities included in the study, the selection of experts, the questionnaire and the details of the survey

4.1 Overview of coastal resources of Thailand

Thai coastal areas face problems associated with the rapid increase in population and human activities. Coastal resources are heavily exploited by various activities and many conflicts arise among multiple users and other interest groups. Fishing is one of the most important activities in coastal areas, as it involves a large number of people, either as fishers, boat builders, fish processors, wholesalers and/or distributors, etc. Although fisheries GDP in 1992 was only 41 billion Baht[a] (12.5% of agricultural GDP and 1.5% of the country's GDP), it had expanded at a very high annual rate of 17% from 1984 to 1992 (Midas Agronomics, 1995). Coastal fisheries involve more than 50,000 households, 67% of which are small-scale fishers with outboard powered boats (Department of Fisheries, 1996). Commercial fishers operate from many ports in major towns, but more dominant are small communities of small-scale fishers scattering along the coastal areas and on the

[a] In spite of recent fluctuations of the exchange rate between Thai Baht and Canadian Dollars, a single fixed rate of 30 Thai Baht to 1 Canadian Dollar is used throughout this thesis.

islands. Competition and disagreement between commercial and small-scale fishers intensify, as fisheries resources become less abundant. Fisheries in the Gulf of Thailand have been greatly depleted since the introduction of trawls in 1960s (Pauly, 1979). The regulation prohibiting trawlers to operate within 3 km from shore is not effective and disputes between trawlers and small-scale fishers using other gear remain (Department of Fisheries, 1996).

Another example of conflicting uses of coastal resources is related to mangrove forests. The mangrove forest area in Thailand has steadily decreased in the past 32 years, from 367,900 ha in 1961 to 168,683 ha in 1993 (Royal Forestry Department, 1996). Recent development of the shrimp farming industry in Thailand is one of the major causes of the decrease in mangrove forests. LANDSAT data from 1993 showed that 17% of original mangrove areas were converted into shrimp farms (Charuppat and Ongsomwang, 1995). Several studies show that impacts of shrimp farming on mangrove ecosystem are vast, including excessive siltation or sedimentation, overloading of nutrients, and alteration of water quality in mangrove forest areas (see for example, Chantadisai, 1989 and Dierberg and Kiattisimkul, 1996). Other studies describe the negative impacts of clear-cutting of mangrove forests on fisheries production as mangrove forests provide nursery areas for juvenile fish, shrimps and crustaceans (Paw and Chua, 1991).

It should be recognised, however, that shrimp farming is not the only cause of mangrove degradation. In fact, conversion of mangrove forests into shrimp farms is no longer a common practice in Thailand for several reasons. First, the availability of mangrove forest areas for such purpose has declined significantly in recent years and second, the regulations and the zoning of mangrove areas are being strictly enforced (S.

Ratanasermpong, pers. com.). More importantly, some shrimp farmers now consider that having shrimp farms near mangrove forest areas could be harmful to their production. Although the intake and the exchange of seawater can easily be done when the farms are near the sea, the risk of disease outbreaks is much greater for intensive shrimp farms situated in or near mangrove forests. As a result, shrimp farming is moving upland into rubber plantations, oil palm plantations, rice fields and other agricultural areas. Nowadays, shrimp farms can be found more than 5 km in land. These farms rely on land transportation of water, and mostly are operated in a semi-closed system, or closed system (very little or no exchange of water). Thus, concerns regarding shrimp farming in Thailand have shifted from its environmental impacts on mangrove forests and coastal areas to other problems such as saltwater seapation into the agricultural areas adjacent to shrimp farms.

Other coastal activities, such as industrial development, port development, urban development, tourism and mining also have impacts on mangrove ecosystems, as well as other coastal resources and coastal ecosystem. Some of these activities will be discussed in the following section.

4.2 Description of the study sites: Ban Don Bay and Phangnga Bay

4.2.1. Ban Don Bay

Ban Don Bay covers the coastal area of Surat Thani Province, from Chaiya District on the west to Don Sak District, on the east (figure 4.1). In this study, a coastal area is defined as

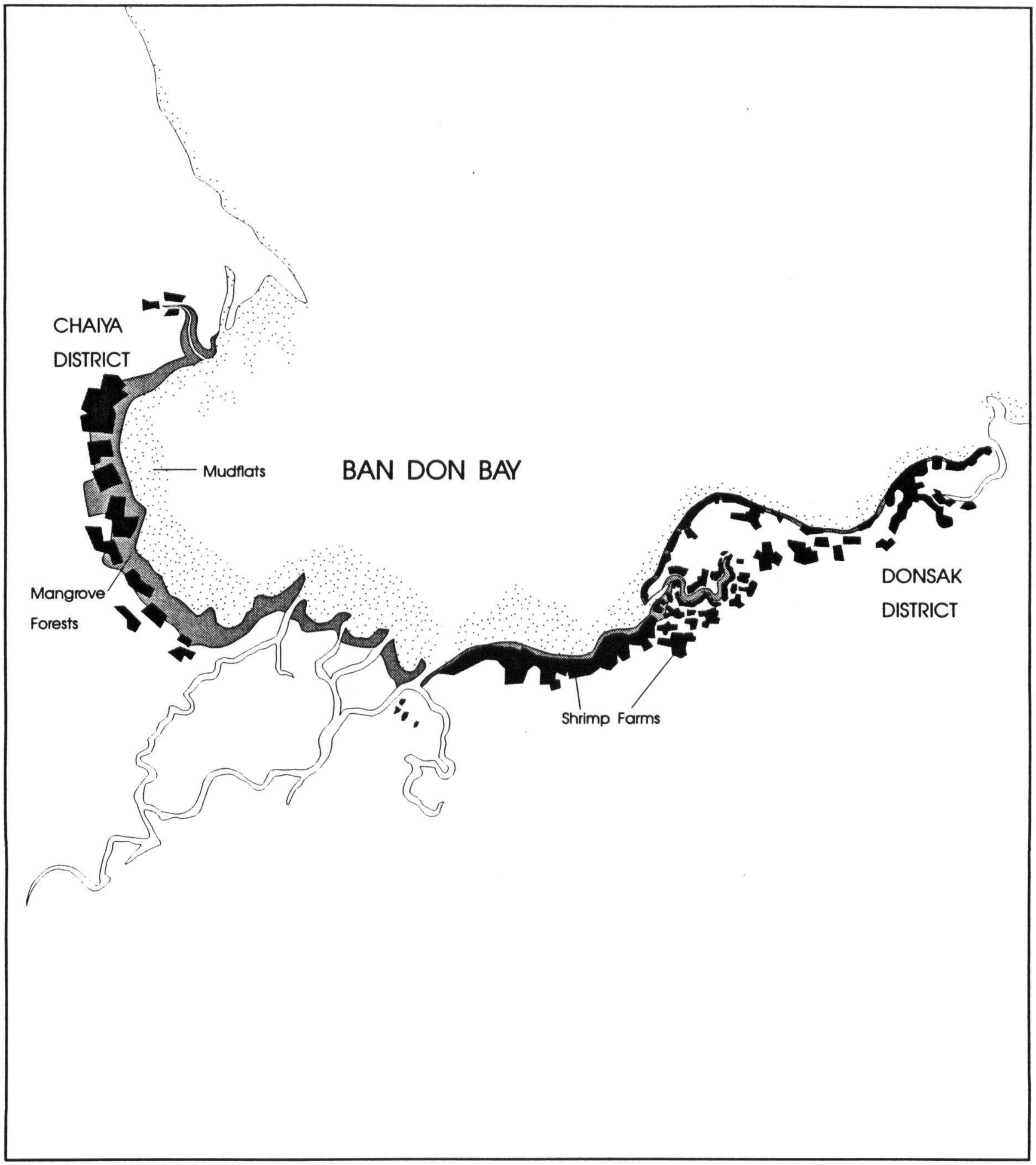


Figure 4.1 Map of Ban Don Bay

upland areas within 5 km from shore (landward), shore area (intertidal), and extends seaward to about 5 km.

Ban Don Bay is a small, open bay and is fully exposed during the monsoon season. High turbidity is caused by strong wave and wind action, especially during the northeast monsoon season (October to April). The coastal area has a gradual slope and the water is shallow. A large mudflat extends along the coast to about 2 km from shore, contributing to the high sedimentation rate within the bay. The area is connected to many freshwater canals and to the large Tapi River. This flow of freshwater results in low salinity, accumulation of organic matter from freshwater sources, and wastes from toxic chemicals from industry and agriculture.

Important coastal resources of Ban Don Bay include mangrove forests, shellfish such as shrimps and molluscs (mainly green mussels, *Perna viridis* and cockles, *Arca granulosa*), and pelagic fish, particularly Indian mackerel (*Rastrelliger* spp.). About 3,300 households in Surat Thani province rely on fisheries for their major source of income (Department of Fisheries, 1996), 83% of which are small-scale fishers, operating with outboard powered boats. Fishing is concentrated in Don Sak district where shrimp gill net and squid traps are the pre-dominant gear types. The number of trawlers and push nets continues to increase (from 10,670 in 1979 to 14,784 sets in 1990), despite the 1979 regulation prohibiting their deployment within the 3 km from shoreline (Indo-Pacific Fishery Commission, 1994). Fish processing is also an important industry in the area. In Don Sak District, there are fifteen dried fish factories and eight dried shrimp factories. Another nine clam canning factories and three fishmeal factories are in Muang District, which also hosts a group of fish processing and other canning plants. Raw materials for canning include crabs, shrimps, clams and fish.

Because of the large mudflat areas, Ban Don Bay area is rich with shellfish resources, such as cockles, mussels, mud crab (*Scylla* spp.) and oysters (*Crassostrea* spp.). The bay area is one of the best locations for coastal aquaculture, particularly for large oyster (*Crassostrea belcheri*), which has a very high market demand (Khaonuna, 1994).

Both the fishing ground and coastal aquaculture areas of Ban Don Bay are being degraded due to human activities, including urban and industrial development. A plan to develop a southern seaboard project in the south of Surat Thani has been proposed. This project involves the development of a petroleum industry, among other heavy industries, and thus could have great impacts on the natural resources and coastal environment of Ban Don Bay.

As mentioned above, conversion of mangrove forests is one of the major causes of environmental degradation in Ban Don Bay. LANDSAT images and the Geographical Information System (GIS) mapping of the bay in 1984 and 1993 clearly show changes in land use pattern (table 4.1). Losses in land areas are due to the reduction of, from the highest percentage to the lowest, paddy fields (43%), rubber plantations (26%), land forests (28%) and mangrove forests (15%). On the other hand, land areas for shrimp pond and urban development greatly increase during this period (197% for shrimp pond and 175% for urban area). According to GIS maps, areas contributing to the increase in shrimp ponds come mainly from mangrove forests, orchards and paddy fields. Due to shrimp farming, only a narrow band of mangrove forests, 50-100 meter wide, has been left in Ban

Table 4.1 Changes in land use pattern in Ban Don Bay, from 1984 to 1993, based on satellite images and GIS mapping (based on unpublished data supplied by R. Ratanasermpong).

Land use	**1984**		**1993**		**Changes**	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Forest	958	0.9	686	0.6	-272	-28.4
Scrub	4,649	4.3				
Mangrove	2,740	2.5	2,332	2.2	-408	-14.9
Orchard	17,269	16.0	16,114	14.9	-1,155	-6.7
Homestead garden	383	0.4				
Rubber plantation	16,843	15.6	12,432	11.5	-4,411	-26.2
Oil palm plantation	1,892	1.8	1,889	1.7	-3	-0.2
Paddy field	24,805	23.0	14,082	13.0	-10,723	-43.2
Tropical grass	1,355	1.3				
Urban area	694	0.6	1,910	1.8	1,216	175.2
Swamp area	4,318	4.0	6,147	5.7	1,829	42.4
Shrimp pond	2,176	2.0	6,456	6.0	4280	196.7
River and sea	29,962	27.7	29,936	27.7	-26	-0.1
Mixed orchard	-	-	2,484	2.3	-	-
Oil palm	-	-	65	0.1	-	-
Others	-	-	13,511	12.5	-	-
Total	108,044	100	108,044	100	-	-

Don Bay (figure 4.1). The most severe mangrove destruction in Ban Don Bay was found in Don Sak district where the conversion amounted to a 92% loss of mangroves (Rattakul, 1995).

The development of shrimp farming is more intensive in Ban Don Bay than on the western coast of Thailand. The area is considered suitable because of the abundance of natural stocks of shrimp larvae, including the economically important *Penaeus monodon* (black tiger prawn) and *P. merguiensis* (banana shrimp). Development of shrimp farming, mainly black tiger prawns, has received support from the Department of Fisheries (DOF), the Asian Development Bank (ADB) and the World Bank. In 1994, there were 1,845 shrimp farms in Surat Thani Province, taking up an area of 9,900 ha (a 53% increase from 1993) (Surat Thani Provincial Fisheries Office, unpublished data). This increase was not as dramatic as in 1995, when 2,144 farms took up an area of about 10,760 ha.

The effect of the loss of mangrove forests is highly significant, considering its major role as natural habitat for many marine animals, such as crabs, shrimps and juvenile fish. An example is in the reported annual decrease in the natural production of mud crabs (*Scylla serrata*), one of the most important fishery resources harvested commercially in Ban Don Bay (Khaonuna and Ratanachote, 1994).

4.2.2. Phangnga Bay

Phangnga Bay is a large, semi-closed bay along the Andaman Sea (west of the southern coast of Thailand). Phangnga Bay covers coastal areas in three provinces, Phuket (east side), Phangnga (inner bay area) and Krabi (western part up to Muang District) (figure

4.2). Using the same criteria as in Ban Don Bay, the coastal area includes 5 km of landward area and extends approximately 5 km seaward.

The bay is wide and irregular and has many small islands that provide shelter. The sea bottom is mainly mud and sandy-mud. The deepest part is about 35 metres. There are two tidal movements a day, and the tidal range is larger than that of Ban Don Bay. The bay is influenced by the wet southwest monsoon (May-October), with strong westerly winds and peak rainfall in July, and the dry northeast monsoon (November-April). In the rainy season, the diluting effect of fresh water can extend up to 10 km further south into the bay than in the dry season (Limpsaichol, 1988).

LANDSAT images of Phangnga Bay have been obtained recently, but the GIS mapping is not yet complete. Thus, there is no data to show the pattern of land use and compare that to the past. In general, land use conflicts are due to invasion of upland forests for rubber plantation and agriculture, and also conversion of land suitable for fruit orchards to rice farming. A new trend is, however, the conversion of rubber plantations into shrimp farms which could cause saltwater leakage into adjacent agricultural lands. Problems with mangrove forests are similar to those of Ban Don Bay including the conversion to shrimp farming, urban development and illegal cutting. Table 4.2 shows some land use patterns in mangrove areas in 1993 of three provinces. According to this data, there is a substantial amount of mangrove forests in Phangnga and Krabi provinces, which could be used for economic activities.

Dominant coastal ecosystems along the coast of Andaman Sea, including Phangnga Bay, are mangroves, coral reefs and seagrass beds (Chansang and Poovachiranon, 1994).

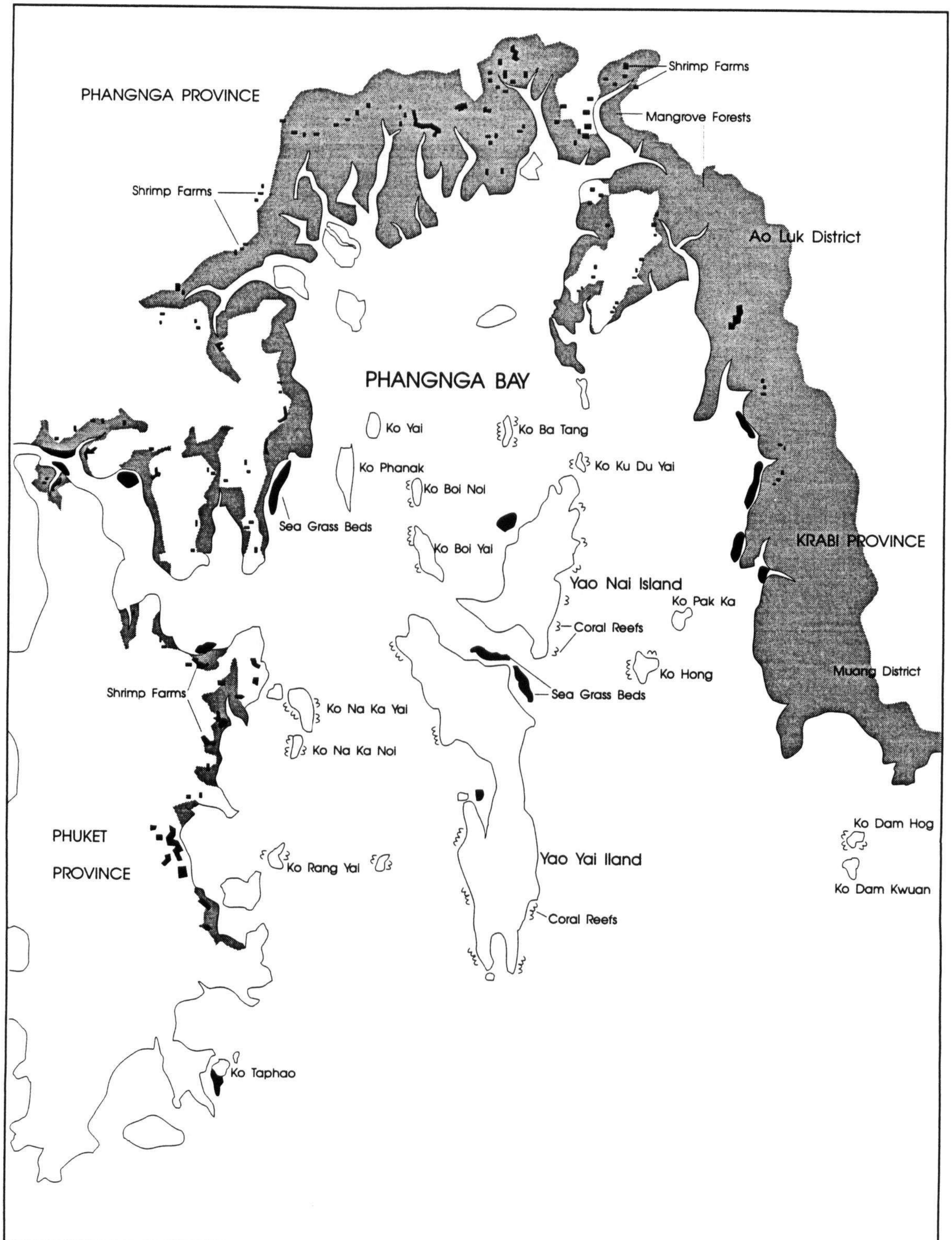


Figure 4.2 Map of Phangnga Bay

Table 4.2 Land uses in mangrove forests, Phuket, Phangnga and Krabi provinces, 1993, in ha. (from Charuppat and Ongsomwang, 1995)

Type of use	**Conservation Zone**	**Econ.Zone A**	**Econ.Zone B**	**Total**
Phuket				
Mangrove forests	265	1,283	-	1,548
Shrimp ponds	3	98	-	101
Urban area	1	10	-	11
Others	172	938	-	1,110
Sub-total	441	2,329	-	2,770
Phangnga				
Mangrove forests	10,118	19,542	1,056	30,716
Shrimp ponds	54	745	27	826
Urban area	-	-	-	-
Others	712	10,925	799	12,436
Sub-total	10,884	31,212	1,882	43,978
Krabi				
Mangrove forests	2,586	25,367	574	28,527
Shrimp ponds	660	388	19	1,067
Urban area	-	-	-	-
Others	1,919	7,135	1,271	10,325
Sub-total	5,165	32,890	1,864	39,919
Grand total	**16,490**	**66,431**	**3,746**	**86,667**

Phangnga Bay is surrounded by about 3000 km^2 of mangrove forests. Sea grasses are found in many parts of the bay and around small islands (figure 4.2). Many rivers flow into the bay, supplying it with nutrients and minerals. This has made Phangnga Bay an important habitat for many economically important species, such as marine shrimps (mainly *Penaeus semisulcatus* and *P. merguiensis*), lobsters (*Panulirus* spp.), swimming crabs (*Portunus pelagicus*), mud crabs (*Scylla spp.*), clams (*Paphia* spp.), Indian mackerel (*Rastrelliger spp.*) and pomfret (*Parastromateus niger*) (Pimonjinda, 1995).

Mangrove forests in Phangnga Bay are classified as old growth stands whereas those in Ban Don Bay are young growth stands that have been under heavy selective cutting for human utilisation (Paphavasit, 1995). Mangrove forests in Phangnga Bay, especially in the inner part of the bay, are protected in national conservation forest areas. Some of the dominant species are *Rhizopera mucronata*, *R. apiculata* and *Avicennia* spp. (Wattayakorn et al., 1995). Several species of benthos, such as molluscs and crustaceans, inhabit the mangrove area (Paphavasit, 1995).

The fisheries started as small-scale operations in front of the bay, but have developed into large-scale fishing with more efficient technologies. Common fishing gears used are trawler and small otter board trawler, anchovy purse seine, shrimp gill net, crab gill net, push net and fish trap (Pimonchinda, 1995). Fisheries resources have been degraded due to destructive fishing gears that are illegal, but are nevertheless used. Push nets are one good example of illegal gear. Catches from push nets are comprised of 85 % trash fish, while shrimps, the target species, comprise only about 10 %. Furthermore, push nets are in conflict with other gears such as gill nets (they compete for the same fishing ground and same target species), crab gill nets and fish traps for groupers (Boonragsa and Nootmorn, 1990). Because of these, push nets are banned within 3 km from shore and around marine conservation area in Phangnga Bay (Boonragsa, 1988). Regulations for push nets to stay 3 km from shore are not practical from the push netters' point of view. Their boats are not equipped to go far offshore and could only be operated in shallow water of no deeper than 10 metre.

Coastal aquaculture in Phangnga Bay started about ten years ago, with black tiger prawns, cockles and oysters. Cage culture of snapper (Fam. Lutjanidae) and, in particular, of groupers (*Epinephelus spp.*), is also important due to their high market demand. In general, shellfish culture in Phangnga Bay is not as successful as in Ban Don Bay, as the products receive much lower prices due to smaller size and poorer quality (Pimonjinda, 1995).

Land development and real estate are major businesses since it is becoming more popular for people, both Thais and non-Thais, to acquire second homes in the area. Industrial development, in particular the proposed southern seaboard project linking development in Krabi with the one proposed in the south of Surat Thani, will have direct impacts on the coastal environment of Phangnga Bay (Krabi Provincial Office, 1994). The 'economic bridge' includes the building of a deep sea port, a jetty for oil tankers, a railroad or pipeline for transportation of oil, as well as oil-based and gas-based industries. This rapid development, coupled with the expansion of tourism-related business, may result in the destruction and degradation of coastal ecosystems, including mangrove forests, sandy beaches, seagrass beds and coral reefs.

4.3 Description of the fieldwork

The fieldwork for the study was conducted during April 1996 to May 1997, in four main phases: background information collection, pre-survey, questionnaire design and pre-testing, and the actual survey. The first month was spent in Bangkok to gather available published data about the study sites. Researchers working for various government agencies in Bangkok, such as the Department of Fisheries, the Royal Forestry Department, and the National Board of Environment, were visited and asked to provide background information about the resources and activities in the study areas. Additional information was obtained from researchers and professors from two universities in Bangkok, Kasetsart University and Chulalongkorn University, as well as from researchers of other non-governmental institutes, such as the Thailand Development Research Institute Foundation and the Thailand Environmental Institute. At the same time that the background information was being gathered, a list of potential experts was developed, based initially on the list of researchers nation wide, collated by the National Research Council of Thailand.

The first visit to the study areas took place in May 1996. Two main government research units provided bases during the field visits; the Coastal Aquaculture Research Station in Surat Thani Province for Ban Don Bay study, and Phuket Marine Biological Center, in Phuket Province for Phangnga Bay study. The objective of the first trip was to become familiar with the study areas and to meet with the local pre-identified experts. In Ban Don Bay, the only access to shellfish culture grounds was by a small long-tail boat. Similarly, to visit fish cage culture and shellfish culture areas in Phangnga Bay, a boat trip was necessary. For Ban Don Bay, Surat Thani was the only province covered in the study. In

Phangnga Bay, however, the trip extended to three adjacent provinces, namely Phuket, Phangnga and Krabi. Apart from the visit to the two study areas, a trip was taken to Songkhla Province where the Prince of Songkhla University is located. Several researchers in that university, in particular the Coastal Resources Institute (CORIN), conducted several studies in the areas and were considered potential experts for this study.

An informal pre-survey was conducted in June 1996 to determine what coastal resources and activities should be included in the study. A group of pre-identified experts (both formal and lay) were asked to complete the questionnaire by indicating the level of importance of the resources and activities included in the list. The questionnaire was designed based on the results from the pre-survey and the background information. The questionnaire underwent several revisions and was tested in the field three times and once in a classroom setting, before the actual survey was conducted during March and April 1997. The detailed description of the questionnaire and the account of the survey are given in the following sections.

4.4 Selection of coastal resources and activities for paired comparison questions

Due to the limitation on the number of pairs that could be included in the paired comparisons study, as discussed in Chapter 3, an informal pre-survey was conducted to determine which resources and activities should be included in the questionnaire developed for each study area. The objective was to ensure that resources and activities of different levels of importance were considered in the study, which would then provide starting points on the importance scales for interpolation and of other losses or activities of different form or magnitude, which are not included in the survey.

Pre-identified experts in different disciplines were asked in the pre-survey questionnaire to indicate the level of importance of various resources and activities in the study areas. Results from this pre-survey, together with the information obtained from field visits, personal interviews and a literature review, were used to formulate the initial list of resources and activities to be considered in each study area. These lists were later adjusted following the responses to the pre-testing surveys. Table 4.3 summarises the coastal resources and activities included in the study.

The measure of relative importance of resources in this study was determined in the form of losses or damages to the resources. For each study area, a different set of four resources was chosen, each with two levels of losses or damages. Table 4.4 shows the eight resource losses or damages included in the study for Ban Don Bay and Phangnga Bay. The selected resources were natural habitats in different coastal transects, from inshore, intertidal to offshore areas. Resources considered in each study area represented those with different levels of importance, as suggested by the pre-survey.

Table 4.5 lists selected impacting activities presented for paired comparisons in each study area. These included activities reported by respondents of the pre-survey as having, or potentially having, negative impacts on coastal resources in the areas. Three activities were considered, two of which were common in both study areas (shrimp farming and oil spills). Three levels of impacts were indicated for two activities (shrimp farming and housing development for Ban Don Bay or hotel development for Phangnga Bay) and two

Table 4.3 Coastal resource systems under study: Ban Don Bay and Phangnga Bay.

	Ban Don Bay	Phangnga Bay
Resource components	Mangrove forests Mudflats Shellfish culture grounds Fishing grounds	Sandy beaches Mangrove forests Seagrass beds Coral reefs
Coastal activities	Shrimp farming Housing development Oil spill	Shrimp farming Hotel development Oil spill

Table 4.4 List of resource losses or damages in Ban Don Bay and Phangnga Bay.

Ban Don Bay

	Resource Loss/Damage	Code
1	Severe damage to mangrove forests	MF1
2	Clear-cutting of mangrove forests	MF2
3	Partial damage to mudflats	MUD1
4	Severe damage to mudflats	MUD2
5	Partial damage to shellfish culture grounds	SCG1
6	Severe damage to shellfish culture grounds	SCG2
7	Partial damage to fishing grounds	FG1
8	Severe damage to fishing grounds	FG2

Phangnga Bay

	Resource Loss/Damage	Code
1	Partial damage to sandy beaches	SB1
2	Severe damage to sandy beaches	SB2
3	Severe damage to mangrove forests	MF1
4	Clear-cutting of mangrove forests	MF2
5	Partial damage to seagrass beds	SG1
6	Severe damage to seagrass beds	SG2
7	Partial damage to coral reefs	CR1
8	Severe damage to coral reefs	CR2

Table 4.5 List of impacting activities in Ban Don Bay and Phangnga Bay.

Ban Don Bay

	Impacting activities	Code
1	Shrimp farming, 25 rai, no clear-cutting of mangrove forests	SHRIMP1
2	Shrimp farming, 100 rai, no clear-cutting of mangrove forests	SHRIMP2
3	Shrimp farming, 100 rai, with clear-cutting of mangrove forests	SHRIMP3
4	Housing development project, 50 units, no clear-cutting of mangrove forests	HOUSE1
5	Housing development project, 100 units, no clear-cutting of mangrove forests	HOUSE2
6	Housing development project, 100 units, with clear-cutting of mangrove forests	HOUSE3
7	Offshore crude oil spill of 20,000 litre	OIL1
8	Offshore crude oil spill of 200,000 litre	OIL2

Phangnga Bay

	Impacting activities	Code
1	Shrimp farming, 25 rai, no clear-cutting of mangrove forests	SHRIMP1
2	Shrimp farming, 50 rai, no clear-cutting of mangrove forests	SHRIMP2
3	Shrimp farming, 50 rai, with clear-cutting of mangrove forests	SHRIMP3
4	Hotel development project, 75 units, with sewage system, no clear-cutting of mangrove forests	HOTEL1
5	Hotel development project, 75 units, without sewage system, no clear-cutting of mangrove forests	HOTEL2
6	Hotel development project, 75 units, without sewage system, with clear-cutting of mangrove forests	HOTEL3
7	Offshore crude oil spill of 20,000 litre	OIL1
8	Offshore crude oil spill of 200,000 litre	OIL2

levels were considered for oil spills. The scenario presented for each activity was based either on existing conditions or potential situation.

4.5 Selection of experts

The target population for the survey was formal experts and layexperts. Formal experts included researchers, academics, administrators and policy-makers. Formal experts were selected based on their knowledge and experience in the study areas. Those who were responsible for the management of the coastal resources were also included. Formal experts had different specialisation including biology, fisheries, mangrove forest ecology, economics, social sciences, etc. A list of formal experts was made, based on suggestions from pre-identified experts and from the National Research Council of Thailand, and was used as a starting point for the selection of the formal experts. Formal experts could be living in the study areas or could be from other parts of the country.

Layexperts included resource users, stakeholders and other people residing in the coastal areas. Layexperts were divided into groups based on their occupation, in order to test for differences in the rankings of those with various interests in the resources. There were four occupational groups of layexperts in each of the two study areas, three of which were common in both cases, namely fishers, shrimp farmers and others. In Ban Don Bay, the fourth layexpert group was shellfish culturers and in Phangnga Bay the fourth group included people in tourism-related business (or tourism, for short). Quota sampling was used to obtain a reasonable number of experts in each occupational group. Layexperts were not selected at random, but rather based largely on their ability and their willingness to answer the questionnaire.

4.6 The questionnaire

A four-part questionnaire, containing series of paired comparison questions, was used as the key instrument of the study. Considerable effort was put into developing the questionnaire and several pre-tests were performed. Sufficient information about the resources and activities in consideration was given at the beginning of the questionnaire, as a means to standardise the various backgrounds, experiences, and interests of all respondents. Furthermore, reference tables of resource losses and impacting activities, outlining certain attributes of the resources/activities that may be needed when making the comparisons, were provided. Several layouts of the questionnaire were tested since it was considered as one of the key determinants of the success of data collection. The format that seemed to work well was to have only one paired comparison question on a half-sheet paper. Although, the questionnaires contained several pairs for comparisons, the number did not appear to be too large when the four parts were kept separated and independent of each other.

Part I of the questionnaires contained a series of paired comparison questions involving the eight resource losses or damages listed in table 4.4. Part III was developed in the same manner using the eight activities in table 4.5. Part II was slightly different since its paired comparisons involved the four resource losses of Part I and the losses of four amounts of money. Part IV asked information about the respondents and their opinion on management of coastal resources of Thailand (see Appendix I for sample questionnaire. Note that the actual questionnaire was written in Thai. The unit area used in the questionnaire was 'rai', and 6.25 rai equals 1 ha).

Examples of the paired comparison questions were provided to respondents, together with the map of the study area and general descriptions of resources and their usefulness. A reference table was provided, listing the four resources included in Part I of the study, level of losses, expected changes in the level of productivity due to such losses, and recovery period. Similar tables were provided for Part II and Part III of the questionnaire. The latter additionally contained general descriptions of each coastal activity. Respondents were encouraged to refer to these tables as often as they needed while completing the questionnaire.

For each of the paired comparison questions, respondents were asked to choose the item that they considered to be more important or more damaging, not only to themselves, but also to the environment, to the economic and social values of the community and to the future of the area. An exception was in Part II where respondents compared a resource loss with a one-time loss of money to themselves and every household in the study area. It was stated clearly at the beginning of Part II that the money lost would neither be used to eliminate or reduce the resource loss nor to benefit the community in any other way.

The paired comparison questions in the first three parts were arranged in a half-sheet booklet, and were colour coded in accord with the information sheet for each part. Each page contained only one pair of objects, A and B, which were put side by side. Random orderings of pairs, and also random positioning of A and B (right or left side) were used to avoid bias due to the sequencing of pairs.

A typical question in Part I of the questionnaire was:

Which of the two losses is more important, **A** or **B** (circle one)?

A	B
Severe damage to 25% of **marine fishing grounds** in Ban Don Bay. Productivity in these areas would be **almost all reduced**. Recovery would take 3 to 5 years.	**Severe damage** to 40 rai of **mangrove forests** in economic zone B in Ban Don Bay. Productivity in these areas would be **almost all reduced**. Recovery would take 10 to 15 years.

Instead of using all possible 28 pairs for comparisons of eight resource losses in Part I, the questionnaire excluded the three obvious pairs in each study area. It was assumed that a severe damage of a resource should always be considered more important or more severe than a partial damage of that same resource. For Ban Don Bay, the exclusions were partial damage vs. severe damage to mudflats, to shellfish culture grounds and to fishing grounds. For Phangnga Bay, partial damage vs. severe damage to sandy beach, seagrass beds and coral reefs were omitted. However, the comparison between severe damage to mangrove forests and clear-cutting of mangrove forests was left in the questionnaire since it was not very obvious how the respondents would consider these two losses. The total number of pairs for comparisons in Part I of the questionnaire was therefore 25 in each study area.

Part II contained pairs of comparisons between a resource loss or damage with a loss of money. Four resource losses and four amounts of money were included in the paired comparisons. The total number of pairs for Part II was 16, instead of 28, as should be the case when eight objects were paired in all possible combination. Twelve pairs were excluded for two reasons. First, there was no need to include the six paired comparisons of the four resource losses which were already performed in Part I. Another six pairs that were excluded were the comparisons of the loss of the four amounts of money. It was assumed that the loss of a higher amount of money must be more important than the loss of a smaller amount of money. A detailed description of the resource losses and monetary losses included in this part of the questionnaire is provided in Chapter 7.

The paired comparisons in Part II followed the same format as in Part I, as in the example.

Which of the two losses is more important, **A** or **B** (circle one)?

A	B
Severe damage to 40 rai of **mangrove forests** in economic zone B in Ban Don Bay. Productivity in these areas would be **almost all reduced**. Recovery would take 10 to 15 years.	A one-time loss of **700 Baht** to you and every household in Ban Don Bay.

Unlike the first two parts, Part III included all 28 possible pairs of the eight impacting activities for comparisons. This was because of an additional question in Part III, asking respondents to indicate the level of impact of the chosen activity, relative to the other one. For example, it may be obvious that shrimp farming of 100 rai, with clear-cutting of mangrove forests was more damaging than the same size shrimp farm that involved no clear-cutting, but how much more was unknown (6.25 rai is 1 hectare). The extra question was added in order to perform a different analysis on the paired comparison data that may provide more accurate scale values, as is discussed in Chapter 5.

An example of Part III question is:

Which one of the two activities is more important, **A** or **B**? Circle one.

A	B
A spill of **20,000 litre** of crude oil near the deep sea port, Kanom District. About 10% of the spilled oil will be washed into Ban Don Bay.	Construction of a new **shrimp farm** of **25 rai** in the coastal area of Ban Don Bay, with **no cutting** of mangrove forests.

Then, indicate the level of importance of the selected activity, in comparison to the other one, by putting a ' ✓ ' in the appropriate box.

Much more important	More Important	Slightly more important	Nearly equal
☐	☐	☐	☐

Part IV used close-ended questions to ask respondents about their occupation, the time they had been living in the area, their age, gender, education and whether they had ever been involved in the management of coastal resources in the area. There was also a set of 10 statements where respondents were asked to express their opinion about the resource management by stating their agreement or disagreement with those statements. The half-sheet booklet format was also used in this part of the questionnaire.

4.7 The survey

The actual survey was conducted on two separate trips, first in Ban Don Bay (March 1997), then in Phangnga Bay (April 1997). Field assistants helped with the preparation of the questionnaires (manually randomising the pairs and putting them into booklets) and the data collection. In each study area, the questionnaire was given to respondents who were asked to complete it on their own. This method of data collection was chosen instead of personal interviews to reduce biases that may be induced by different enumerators. The trade-off was, however, an exclusion of illiterate respondents.

In general, formal experts were individually approached and, after an explanation, the questionnaires were left for them to complete and return at a later date, either by personal collection or by mail. Most of the formal experts were pre-identified, but some new ones were suggested and added during the survey. There was no limit on the number of formal experts surveyed, although special effort was made to collect data from experts in as many disciplines as possible.

The survey of layexperts was done mostly on the spot, on an individual voluntary basis, and without prior arrangement. They were reassured that their answers would be used for academic purpose and would be treated with strict confidence. Enumerators conducted the survey part by part, and were present to answer any questions. Only in Phangnga Bay, when surveying layexperts working in hotels and in the tourism business, the questionnaires were left for the respondents to complete and were picked up at a later time or date. On average, layexperts spent 45 minutes on the questionnaire.

There were no major problems in conducting the survey, apart from the time required of the respondents. When layexperts failed to complete the questionnaire due to time constraints, they were asked to at least complete Part I and Part IV. Otherwise, their cases were removed and they were not considered as respondents to the survey. In general, respondents were willing to complete the questionnaire once they understood what they were asked to do. Most formal experts were contacted prior to the survey and thus were prepared to do the questionnaire.

CHAPTER 5

Analysis of Data and Resulting Scales of Relative Importance

This chapter summarises the results of the analyses of responses and presents the resulting scales of relative importance. The first section of the chapter covers issues related to the total number of respondents, incomplete responses and intransitive responses. Section 5.2 reports the scale values and the rankings of resource losses and activities obtained for the two study areas. The results of Part I (resource losses) are presented first for Ban Don Bay and then for Phangnga Bay. These are followed by the results of Part III (impacting activities), again for Ban Don Bay and Phangnga Bay.

Results from validity tests of the scale values of resource losses and activities are reported in Section 5.3. Section 5.4 shows the resulting scales of relative importance obtained for Ban Don Bay and Phangnga Bay. These interval scales of relative importance were later used in Chapter 6 to develop damage schedules. Section 5.5 presents the general discussion of the results in relation to the attributes of the respondents, such as gender, age, education, etc. and their effects on the scale values. The final section shows the results of the additional analysis performed on the responses about the level of intensity of activities considered in the study.

5.1 Number of respondents and intransitive responses

A total of 210 and 223 respondents answered the questionnaire for Ban Don Bay and Phangnga Bay, respectively. The questionnaires were checked for completeness, part by part. Respondents with missing data (e.g. they accidentally skipped a page of paired comparison questions) in any part of the questionnaire were excluded from the data analysis of that part. Each part of the questionnaire was independently analysed and thus the number of respondents in each part tends to be different (table 5.1). The analysis of Part IV included only those who completed at least Part I of the questionnaire. Table 5.1 also shows the number of formal experts and number of layexperts, in four occupation groups, included in the analysis of each part. The number of respondents in each of these five groups was reasonably equal, and was comparable in the two study areas.

Before further analyses of the data, the level of intransitivity was determined for each individual respondent. Several tests were conducted to verify the effect of intransitivity on the scale values and the rankings of importance. The results showed that while intransitivities occurred, they did not have a significant impact on the scale values and the rankings. The following subsections described the procedures used to deal with intransitivity.

5.1.1 Determination of intransitivity

Intransitive responses were determined for respondents to Part I and Part III of the questionnaire, using the method described in Chapter 3. The number of respondents in each intransitive group is shown in table 5.2. 'Intransitive group 0' referred to respondents with no intransitive choice. When there was only one pair of responses that needed to be switched in order to obtain transitivity, the respondents were placed in 'intransitive group 1'. When there were two pairs that needed switching, they were recorded as 'intransitive group 2'. 'Intransitive group > 2' included those with more than 2 pairs of intransitive responses.

Table 5.1 Total number of respondents for each part of the questionnaire, in Ban Don Bay and Phangnga Bay.

Ban Don Bay

	Total surveyed	Total analysed			
		Part I	Part II	Part III	Part IV
Formal experts	43	41	42	43	41
Fishers	47	45	47	45	45
Shrimp farmers	40	40	40	38	40
Shellfish culturers	44	43	44	42	43
Others	36	35	35	34	33
Total	210	204	208	202	202

Phangnga Bay

	Total surveyed	Total analysed			
		Part I	Part II	Part III	Part IV
Formal experts	52	51	52	52	51
Fishers	45	45	45	44	45
Shrimp farmers	41	40	38	35	37
Tourism	39	39	39	35	37
Others	46	46	46	43	39
Total	223	221	220	209	209

Table 5.2 Number of respondents by occupation and by intransitive group (numbers in parenthesis are percentages of total).

Ban Don Bay - Part I

Group of experts	Intransitive group				Total
	0	1	2	> 2	analyzed
Formal experts	14	14	4	9	41
	(34.1)	(34.1)	(9.8)	(22.0)	(100)
Fishers	4	9	11	21	45
	(8.9)	(20.0)	(24.4)	(46.7)	(100)
Shrimp farmers	5	8	6	21	40
	(12.5)	(20.0)	(15.0)	(52.5)	(100)
Shellfish culturers	8	15	7	13	43
	(18.6)	(34.9)	(16.3)	(30.2)	(100)
Others	7	7	4	17	35
	(20.0)	(20.0)	(11.4)	(48.6)	(100)
All groups	38	53	32	81	204
	(18.6)	(26.0)	(15.7)	(39.7)	(100)

Phangnga Bay - Part I

Group of experts	Intransitive group				Total
	0	1	2	> 2	analyzed
Formal experts	28	12	5	6	51
	(54.9)	(23.5)	(9.8)	(11.8)	(100)
Fishers	18	9	5	13	45
	(40.0)	(20.0)	(11.1)	(28.9)	(100)
Shrimp farmers	14	11	0	15	40
	(35.0)	(27.5)	(0.0)	(37.5)	(100)
Tourism	13	12	3	11	39
	(33.3)	(30.8)	(7.7)	(28.2)	(100)
Others	14	11	5	16	46
	(30.4)	(23.9)	(10.9)	(34.8)	(100)
All groups	87	55	18	61	221
	(39.4)	(24.9)	(8.1)	(27.6)	(100)

Table 5.2 (Continued)

Ban Don Bay - Part III

Group of experts	Intransitive group 0	1	2	> 2	Total analyzed
Formal experts	24 (55.8)	7 (16.3)	7 (16.3)	5 (11.6)	43 (100)
Fishers	5 (11.1)	11 (24.4)	9 (20.0)	20 (44.4)	45 (100)
Shrimp farmers	13 (34.2)	9 (23.7)	4 (10.5)	12 (31.6)	38 (100)
Shellfish culturers	14 (33.3)	9 (21.4)	6 (14.3)	13 (31.0)	42 (100)
Others	8 (23.5)	11 (32.4)	6 (17.7)	9 (26.5)	34 (100)
All groups	64 (31.7)	47 (23.3)	32 (15.8)	59 (29.2)	202 (100)

Phangnga Bay - Part III

Group of experts	Intransitive group 0	1	2	> 2	Total analyzed
Formal experts	27 (51.9)	20 (38.5)	2 (3.9)	3 (5.8)	52 (100)
Fishers	13 (29.6)	20 (45.5)	4 (9.1)	7 (15.9)	44 (100)
Shrimp farmers	8 (22.9)	15 (42.9)	4 (11.4)	8 (22.9)	35 (100)
Tourism	17 (48.6)	9 (25.7)	6 (17.1)	3 (8.6)	35 (100)
Others	17 (39.5)	12 (27.9)	5 (11.6)	9 (20.9)	43 (100)
All groups	82 (39.2)	76 (36.4)	21 (10.1)	30 (14.4)	209 (100)

Generally, respondents to the Phangnga Bay questionnaire were more transitive than those responding to the Ban Don Bay questionnaire. Only about 19% of total respondents to Part I of the Ban Don Bay questionnaire made no intransitive choices, and only 32% of those respondents were without intransitive responses to Part III. The number of respondents with no intransitive response was higher in Phangnga Bay (about 39% in both Part I and Part III) (table 5.2).

Formal experts were more transitive in their responses than layexperts. In Ban Don Bay Part I, 34% of total formal experts completed the questionnaire with no intransitive response. In contrast, only 9% of fishers, 13% of shrimp farmers, 19% of shellfish culturers and 20% of others were in '0 intransitive' group. In Ban Don Bay Part III, the percentage of respondents with no intransitive response was higher for both formal experts (56%) and layexperts (11% fishers, 34% shrimp farmers, 33% shellfish culturers, and 24% others) (table 5.2).

In Phangnga Bay, the percentage of formal experts in the '0 intransitive' group was also higher than for any layexpert group (table 5.2). For example, in Part I, 55% of formal experts had no intransitive responses, while the percentages for the fisher, shrimp farmer, tourism, and other groups were 40%, 35%, 33% and 30%, respectively. However, the percentage of respondents with no intransitive response in Part III of the questionnaire was lower for all groups (including formal experts), with the exception of layexperts in tourism-related business and in the layexpert group of other occupations.

5.1.2 Effects of intransitivity on the scale values and the rankings

To determine the effect of intransitivity on the scale values, rank correlation analysis was performed on the rankings of the relative importance of resource losses and activities. The scale values were calculated using Dunn-Rankin's method for four sets of respondents (combining across expert groups and occupations) according to the level of intransitivity, as shown in table 5.3. First, only respondents with no intransitive response were included ('0 intran'). Then respondents with one intransitive response were added to the first group, which yielded the second group listed as '0+1 intran'. The third set of scale values were calculated based on respondents with 0, 1 or 2 intransitive responses ('0+1+2 intran'). The last set of scale values was calculated using responses from all respondents, labelled as 'All cases' in table 5.3. Rankings were manually assigned to the resource losses and activities based on these scale values and a measure of association, Kendall *u*, was calculated.

In general, the agreement among respondents in all four sets was significant (the observed X^2 for Kendall *u* was greater than the critical value of chi-square of 56.89 at α = 0.001, and 28 degrees of freedom in all cases) (table 5.3). Therefore, it can be concluded that the agreement among respondents in each of the four sets was higher than it would have been had their rankings been random or independent. The null hypothesis that the respondents' rankings were unrelated to each other was rejected, and thus there was a good consensus among respondents in the ranking of the relative importance of resource losses and impacting activities.

Table 5.3 Scale values and rankings of resource losses and activities based on respondents in different intransitive groups.

Ban Don Bay Part I

Resource loss	0 intran.		0+1 intran.		0+1+2 intran.		All cases	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Severe damage to mangrove forests	84.21	2	72.84	2	70.85	2	69.47	2
Clear-cutting of mangrove forests	98.12	1	86.97	1	85.83	1	72.97	1
Partial damage to mudflats	15.79	7	20.25	7	20.67	7	22.90	8
Severe damage to mudflats	45.11	5	49.45	5	49.59	5	50.07	5
Partial damage to shellfish culture grounds	15.04	8	19.15	8	20.44	8	26.82	7
Severe damage to shellfish culture grounds	46.24	4	49.61	4	50.41	4	53.92	4
Partial damage to fishing grounds	32.33	6	35.16	6	35.08	6	37.89	6
Severe damage to fishing grounds	63.53	3	66.72	3	67.25	3	66.04	3
N		38		91		123		204
Kendall u		0.6322		0.4355		0.4049		0.2845
Observed chi-square		682.95		1125.49		1411.22		1645.14

Phangnga Bay Part I

Resource loss	0 intran.		0+1 intran.		0+1+2 intran.		All cases	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Partial damage to sandy beach	7.72	8	9.96	8	10.09	8	14.67	8
Severe damage to sandy beach	33.83	6	37.22	6	37.77	6	40.27	6
Severe damage to mangrove forests	69.46	3	68.71	3	68.13	3	65.80	3
Clear-cutting of mangrove forests	92.61	1	90.54	1	90.27	1	83.06	1
Partial damage to seagrass beds	17.90	7	17.51	7	17.77	7	20.43	7
Severe damage to seagrass beds	43.02	5	42.05	5	42.59	5	44.09	5
Partial damage to coral reefs	54.84	4	53.92	4	53.75	4	53.91	4
Severe damage to coral reefs	80.62	2	80.18	2	79.73	2	77.83	2
N		87		142		160		221
Kendall u		0.6483		0.5923		0.5813		0.4683
Observed chi-square		1589.10		2366.23		2615.90		2912.52

Table 5.3 (Continued)

Ban Don Bay Part III

Impacting activities	0 intran. Scale value	0 intran. Rank	0+1 intran. Scale value	0+1 intran. Rank	0+1+2 intran. Scale value	0+1+2 intran. Rank	All cases Scale value	All cases Rank
Shrimp farming , 25 rai, no clear-cut	12.05	8	16.86	7	17.38	7	21.85	7
Shrimp farming , 100 rai, no clear-cut	35.49	6	40.15	5	41.16	5	43.21	5
Shrimp farming , 100 rai, clear-cut	82.37	1	84.81	1	85.31	1	82.67	1
Housing, 50 units, no clear-cut	16.52	7	16.34	8	16.48	8	20.86	8
Housing, 100 units, no clear-cut	38.39	5	38.35	6	37.96	6	37.55	6
Housing, 100 units, clear-cut	72.32	3	72.20	3	72.23	3	69.31	3
Oil spill, 20,000 litre	61.16	4	54.70	4	53.15	4	52.90	4
Oil spill, 200,000 litre	81.70	2	76.58	2	76.32	2	71.64	2
N		64		111		143		202
Kendall u		0.5567		0.4975		0.4917		0.3813
Observed chi-square		1009.94		1560.25		1983.19		2173.96

Phangnga Bay Part III

Impacting activities	0 intran. Scale value	0 intran. Rank	0+1 intran. Scale value	0+1 intran. Rank	0+1+2 intran. Scale value	0+1+2 intran. Rank	All cases Scale value	All cases Rank
Shrimp farming , 25 rai, no clear-cut	14.81	7	15.91	7	16.36	7	17.84	7
Shrimp farming , 50 rai, no clear-cut	33.45	6	33.91	6	34.48	6	35.06	6
Shrimp farming , 50 rai, clear-cut	72.65	3	73.42	3	73.98	3	73.62	3
Hotel, 75 units, sewage, no clear-cut	6.62	8	8.05	8	8.46	8	11.76	8
Hotel, 75 units, no sewage, no clear-cut	46.86	5	47.74	5	47.73	5	47.92	5
Hotel, 75 units, no sewage, clear-cut	81.88	2	83.27	1	82.52	1	82.02	1
Oil spill, 20,000 litre	59.06	4	55.61	4	54.99	4	53.59	4
Oil spill, 200,000 litre	85.19	1	82.37	2	81.72	2	78.40	2
N		82		158		179		209
Kendall u		0.6101		0.5731		0.5585		0.5062
Observed chi-square		1411.61		2547.22		2811.69		2975.90

The next test was to measure the relationship between the rankings of the relative importance obtained from these four sets of respondents. The Kendall rank-order coefficient of correlation *T*, estimated based on mean ranks, showed that correlation among all four sets of respondents was significant at 0.05 level of probability (table 5.4). The null hypothesis was rejected and the conclusion that all sets of rankings were related was drawn.

To further examine the effect of intransitivity, the number of circular triads, indicating the upper bound of the degree of intransitivity in responses, was determined based on the total number of respondents. Table 5.5 presents the number of respondents with circular triads from 0 (coefficient of consistence, z = 1) to the maximum of 20 (z = 0). From 76% (Ban Don Bay Part I) to 90% (Phangnga Bay Part III) of all respondents had high coefficients of consistence of 0.65 or greater. This result showed that most respondents were fairly consistent in their rankings of the relative importance of resource losses and activities.

The above findings also suggest that adding the respondents with intransitive responses into the sample did not significantly alter the resulting scale values and the importance rankings of the resource losses and activities. Thus, it can be concluded that the impact of intransitive responses on the scale values and the rankings was negligible. As a result, all respondents were used in the subsequent analyses, regardless of the level of intransitivity.

Table 5.4 Kendall correlation coefficient T of the rankings of resource losses and impacting activites by respondents in different intransitive groups.

Ban Don Bay Part I

	0 intran.	0+1	0+1+2	All cases
0 intran.	1.0000			
0+1	1.0000	1.0000		
0+1+2	0.9286	0.9286	1.0000	
All cases	0.9286	0.9286	1.0000	1.0000

Phangnga Bay Part I

	0 intran.	0+1	0+1+2	All cases
0 intran.	1.0000			
0+1	1.0000	1.0000		
0+1+2	1.0000	1.0000	1.0000	
All cases	1.0000	1.0000	1.0000	1.0000

Ban Don Bay Part III

	0 intran.	0+1	0+1+2	All cases
0 intran.	1.0000			
0+1	0.8571	1.0000		
0+1+2	0.8571	1.0000	1.0000	
All cases	0.8571	1.0000	1.0000	1.0000

Phangnga Bay Part III

	0 intran.	0+1	0+1+2	All cases
0 intran.	1.0000			
0+1	0.9286	1.0000		
0+1+2	0.9286	1.0000	1.0000	
All cases	0.9286	1.0000	1.0000	1.0000

Table 5.5 Frequency of respondents based on the number of circular triads.

		Ban Don Bay Part I		Phangnga Bay Part I		Ban Don Bay Part III		Phangnga Bay Part III	
c*	z**	Total	cum %	Total	cum %	Total	cum %	Total	cum %
0	1.00	38	18.6	87	39.4	64	31.7	82	39.2
1	0.95	25	30.9	22	49.3	22	42.6	46	61.2
2	0.90	22	41.7	19	57.9	26	55.4	22	71.8
3	0.85	23	52.9	22	67.9	17	63.9	16	79.4
4	0.80	14	59.8	15	74.7	22	74.8	8	83.3
5	0.75	8	63.7	11	79.6	13	81.2	6	86.1
6	0.70	12	69.6	6	82.4	6	84.2	5	88.5
7	0.65	14	76.5	6	85.1	9	88.6	4	90.4
8	0.60	13	82.8	4	86.9	4	90.6	6	93.3
9	0.55	5	85.3	2	87.8	3	92.1	1	93.8
10	0.50	9	89.7	8	91.4	2	93.1	2	94.7
11	0.45	0	89.7	2	92.3	3	94.6	4	96.7
12	0.40	4	91.7	5	94.6	4	96.5	2	97.6
13	0.35	3	93.1	3	95.9	1	97.0	1	98.1
14	0.30	4	95.1	3	97.3	3	98.5	0	98.1
15	0.25	4	97.1	3	98.6	1	99.0	1	98.6
16	0.20	3	98.5	2	99.5	1	99.5	1	99.0
17	0.15	2	99.5	1	100.0	1	100.0	0	99.0
18	0.10	1	100.0	0	100.0	0	100.0	2	100.0
19	0.05	0	100.0	0	100.0	0	100.0	0	100.0
20	0.00	0	100.0	0	100.0	0	100.0	0	100.0
Total		204		221		202		209	

* c is the number of circular triads;
** z is the coefficient of consistence.

5.2 Scale values and rankings of resource losses and activities

This section summarises the resulting scale values and the rankings of resource losses and activities for Ban Don Bay and Phangnga Bay. Three main conclusions could be drawn from the analyses of the responses. First, respondents were able to provide consistent rankings of the resource losses and activities, based on the paired comparison questions of the relative importance. The highly significant level of agreement (alpha level 0.01) in the rankings of resource losses and activities by all respondents supported this conclusion. Second, rank-order correlation analyses showed significant relation (alpha level 0.05) between formal experts and layexperts and among the four layexpert groups. These findings implied that a single scale of values could be calculated using the responses from all respondents. Lastly, the scale values obtained from the study clearly indicated which resource losses or activities were more important. This final conclusion confirmed that the scales of relative importance of resource losses and activities could be constructed based on these field responses.

The presentation of the results starts from the scale values of resource losses (based on Part I of the questionnaire) for Ban Don Bay and Phangnga Bay, followed by the scale values of impacting activities (based on Part III of the questionnaire) for Ban Don Bay and Phangnga Bay. In these first two subsections, scale values are reported for seven groups of respondents:

1) all respondents;
2) all formal experts;
3) all layexperts;

4) fishers;

5) shrimp farmers;

6) shellfish culturers in Ban Don Bay or tourism in Phangnga Bay; and

7) others.

Dunn-Rankin's variance stable rank sums method was used to calculate the scale values reported in this study. To verify that this method was appropriate for the study, scale values based on total respondents were also calculated using Thurstone's case V method. Table 5.6 compares the values obtained from both methods. The resource losses and the activities were arranged from the highest scale value (rank = 1) to the lowest scale value (rank = 8). The rankings of the resource losses and the impacting activities, based on the scale values obtained from both methods, were identical. The scale values from the two methods were highly correlated (figure 5.1). This result supported the findings of Dunn-Rankin (1983) that the values obtained from both methods were isomorphic. Dunn-Rankin's method was chosen for the analysis of the paired-comparison data in this study since it was simpler than Thurstone's method.

5.2.1 Scale values of resource losses

5.2.1.1 Ban Don Bay

The scale values and the rankings of resource losses in Ban Don Bay are shown in table 5.7 for the seven respondent groups. Despite the low Kendall *u* values (from 0.2466 to 0.3156), the null hypothesis that there was no agreement among the respondents in each respondent group was rejected (the observed X^2 was greater than the critical value of chi-

Table 5.6 Comparison of scale values using Dunn-Rankin and Thurstone methods.

Ban Don Bay, Part I

Rank	Resource loss	Dunn-Rankin Scale value	Thurstone Scale value
1	Clear-cutting of mangrove forests	72.97	1.292
2	Severe damage to mangrove forests	69.47	1.273
3	Severe damage to fishing grounds	66.04	1.249
4	Severe damage to shellfish culture grounds	53.92	0.946
5	Severe damage to mudflats	50.07	0.845
6	Partial damage to fishing grounds	37.89	0.387
7	Partial damage to shellfish culture grounds	26.82	0.122
8	Partial damage to mudflats	22.90	0.000

Correlation coefficient = 0.9930

Phangnga Bay, Part I

Rank	Resource loss	Dunn-Rankin Scale value	Thurstone Scale value
1	Clear-cutting of mangrove forests	83.06	2.392
2	Severe damage to coral reefs	77.83	2.314
3	Severe damage to mangrove forests	65.80	1.812
4	Partial damage to coral reefs	53.91	1.520
5	Severe damage to seagrass beds	44.09	1.384
6	Severe damage to sandy beach	40.27	1.299
7	Partial damage to seagrass beds	20.43	0.592
8	Partial damage to sandy beach	14.67	0.000

Correlation coefficient = 0.9806

Ban Don Bay, Part III

Rank	Resource loss	Dunn-Rankin Scale value	Thurstone Scale value
1	Shrimp farming , 100 rai, clear-cut	82.67	2.038
2	Oil spill, 200,000 litre	71.64	1.671
3	Housing, 100 units, clear-cut	69.31	1.665
4	Oil spill, 20,000 litre	52.90	1.121
5	Shrimp farming , 100 rai, no clear-cut	43.21	0.902
6	Housing, 100 units, no clear-cut	37.55	0.742
7	Shrimp farming , 25 rai, no clear-cut	21.85	0.294
8	Housing, 50 units, no clear-cut	20.86	0.000

Correlation coefficient = 0.9932

Phangnga Bay, Part III

Rank	Resource loss	Dunn-Rankin Scale value	Thurstone Scale value
1	Hotel, 75 units, no sewage, clear-cut	82.02	2.207
2	Oil spill, 200,000 litre	78.40	2.052
3	Shrimp farming , 50 rai, clear-cut	73.62	1.949
4	Oil spill, 20,000 litre	53.59	1.221
5	Hotel, 75 units, no sewage, no clear-cut	47.92	1.135
6	Shrimp farming , 50 rai, no clear-cut	35.06	0.784
7	Shrimp farming , 25 rai, no clear-cut	17.84	0.120
8	Hotel, 75 units, sewage, no clear-cut	11.76	0.000

Correlation coefficient = 0.9985

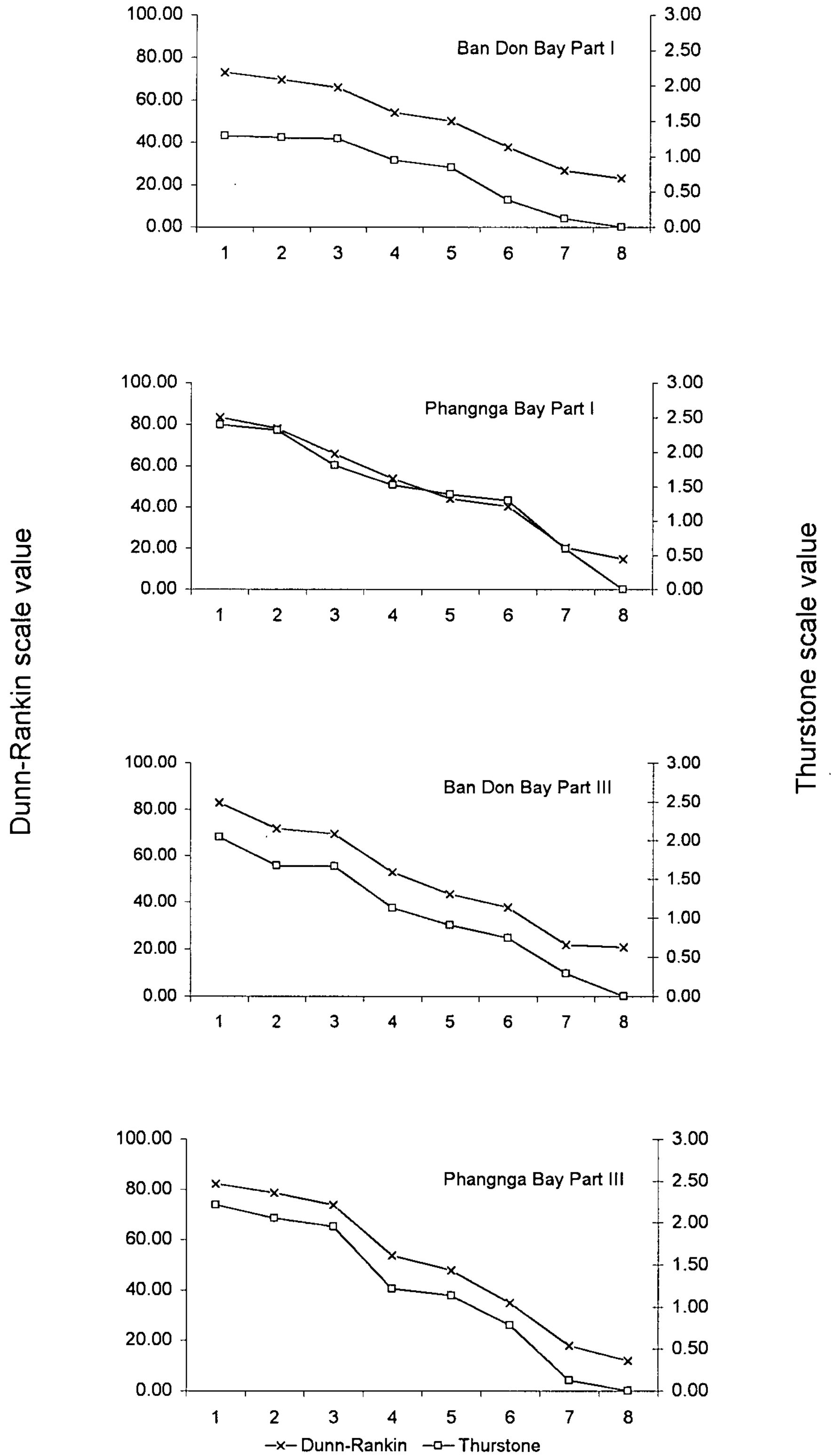


Figure 5.1 Relationship of scale values from Dunn-Rankin's and Thurstone's methods.

Table 5.7 Scale values and rankings of resource losses in Ban Don Bay based on respondents in different expert groups.

Resource Loss	All respondents		Formal experts		Layexperts	
	Scale value	Rank	Scale value	Rank	Scale value	Rank
Severe damage to mangrove forests	69.47	2	68.64	2	69.68	2
Clear-cutting of mangrove forests	72.97	1	74.91	1	72.48	1
Partial damage to mudflats	22.90	8	24.39	7	22.52	8
Severe damage to mudflats	50.07	5	50.17	5	50.04	5
Partial damage to shellfish culture grounds	26.82	7	21.25	8	28.22	7
Severe damage to shellfish culture grounds	53.92	4	54.70	4	53.72	4
Partial damage to fishing grounds	37.89	6	37.28	6	38.04	6
Severe damage to fishing grounds	66.04	3	68.64	2	65.38	3
N		204		41		163
Kendall u		0.2845		0.3045		0.2782
Observed chi-square		1645.14		369.07		1290.00

Resource Loss	Fishers		Shrimp farmers		Shellfish culturers		Others	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Severe damage to mangrove forests	71.75	2	74.29	2	62.79	3	70.20	2
Clear-cutting of mangrove forests	73.97	1	74.64	1	70.10	1	71.02	1
Partial damage to mudflats	25.71	7	23.57	8	17.94	8	22.86	8
Severe damage to mudflats	50.48	4	52.14	4	48.17	5	49.39	5
Partial damage to shellfish culture grounds	25.71	7	23.93	7	34.55	7	28.57	7
Severe damage to shellfish culture grounds	50.16	5	51.07	5	62.46	4	50.61	4
Partial damage to fishing grounds	38.41	6	35.36	6	37.21	6	41.63	6
Severe damage to fishing grounds	64.13	3	65.00	3	66.78	2	65.71	3
N		45		40		43		35
Kendall u		0.2853		0.3156		0.2466		0.2694
Observed chi-square		379.47		372.60		318.05		284.46

square of 56.89 at the 0.001 level of probability). The agreement among formal experts (Kendall u = 0.3045), was higher than that among layexperts (u = 0.2782). However, with almost the same number of respondents in the group, the u value of shrimp farmers (0.3156) was slightly higher than that of formal experts. The correlation coefficients of the rankings of resource losses in Ban Don Bay were highly significant at alpha level 0.05 among all groups of respondents (table 5.8).

In Ban Don Bay, clear-cutting of mangrove forests was considered to be the most important loss by all respondent groups (table 5.7). Severe damage of mangrove forests was the second most important loss, according to all groups, except shellfish culturers. The next most important resource loss was severe damage to fishing grounds. The resource losses with little importance were partial damage to mudflats and partial damage to shellfish culture grounds.

Scale values of the eight resource losses included in the study, based on the responses from all respondents, ranged from 22.90 for partial damage to mudflats to 72.97 for clear-cutting of mangrove forests. This difference of about 50 points in scale value suggests that, although the respondents were able to rank the resource losses in terms of their relative importance, the differences between some losses may be small and insignificant. This issue is discussed in a later section.

5.2.1.2 Phangnga Bay

The level of agreement among respondents in all seven groups was higher in Phangnga Bay than in Ban Don Bay (table 5.9). Formal experts showed the highest degree of

Table 5.8 Kendall correlation coefficient T of the rankings of resource losses in Ban Don Bay by respondents in different expert groups*.

	All cases	**Formal experts**	**Lay experts**	**Fishers**	**Shrimp farmers**	**Shellfish culturers**	**Others**
All cases	1.0000						
Formal	0.8571	1.0000					
Layexperts	1.0000	0.8571	1.0000				
Fishers	0.9286	0.7857	0.9286	1.0000			
Shrimp	0.8571	0.7143	0.8571	0.9286	1.0000		
Shellfish	0.8571	0.8571	0.8571	0.7857	0.7143	1.0000	
Others	0.9286	0.7857	0.9286	0.8571	0.9286	0.7857	1.0000

* All correlations are significant at alpha level 0.05.

Table 5.9 Scale values and rankings of resource losses in Phangnga Bay based on respondents in different expert groups.

Resource Loss	All respondents		Formal experts		Layexperts	
	Scale value	Rank	Scale value	Rank	Scale value	Rank
Partial damage to sandy beach	14.67	8	6.16	8	17.23	8
Severe damage to sandy beach	40.27	6	30.53	6	43.19	5
Severe damage to mangrove forests	65.80	3	61.62	3	67.06	3
Clear-cutting of mangrove forests	83.06	1	84.59	1	82.61	1
Partial damage to seagrass beds	20.43	7	24.37	7	19.24	7
Severe damage to seagrass beds	44.09	5	50.98	5	42.02	6
Partial damage to coral reefs	53.91	4	58.54	4	52.52	4
Severe damage to coral reefs	77.83	2	83.19	2	76.22	2
N		221		51		170
Kendall u		0.4683		0.5525		0.4523
Observed chi-square		2912.50		801.49		2168.40

Resource Loss	Fishers		Shrimp farmers		Tourism		Others	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Partial damage to sandy beach	19.05	7	18.21	8	11.72	8	19.25	7
Severe damage to sandy beach	40.63	6	44.29	5	40.66	6	46.89	5
Severe damage to mangrove forests	71.75	3	66.79	3	64.47	3	64.91	3
Clear-cutting of mangrove forests	84.13	1	81.43	1	80.22	1	84.16	1
Partial damage to seagrass beds	18.41	8	19.64	7	23.08	7	16.46	8
Severe damage to seagrass beds	41.59	5	40.71	6	44.69	5	41.30	6
Partial damage to coral reefs	51.11	4	52.50	4	56.41	4	50.62	4
Severe damage to coral reefs	73.33	2	76.43	2	79.12	2	76.40	2
N		45		40		39		46
Kendall u		0.4667		0.4267		0.4644		0.4401
Observed chi-square		602.93		494.00		522.15		582.52

agreement (highest Kendall *u* of 0.5525). Among the four layexpert groups, the agreement in the rankings was highest among fishers (u = 0.4667). The rankings of importance of resource losses of these two groups of respondents (the formal experts and layexperts in tourism-related business) were also identical. The Kendall correlation coefficient *T* was significant at alpha level 0.05 (table 5.10).

Similar to Ban Don Bay, clear-cutting of mangrove forests in Phangnga Bay was ranked first in terms of importance by all groups of respondents (table 5.9). Severe damage of coral reefs was considered the second most important resource loss by all groups of respondents, moving severe damage to mangrove forests to third place. The least importance resource losses were partial damage to sandy beaches and to seagrass beds.

The difference between the scale values of the most important and the least important resource losses was larger than that in Ban Don Bay, at 68 points. This implies that, according to all respondents in Phangnga Bay, the importance of clear-cutting of mangrove forests (scale value 83.06) was considered to be much higher than the importance of partial damage to sandy beaches (scale value 14.67).

5.2.2 Scale values of impacting activities

5.2.2.1 Ban Don Bay

Ban Don Bay respondents were, in general, more in agreement about the importance of activities than they were about the importance of resource losses, as seen by higher Kendall *u* values in all cases (Kendall *u* values in table 5.11 are higher than those in table

Table 5.10 Kendall correlation coefficient T of the rankings of resource losses in Phangnga Bay by respondents in different expert groups*.

	All cases	Formal experts	Lay experts	Fishers	Shrimp farmers	Tourism	Others
All cases	1.0000						
Formal	0.9286	1.0000					
Layexpert	0.9286	0.9286	1.0000				
Fishers	0.9286	0.9286	0.8571	1.0000			
Shrimp	0.9820	0.9286	1.0000	0.8571	1.0000		
Tourism	0.8571	0.9820	0.9092	0.9092	0.9092	1.0000	
Others	1.0000	0.8571	0.9286	0.9286	0.9286	0.8365	1.0000

* All correlations are significant at alpha level 0.05.

Table 5.11 Scale values and rankings of impacting activities in Ban Don Bay based on respondents in different expert groups.

Activity	All respondents Scale value	All respondents Rank	Formal experts Scale value	Formal experts Rank	Layexperts Scale value	Layexperts Rank
Shrimp farming , 25 rai, no clear-cut	21.85	7	12.62	8	24.35	7
Shrimp farming , 100 rai, no clear-cut	43.21	5	36.88	6	44.92	5
Shrimp farming , 100 rai, clear-cut	82.67	1	80.73	1	83.20	1
Housing, 50 units, no clear-cut	20.86	8	26.25	7	19.41	8
Housing, 100 units, no clear-cut	37.55	6	47.51	5	34.86	6
Housing, 100 units, clear-cut	69.31	3	77.08	2	67.21	3
Oil spill, 20,000 litre	52.90	4	48.17	4	54.18	4
Oil spill, 200,000 litre	71.64	2	70.76	3	71.88	2
N		202		43		159
Kendall u		0.3813		0.4309		0.3775
Observed chi-square		2174.00		534.79		1698.00

Activity	Fishers Scale value	Fishers Rank	Shrimp farmers Scale value	Shrimp farmers Rank	Shellfish culturers Scale value	Shellfish culturers Rank	Others Scale value	Others Rank
Shrimp farming , 25 rai, no clear-cut	32.70	6	18.68	8	23.47	7	21.01	7
Shrimp farming , 100 rai, no clear-cut	52.70	4	39.56	6	44.22	5	42.44	5
Shrimp farming , 100 rai, clear-cut	85.71	1	80.22	1	81.97	1	84.87	1
Housing, 50 units, no clear-cut	18.10	8	21.98	7	17.69	8	21.01	7
Housing, 100 units, no clear-cut	31.11	7	43.96	5	30.95	6	35.29	6
Housing, 100 units, clear-cut	62.54	3	70.70	2	66.67	3	70.17	3
Oil spill, 20,000 litre	49.21	5	54.58	4	58.50	4	53.36	4
Oil spill, 200,000 litre	67.94	2	70.33	3	76.53	2	71.85	2
N		45		39		42		34
Kendall u		0.3476		0.3649		0.4136		0.4146
Observed chi-square		456.27		406.00		502.86		411.06

5.7). Unlike the case of resource losses, the agreement was highest among formal experts (*u* = 0.4309), followed by others (*u* = 0.4146), shellfish culturers (*u* = 0.4136), shrimp farmers (*u* = 0.3649) and fishers (*u* = 0.3476). The rankings of importance of activities were identical for formal experts and shrimp farmers. All correlation coefficients were significant at the 0.05 probability level (table 5.12).

All groups of respondents agreed that 100 rai of shrimp farming, with clear-cutting of mangrove forests, was the most impacting activity in the area (table 5.11). Most layexperts considered a 200,000 litre oil spill to be the second most impacting, but formal experts considered housing development with clear-cutting of mangrove forests to be the second most important activity. The least impacting activities were small-scale shrimp farming and housing development without any clear-cutting. The difference in scale value between the most important and the least important activity was 62 points, which was 12 points greater than the difference in the case of resource losses.

According to layexperts, the three shrimp farming activities were more important than the respective three comparable housing activities. While shrimp farming activities had the rankings of 1, 5, and 7, the housing activities were given ranks of 3, 6, and 8. Formal experts, however, ranked these two sets of activities differently; housing activities were ranked higher than shrimp farming, with the exception of shrimp farming with clear-cutting which was considered to be more important than housing with clear-cutting (2, 5, 7 for housing and 1, 6, 8 for shrimp farming).

Table 5.12 Kendall correlation coefficient T of the rankings of impacting activities in Ban Don Bay by respondents in different expert groups*.

	All cases	Formal experts	Lay experts	Fishers	Shrimp farmers	Shellfish culturers	Others
All cases	1.0000						
Formal	0.7857	1.0000					
Layexpert	1.0000	0.7857	1.0000				
Fishers	0.8571	0.6429	0.8571	1.0000			
Shrimp	0.8365	0.9820	0.8365	0.6910	1.0000		
Shellfish	1.0000	0.7857	1.0000	0.8571	0.8365	1.0000	
Others	0.8571	0.9286	0.8571	0.7143	0.9092	0.8571	1.0000

* All correlations are significant at alpha level 0.05.

5.2.2.2 Phangnga Bay

Table 5.13 shows a high degree of agreement in rankings of the importance of activities among all of the different groups of respondents in Phangnga Bay. Kendall *u* of each group was highly significant and the null hypothesis could be rejected at alpha level 0.001. As in Ban Don Bay, the level of agreement was higher in the rankings of the activities than in those of resource losses. The group with the highest Kendall *u* was again formal experts (u = 0.5301), while for layexperts, shrimp farmers showed greater agreement than the other three groups. The rankings were identical between tourism and others. Kendall *T* was significant at alpha level 0.05 in all cases (table 5.14).

Formal experts and layexperts in Phangnga Bay agreed in the rankings of importance of all activities, except for the most important one. While formal experts considered a 200,000 litre oil spill to be most impacting activity (scale value 85.71), layexperts, including those in tourism, gave the first rank to hotel development of 75 units with no sewage and involving the clear-cutting of mangrove forests (scale value 82.89) (table 5.13). All respondent groups agreed in the rankings of the three least important activities, i.e., in descending order, shrimp farming 50 rai with no clear-cut (scale value 34.85), shrimp farming 25 rai with no clear-cut (scale value 17.56) and hotel development of 75 units, with sewage system and no clear-cutting (scale value 12.47). The range of the scale values of the importance of activities based on total respondents was 70 points, which was slightly higher than the range of the importance of resource losses.

Table 5.13 Scale values and rankings of impacting activities in Phangnga Bay based on respondents in different expert groups.

Activity	All respondents		Formal experts		Layexperts	
	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	17.84	7	18.68	7	17.56	7
Shrimp farming , 50 rai, no clear-cut	35.06	6	35.71	6	34.85	6
Shrimp farming , 50 rai, clear-cut	73.62	3	71.15	3	74.43	3
Hotel, 75 units, sewage, no clear-cut	11.76	8	9.62	8	12.47	8
Hotel, 75 units, no sewage, no clear-cut	47.92	5	43.41	5	49.41	5
Hotel, 75 units, no sewage, clear-cut	82.02	1	79.40	2	82.89	1
Oil spill, 20,000 litre	53.59	4	56.32	4	52.68	4
Oil spill, 200,000 litre	78.40	2	85.71	1	75.98	2
N		209		52		157
Kendall u		0.5062		0.5301		0.5016
Observed chi-square		2975.90		785.00		2219.10

Activity	Fishers		Shrimp farmers		Tourism		Others	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	18.51	7	15.10	7	19.18	7	17.28	7
Shrimp farming , 50 rai, no clear-cut	34.09	6	35.10	6	33.88	6	36.21	6
Shrimp farming , 50 rai, clear-cut	76.30	2	75.51	2	71.43	3	74.09	3
Hotel, 75 units, sewage, no clear-cut	13.31	8	13.47	8	9.39	8	12.96	8
Hotel, 75 units, no sewage, no clear-cut	48.38	5	51.84	4	51.02	5	47.18	5
Hotel, 75 units, no sewage, clear-cut	82.79	1	85.71	1	81.63	1	82.06	1
Oil spill, 20,000 litre	52.92	4	50.61	5	54.29	4	52.82	4
Oil spill, 200,000 litre	74.68	3	72.65	3	79.18	2	77.41	2
N		44		35		35		43
Kendall u		0.4864		0.5104		0.5059		0.4956
Observed chi-square		613.64		513.94		509.60		610.88

Table 5.14 Kendall correlation coefficient T of the rankings of impacting activities in Phangnga Bay by respondents in different expert groups*.

	All cases	Formal experts	Lay experts	Fishers	Shrimp farmers	Tourism	Others
All cases	1.0000						
Formal	0.9286	1.0000					
Layexpert	1.0000	0.9286	1.0000				
Fishers	0.9286	0.8571	0.9286	1.0000			
Shrimp	0.8571	0.7857	0.8571	0.9286	1.0000		
Tourism	1.0000	0.9286	1.0000	0.9286	0.8571	1.0000	
Others	1.0000	0.9286	1.0000	0.9286	0.8571	1.0000	1.0000

* All correlations are significant at alpha level 0.05.

5.3 Validity tests of the scale values

Despite the significant level of agreement among respondents in the scale values of resource losses and activities and the significant correlation of the rankings of the relative importance among different groups of respondents, other validity tests were conducted on the resulting scale values. First, the Kruskal-Wallis one-way analysis of variance on ranks was performed to determine if different groups of respondents were from the same population. The results showed that in most cases, all respondent groups could be considered as coming from the same population and the scale values based on all respondents could be used to develop the scales of relative importance. However, there were some cases where formal experts differed slightly from layexperts in their judgments. This implied that the use of one single scale of values to represent the judgments of all respondents should be done cautiously.

The second test was the critical range analysis and the calculation of scalability index. They were used to determine if the resource losses and activities included in the paired comparisons differ significantly from each other. The critical range analysis showed that scale values of most resource losses and activities differed significantly from one another. The results also indicated some of the resource losses and activities could be grouped together, as demonstrated in Section 5.3.2.

5.3.1 Kruskal-Wallis test of scale values

The null hypothesis was that all groups of respondents came from the same population and that their median ranks were not significantly different (Krsukal-Wallis test). Rejecting the null hypothesis suggested that at least one pair of respondent groups differed in their rankings of certain resource loss or activity. Multiple comparison tests were then used to determine which pair(s) was different from the rest.

5.3.1.1 Differences in the scale values of resource losses

The Kruskal-Wallis test for the scale values of resource losses in Ban Don Bay showed that the null hypothesis could not be rejected since the observed X^2 was smaller than the critical value of chi-square which was 9.49 (α = 0.05) (table 5.15). Based on the scale values and the rank correlation analysis, it could be concluded that formal experts and the four layexpert groups in Ban Don Bay did not differ in their judgments about the resource losses. They could thus be treated as one group of respondents for the construction of the scale of relative importance of resource loss in Ban Don Bay.

A different conclusion was drawn for the resource losses in Phangnga Bay. The Kruskal-Wallis test showed that respondents in Phangnga Bay differed in their judgments about three resource losses, namely partial damage to sandy beach (SB1), severe damage to sandy beach (SB2) and severe damage to seagrass beds (SG2) (table 5.15). Further analysis, using multiple comparisons to determine which pairs of respondent groups were different, revealed that the difference was found mainly between formal experts and layexperts as a group, and between formal experts and individual groups of layexperts (table 5.16). For example, in the rankings of partial damage to sandy beaches, formal experts differed from fishers, shrimp farmers and others. The four groups of layexperts, however, generally agreed in the rankings of all resource losses.

Table 5.15 Calculated chi-squares of Kruskal-Wallis tests for the difference in the rankings of resource losses by respondents from five expert groups.

Ban Don Bay

Resource loss		Chi-square*
Severe damage to mangrove forests	MF1	6.4549
Clear-cutting of mangrove forests	MF2	2.3277
Partial damage to mudflats	MUD1	4.2432
Severe damage to mudflats	MUD2	1.2512
Partial damage to shellfish culture grounds	SCG1	6.2600
Severe damage to shellfish culture grounds	SCG2	7.8821
Partial damage to fishing grounds	FG1	1.7761
Severe damage to fishing grounds	FG2	1.3714

Phangnga Bay

Resource loss		Chi-square*
Partial damage to sandy beach	SB1	25.7236*
Severe damage to sandy beach	SB2	18.1867*
Severe damage to mangrove forests	MF1	7.6778
Clear-cutting of mangrove forests	MF2	0.5191
Partial damage to seagrass beds	SG1	7.5854
Severe damage to seagrass beds	SG2	12.1747*
Partial damage to coral reefs	CR1	6.3634
Severe damage to coral reefs	CR2	7.3561

* denotes significantly difference chi-square value at alpha level 0.05, with 4 d.f.

Table 5.16 Kruskal-Wallis test of difference in the rankings of resource losse among different respondent groups in Phangnga Bay.

Resource losses with significant different rankings	Pairs of respondent groups with significant different rankings
Partial damage to sandy beaches (SB1)	Formal experts vs. Layexperts
	Formal experts vs. Fishers
	Formal experts vs. Shrimp farmers
	Formal experts vs. Others
Severe damage to sandy beaches (SB2)	Formal experts vs. Layexperts
	Formal experts vs. Shrimp farmers
	Formal experts vs. Others
Severe damage to seagrass beds (SG2)	Formal experts vs. Layexperts

5.3.1.2 Differences in the scale values of impacting activities

Results of the Kruskal-Wallis test for the rankings of importance of activities in Ban Don Bay are shown in table 5.17. The four activities where the null hypothesis was rejected were shrimp farming, 25 rai, no clear-cut (SHRIMP1), shrimp farming, 100 rai, no clear-cut (SHRIMP2), housing development, 100 units, no clear-cut (HOUSE2), and housing development, clear-cut (HOUSE3). The multiple comparison tests indicated that in all four activities, formal experts differed significantly in their judgments from fishers (table 5.18). Fishers and shrimp farmers also differed in the rankings of SHRIMP1 and SHRIMP2. For HOUSE2, the formal experts group was found to be different from fishers, shellfish culturers and others.

In Phangnga Bay, the only activity that showed significance difference in Kruskal-Wallis test was 200,000 litre of oil spill (OIL2) (table 5.17). The pair of expert groups responsible for this difference was formal experts and shrimp farmers (table 5.18).

5.3.2 Critical range analysis and scalability index

The calculations of critical range (CR) and the scalability index (SI) were performed, using the responses from all respondents in each study area, to determine if the objects in the paired comparisons were distinguishable. If the difference in the rank sums of any two objects, obtained from Dunn-Rankin's method, was greater than the critical range at a probability level 0.05, it could be concluded that these two objects were significantly different. The positive test together with the high scalability index lead to a conclusion that the objects differed sufficiently.

Table 5.17 Calculated chi-squares of Kruskal-Wallis tests for the difference in the rankings of impacting activities by respondents from five expert groups.

Ban Don Bay

Impacting activities		Chi-square*
Shrimp farming , 25 rai, no clear-cut	SHRIMP1	25.1772*
Shrimp farming , 100 rai, no clear-cut	SHRIMP2	16.9664*
Shrimp farming , 100 rai, clear-cut	SHRIMP3	2.6952
Housing, 50 units, no clear-cut	HOUSE1	6.2038
Housing, 100 units, no clear-cut	HOUSE2	23.1413*
Housing, 100 units, clear-cut	HOUSE3	13.8339*
Oil spill, 20,000 litre	OIL1	5.4311
Oil spill, 200,000 litre	OIL2	3.9241

Phangnga Bay

Impacting activities		Chi-square*
Shrimp farming , 25 rai, no clear-cut	SHRIMP1	2.3014
Shrimp farming , 50 rai, no clear-cut	SHRIMP2	1.3854
Shrimp farming , 50 rai, clear-cut	SHRIMP3	3.1939
Hotel, 75 units, sewage, no clear-cut	HOTEL1	4.2238
Hotel, 75 units, no sewage, no clear-cut	HOTEL2	4.1432
Hotel, 75 units, no sewage, clear-cut	HOTEL3	2.6450
Oil spill, 20,000 litre	OIL1	3.0290
Oil spill, 200,000 litre	OIL2	13.4066*

* denotes significantly difference chi-square value at alpha level 0.05, with 4 d.f.

Table 5.18 Kruskal-Wallis test of difference in the rankings of impacting activities among different respondent groups, Ban Don Bay and Phangnga Bay.

Ban Don Bay

Impacting activities with significant different rankings	Pairs of respondent groups with significant different rankings		
Shrimp farming, 25 rai, no clear-cut	Formal experts	vs.	Layexperts
(SHRIMP1)	Formal experts	vs.	Fishers
	Formal experts	vs.	Shrimp farmers
Shrimp farming, 100 rai, no clear-cut	Formal experts	vs.	Layexperts
(SHRIMP2)	Formal experts	vs.	Fishers
	Fishers	vs.	Shrimp farmers
Housing, 100 units, no clear-cut	Formal experts	vs.	Layexperts
(HOUSE2)	Formal experts	vs.	Fishers
	Formal experts	vs.	Shellfish culturers
	Formal experts	vs.	Others
Housing, 100 units, clear-cut	Formal experts	vs.	Layexperts
(HOUSE3)	Formal experts	vs.	Fishers

Phangnga Bay

Impacting activities with significant different rankings	Pairs of respondent groups with significant different rankings		
Oil spill, 200,000 litre	Formal experts	vs.	Shrimp farmers
(OIL2)			

When the difference between any two items was not significant, it could be implied that the two items shared some common features, which caused them to be of similar importance. In such cases, they were grouped according to the level of relative importance. It should be noted, however, that the groupings were suggested merely to reflect the similarity of the items, not to imply that those in the same group should be treated as equal. The groupings of the items may be useful in applying management measures, and is discussed in Chapter 8.

Tables 5.19 and 5.20 summarise the results of the critical range analysis. The main result of the critical range analysis was that out of 28 pairs of comparisons of resource losses and of activities, no more than five pairs of these had smaller rank sums than the critical range. The scalability index was very high, at greater than 0.8 in all cases. Therefore, it could be concluded that most of the resource losses and the activities included in this study were different from each other.

The critical range analysis also suggested that the eight resource losses and activities included in the study could be categorised into three levels of importance, namely, high, medium and low. Items were placed in the same group if the differences in their rank sums were smaller than the critical range ($\alpha = 0.05$).

For the resource losses in Ban Don Bay, the scale values of clear-cutting of mangrove forests (MF2, scale value 72.97), severe damage to mangrove forests (MF1, scale value 69.47) and severe damage to fishing grounds (FG2, scale value 66.04) were not significantly different from each other (table 5.19). The other two items that could be grouped together were severe damage to mudflats (MUD2, scale value 53.92) and severe

Table 5.19 Grouping of resource losses in Ban Don Bay and Phangnga Bay using critical range analysis.

Ban Don Bay

Group	Resource losses	Code	Scale value	Rank	Level of importance
1	Clear-cutting of mangrove forests	MF2	72.97	1	
	Severe damage to mangrove forests	MF1	69.47	2	High
	Severe damage to fishing grounds	FG2	66.04	3	
2	Severe damage to shellfish culture grounds	SCG2	53.92	4	
	Severe damage to mudflats	MUD2	50.07	5	Medium
3	Partial damage to fishing grounds	FG1	37.89	6	
4	Partial damage to shellfish culture grounds	SCG1	26.82	7	Low
	Partial damage to mudflats	MUD1	22.90	8	

Scalability index = 0.8214

Phangnga Bay

Group	Resource losses	Code	Scale value	Rank	Level of importance
1	Clear-cutting of mangrove forests	MF2	83.06	1	
	Severe damage to coral reefs	CR2	77.83	2	High
2	Severe damage to mangrove forests	MF1	65.80	3	
3	Partial damage to coral reefs	CR1	53.91	4	
	Severe damage to seagrass beds	SG2	44.09	5	Medium
	Severe damage to sandy beach	SB2	40.27	6	
4	Partial damage to seagrass beds	SG1	20.43	7	Low
	Partial damage to sandy beach	SB1	14.67	8	

Scalability index = 0.8571

Table 5.20 Grouping of impacting activities in Ban Don Bay and Phangnga Bay using critical range analysis.

Ban Don Bay

Group	Impacting activities	Code	Scale value	Rank	Level of importance
1	Shrimp farming , 100 rai, clear-cut	SHRIMP3	82.67	1	High
2	Oil spill, 200,000 litre	OIL2	71.64	2	
	Housing, 100 units, clear-cut	HOUSE3	69.31	3	
3	Oil spill, 20,000 litre	OIL1	52.90	4	
	Housing, 100 units, no clear-cut	HOUSE2	43.21	5	Medium
	Shrimp farming , 100 rai, no clear-cut	SHRIMP2	37.55	6	
4	Housing, 50 units, no clear-cut	HOUSE1	21.85	7	Low
	Shrimp farming , 25 rai, no clear-cut	SHRIMP1	20.86	8	

Scalability index = 0.8571

Phangnga Bay

Group	Impacting activities	Code	Scale value	Rank	Level of importance
1	Hotel, 75 units, no sewage, clear-cut	HOTEL3	82.02	1	
	Oil spill, 200,000 litre	OIL2	78.40	2	High
	Shrimp farming , 50 rai, clear-cut	SHRIMP3	73.62	3	
2	Oil spill, 20,000 litre	OIL1	53.59	4	
	Hotel, 75 units, no sewage, no clear-cut	HOTEL2	47.92	5	Medium
3	Shrimp farming , 50 rai, no clear-cut	SHRIMP2	35.06	6	
4	Shrimp farming , 25 rai, no clear-cut	SHRIMP1	17.84	7	Low
	Hotel, 75 units, sewage, no clear-cut	HOTEL1	11.76	8	

Scalability index = 0.8214

damage to shellfish culture grounds (SCG2, scale value 50.07). The last two items with smallest scale values, i.e. partial damage to shellfish culture ground (SCG1, scale value 26.82) and to mudflats (MUD1, scale value 22.90), were also considered to be similar in terms of their relative importance.

Similar results were found for the resource losses in Phangnga Bay (table 5.19). The scale values of the top two important resource losses (clear-cutting of mangrove forests (MF2, scale value 83.06) and severe damage to coral reefs (CR2, scale value 77.83)) were not significantly different. The three resource losses with medium level of relative importance, i.e. partial damage to coral reefs (CR1, scale value 53.91), severe damage to seagrass beds (SG2, scale value 44.09) and sandy beaches (SB2, scale value 40.27), were with comparable scale values. Finally, the importance of the partial damage of seagrass beds (SG1, scale value 20.43) and sandy beaches (SB1, scale value 14.67) were considered to be in the same level.

In terms of activities in Ban Don Bay, shrimp farming of 100 rai with clear-cutting (SHRIMP3, scale value of 82.67) was significantly different from other activities (table 5.20). Two activities with similar scale values were the large size oil spill (OIL2, scale value 71.64) and the housing development 100 units with clear-cutting (HOUSE3, scale value 69.31). Another set of activities that could be considered at the same level of importance include 20,000 litre oil spill (OIL1, scale value 52.90), housing of 100 units, with no clear-cut (HOUSE2, 43.21), and shrimp farming, 100 rai, no clear-cut (SHRIMP2, 37.55). Finally, the scale value of housing, 50 units, no clear-cut (HOUSE1, scale value 21.85) was not significantly different from shrimp farming, 25 rai, no clear-cutting (SHRIMP1, scale value 20.86).

In Phangnga Bay, the three activities with comparably high scale values were hotel development, 75 units, no sewage, involving clear-cutting of mangrove forests (HOTEL3, scale value 82.02), 200,000 of oil spills (OIL2, scale value 78.40) and shrimp farming of 50 rai with clear-cutting (SHRIMP3, scale value 73.62) (table 5.20). The other two pairs of scale values that did not differ significantly were oil spills of 20,000 litre (OIL1, scale value 53.59) and hotel development, with no sewage, no clear-cutting (HOTEL2, scale value 47.92); and 25 rai of shrimp farming, no clear-cutting (SHRIMP1, scale value 17.84) and 75 units of hotel development, no clear-cutting (HOTEL1, scale value 11.76).

5.4. Scales of relative importance for Ban Don Bay and Phangnga Bay

Based on the above analyses, the scales of relative importance of resource losses and activities were developed using the responses of all respondents. The scales of relative importance were constructed by placing the scale values directly on to the vertical scale of 0 (bottom end of the scale) to 100 (top end of the scale). Using the results of the critical range analyses (tables 5.19 and 5.20), the scales of relative importance were divided into three regions of high (scale value greater than 60), medium (scale value between 35 to 60) and low importance (scale value lower than 35). This division of the scales captured the pattern of the importance values better than by dividing the scales into three equal regions.

5.4.1 Scales of relative importance of resource losses

The scales of relative importance of resource losses for Ban Don Bay and Phangnga Bay were similar, with three resource losses in the high importance region, another three in the medium importance and the remaining two losses in the low importance region (figures 5.2 and 5.3). In both areas, severe damage to a resource was consistently considered to be more important than partial damage. The order of the resource losses was also consistent. In Ban Don Bay, for example, when severe damage of shellfish culture ground (SCG2) was considered to be more important than severe damage to mudflat (MUD2), the results showed that the ranking of partial damage to shellfish culture ground (SCG1) was also higher than that of partial damage to mudflat (MUD1). The same pattern was found in Phangnga Bay.

In both areas, the two losses of mangrove forests (MF1 and MF2) were in the high importance region of the scale. The severe damage of fishing grounds in Ban Don Bay (FG2) and the severe damage to coral reefs in Phangnga Bay (CR2) were also considered to have high importance. The resource losses of low importance were partial damage to shellfish culture grounds (SCG1) and mudflats (MUD1) in Ban Don Bay (figure 5.2) and partial damage to seagrass beds (SG1) and sandy beaches (SB1) in Phangnga Bay (figure 5.3).

The spread of the Ban Don Bay scale values was less than that of Phangnga Bay (scale values range from 23 to 73 in Ban Don Bay as opposed to 15 to 83 in Phangnga Bay). This implied that the relative importance of the resource losses in Phangnga Bay differed more than relative importance values in Ban Don Bay. In both areas, the resource loss

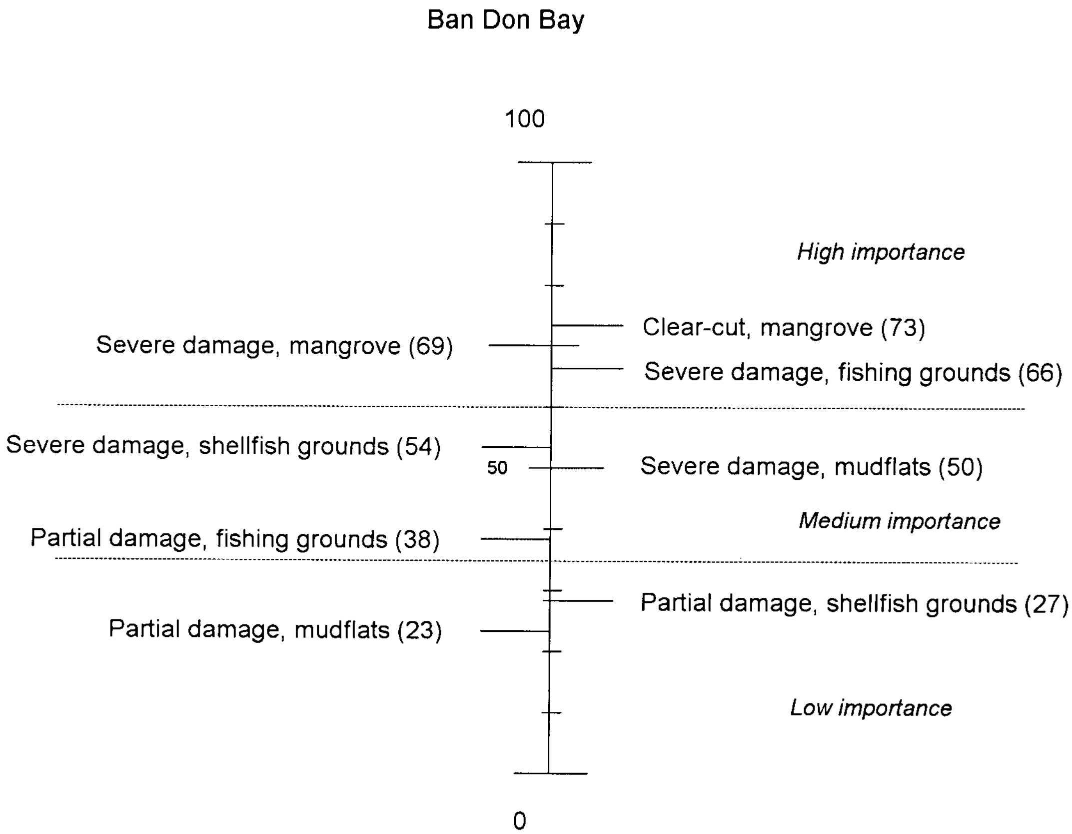


Figure 5.2 Scale of importance of resource losses for Ban Don Bay (based on all respondents).

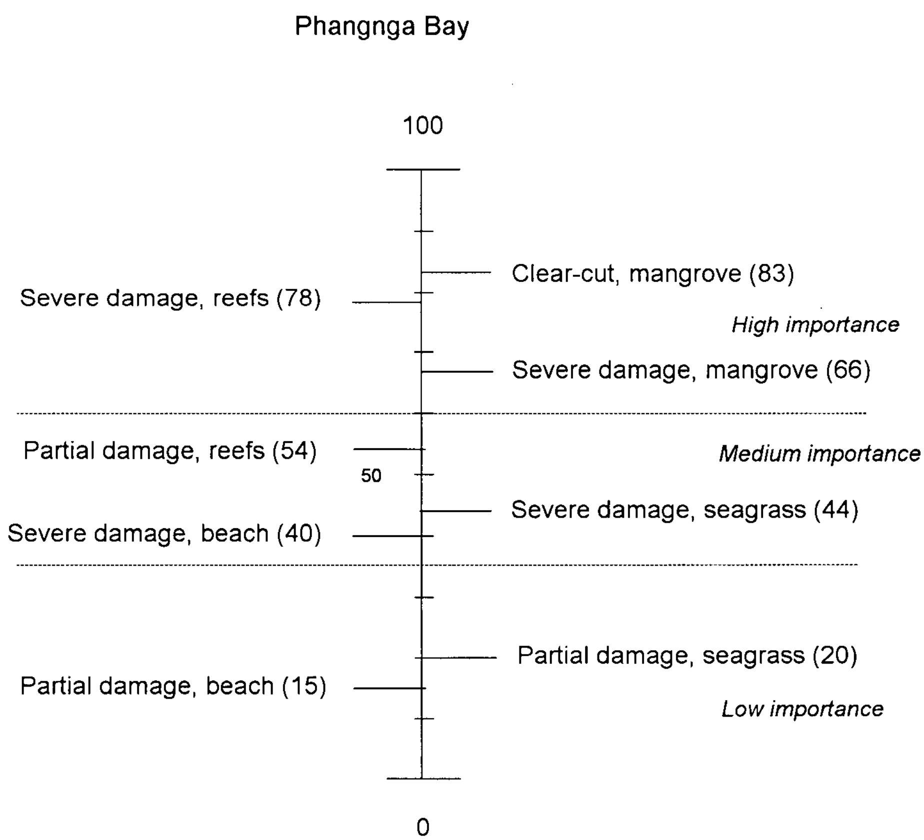


Figure 5.3 Scale of importance of resource losses for Phangnga Bay (based on all respondents).

with the smallest difference in the scale value between the two levels of damages was the loss related to mangrove forests. There was only a 4-point difference in scale value between clear-cutting of mangrove and severe damage to mangrove forests in Ban Don Bay compared with a 17-point difference in Phangnga Bay. For the other three resources in Ban Don Bay (fishing grounds, shellfish culture grounds and mudflats), the difference in the scale values between severe damage and partial damage was much greater. For example, the scale value of severe damage to fishing ground was 28 points higher than that of partial damage. Similar results were found in Phangnga Bay with a 24-point difference in the scale value between partial damage and severe damage of the other three resources (coral reefs, seagrass beds and sandy beaches).

5.4.2 Scales of relative importance of impacting activities

The scales of relative importance of activities for Ban Don Bay and Phangnga Bay are shown in figures 5.4 and 5.5, respectively. As seen in the loss scale, the two scales were similar and consistent in the ordering of the activities.

The top part of the activity scale of Ban Don Bay was slightly different from that of Phangnga Bay. Shrimp farming of 100 rai, involving clear-cutting of mangrove forests (SHRIMP3) was considered to be most damaging in Ban Don Bay, with a scale value of 83 (figure 5.4). The highest intensity of shrimp farming in Phangnga Bay (SHRIMP3) had the scale value of 74, which was less than the hotel development with no sewage system and involving clear-cutting of mangrove forests (HOTEL3), with its scale value of 82 (figure 5.5). It should be noted, however, that the size of a shrimp farm in Phangnga Bay presented in this study was half that of Ban Don Bay. At the bottom end of the scale, the

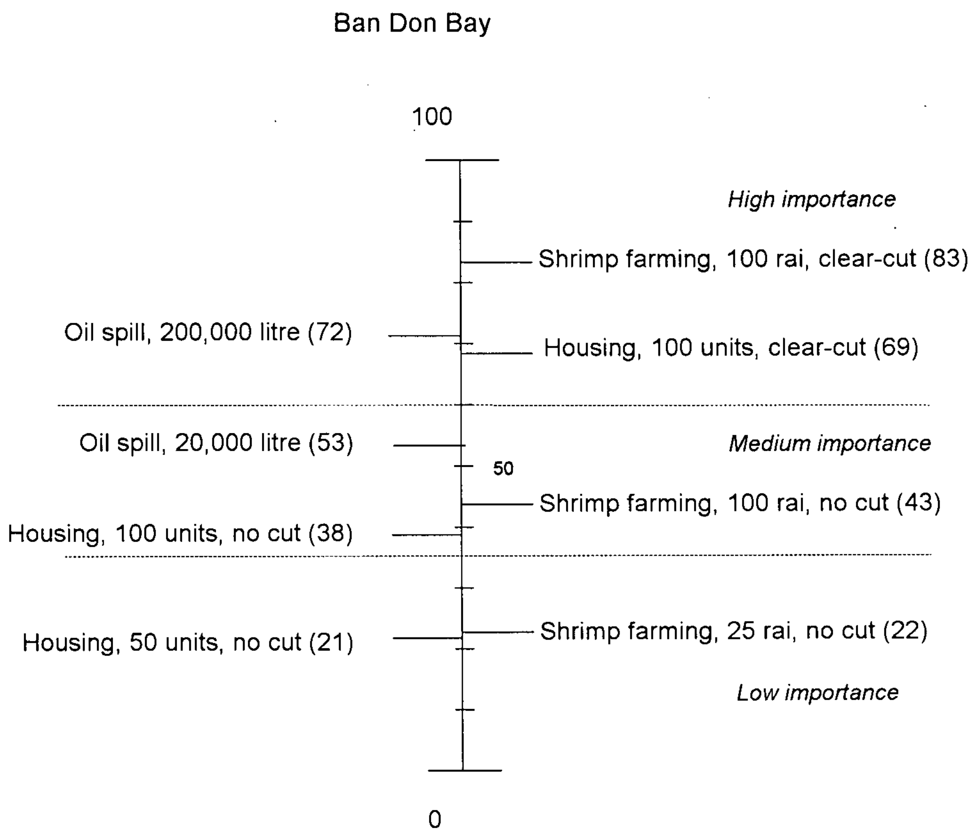


Figure 5.4 Scale of importance of impacting activities for Ban Don Bay (based on all respondents).

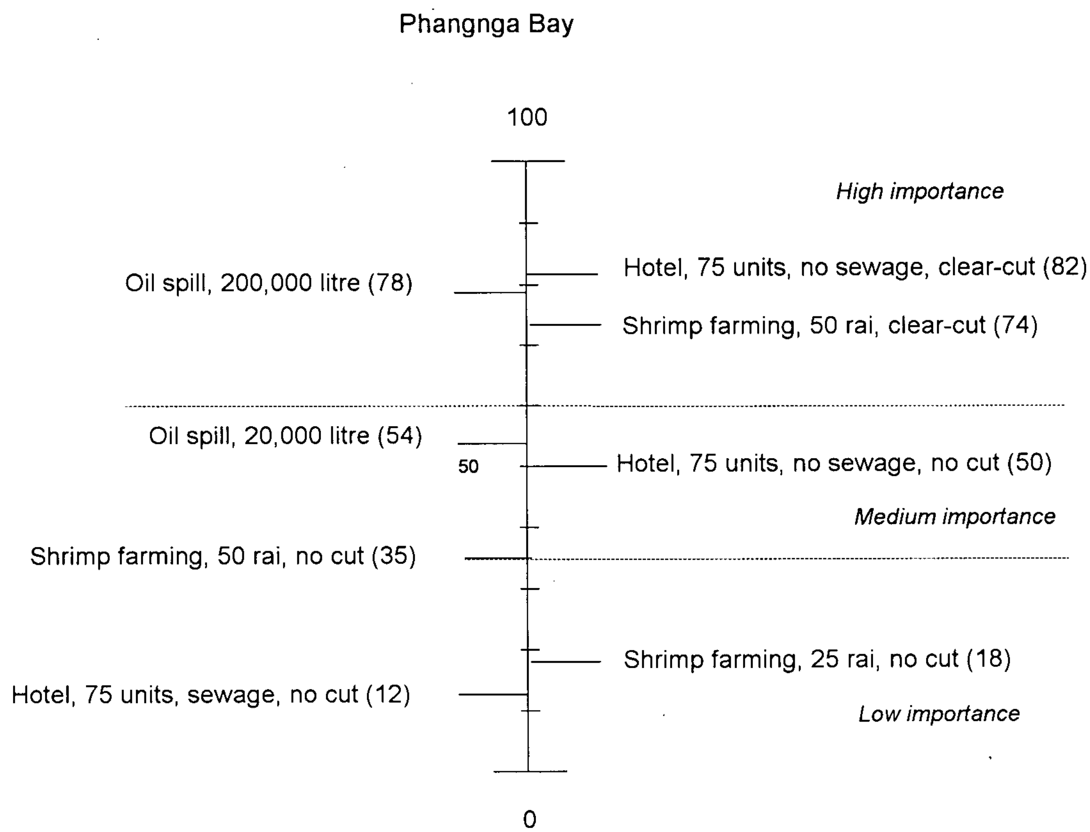


Figure 5.5 Scale of importance of impacting activities for Phangnga Bay (based on all respondents).

importance of shrimp farming, 25 rai, no clear-cut (SHRIMP1) was found for both study areas, with comparable scale values (22 in Ban Don Bay and 18 in Phangnga Bay). Another similarity lies in the importance of oil spills (OIL1, OIL2), where in both study areas, they received the same rank with almost the same scale value (figures 5.4 and 5.5).

A further pattern in the scale values of activities in Ban Don Bay was evident. In the activities with three levels of impact, such as shrimp farming and housing development, the scale value declined at a constant rate from the highest level to the lowest level. For example, the scale value of SHRIMP2 (43) was about half that of SHRIMP3 (83), and the scale value of SHRIMP1 (22) was about half that of SHRIMP2. Similarly, the scale value of HOUSE1 (21) was 45% of that for HOUSE2 (38), similar to the relation between HOUSE2 and HOUSE3 (69).

In Phangnga Bay, the scale value of shrimp farming activities followed a similar pattern, with 53% decrease from SHRIMP3 (74) to SHRIMP2 (35), and another 49% decrease from SHRIMP2 to SHRIMP1 (18). In hotel development activity, however, the sewage system seemed to be an important factor bringing the scale value of HOTEL1 (12) 76% lower than HOTEL2 (50). The impact of clear-cutting of mangrove forests in this activity was less obvious as the scale value only dropped 39% from HOTEL3 (hotel with clear-cutting, scale value 82) to HOTEL2 (hotel without clear-cutting, scale value 50).

5.4.3 Association between the loss scale and the activity scale

The association between resource losses and impacting activities was observed in the scales of relative importance. The two activities involving clear-cutting of the mangrove forests (SHRIMP3, HOUSE3, HOTEL3), in both study areas, were considered to be highly important on the activity scale (figures 5.4 and 5.5), the same as clear-cutting of mangrove forests (MF2) on the loss scale (figures 5.2 and 5.3). Large-scale oil spills (OIL2) were considered to have a high impact on coastal environment, in particular mangrove forests and coral reefs, and thus were placed in the top part of the activity scale. The associated losses, such as severe damage to mangrove forests (MF1) and severe damage to coral reefs (CR2), were also ranked in the upper region of the loss scale. Partial damage of resources and low impact activities fell towards the bottom end of the scale, as expected.

5.5 Characteristics of respondents and their effects on the scales of relative importance

As demonstrated above, the scales of relative importance developed using responses from all respondents, regardless of their expertise and occupation, provided meaningful interpretations of the importance of resources and activities in the study areas. However, respondents differed, not only by their occupations, but also by other attributes, such as gender, age, etc. This section explores the effects that such attributes might have on the scales of relative importance.

Four attributes were considered in this study, i.e. gender, education, number of years lived in the area and age. The descriptive frequencies of respondents according to these attributes are summarised in table 5.21. About 25% of total respondents in Ban Don Bay

Table 5.21 General descriptions of the respondents in Ban Don Bay and Phangnga Bay.

Gender

	Ban Don Bay						Phangnga Bay					
			Formal experts		Lay experts				Formal experts		Lay experts	
	Total	% Total	No.	%	No.	%	Total	% Total	No.	%	No.	%
Female	50	25.4	9	22.0	41	26.3	67	32.2	14	27.5	53	33.8
Male	147	74.6	32	78.1	115	73.7	141	67.8	37	72.5	104	66.2
Total	197	100.0	41	100.0	156	100.0	208	100.0	51	100.0	157	100.0

Education

	Ban Don Bay						Phangnga Bay					
			Formal experts		Lay experts				Formal experts		Lay experts	
	Total	% Total	No.	%	No.	%	Total	% Total	No.	%	No.	%
Doctoral	12	6.2	12	29.3			7	3.5	7	14.3		
Master	8	4.1	7	17.1	1	0.7	16	7.9	16	32.7		
Bachelor	43	22.2	19	46.3	24	15.7	44	21.8	21	42.9	23	15.2
Diploma	21	10.8	3	7.3	18	11.8	29	14.4	5	10.2	24	15.9
High school	27	13.9			27	17.6	37	18.3	2	4.1	35	23.2
Middle school	28	14.4			28	18.3	23	11.4			23	15.2
Grade 4	55	28.4			55	35.9	46	22.8			46	30.5
Total	194	100.0	41	100.0	153	100.0	202	100.0	49	100.0	151	100.0

Years lived in the area

	Ban Don Bay						Phangnga Bay					
			Formal experts		Lay experts				Formal experts		Lay experts	
	Total	% Total	No.	%	No.	%	Total	% Total	No.	%	No.	%
0 year	17	8.6	12	30.0	5	3.2	17	8.3	14	27.5	3	1.9
< 6 yrs	36	18.2	16	40.0	20	12.7	55	26.7	17	33.3	38	24.5
6 - 10 yrs	26	13.1	5	12.5	21	13.3	22	10.7	7	13.7	15	9.7
11 - 20 yrs	32	16.2	6	15.0	26	16.5	33	16.0	13	25.5	20	12.9
21 - 30 yrs	34	17.2	1	2.5	33	20.9	28	13.6	0	0.0	28	18.1
> 30 yrs	53	26.8	0	0.0	53	33.5	51	24.8	0	0.0	51	32.9
Total	198	100.0	40	100.0	158	100.0	206	100.0	51	100.0	155	100.0

Age

	Ban Don Bay						Phangnga Bay					
			Formal experts		Lay experts				Formal experts		Lay experts	
	Total	% Total	No.	%	No.	%	Total	% Total	No.	%	No.	%
< 21 yrs	4	2.0	1	2.4	3	1.9	15	7.2	0	0.0	15	9.6
21 - 30 yrs	58	29.0	2	4.9	56	35.2	68	32.7	14	27.5	54	34.4
31 - 40 yrs	73	36.5	16	39.0	57	35.8	72	34.6	16	31.4	56	35.7
41- 50 yrs	43	21.5	18	43.9	25	15.7	32	15.4	15	29.4	17	10.8
51 - 60 yrs	16	8.0	4	9.8	12	7.5	16	7.7	6	11.8	10	6.4
> 60 yrs	6	3.0	0	0.0	6	3.8	5	2.4	0	0.0	5	3.2
Total	200	100.0	41	100.0	159	100.0	208	100.0	51	100.0	157	100.0

were female. The percentage of female respondents in Phangnga Bay was higher at 32%. Almost half of the formal experts (46% in Ban Don Bay and 43% in PB) had a bachelor's degree, while a large percentage of layexperts (36% in Ban Don Bay and 30% in Phangnga Bay) finished only four years of school. The average number of years that respondents lived in the study area was 20 for Ban Don Bay and 18 for Phangnga Bay. In both study areas, the layexperts had lived in the area much longer than the formal experts (24 years versus 5 years in Ban Don Bay and 22 years versus 6 years in Phangnga Bay). The average age of respondents was 37 years in Ban Don Bay and 35 years in Phangnga Bay. In both study areas, the formal experts were on average older than the layexperts (41 years versus 36 years in Ban Don Bay, and 39 years versus 34 years in Phangnga Bay).

Scale values were calculated using Dunn-Rankin's method based on responses from respondents in different gender, education, years lived in the area and age groups. The results were summarised in Appendix II. In general, none of these attributes had a significant effect on the rankings of the importance of the resource losses and activities in Ban Don Bay and Phangnga Bay. The agreement in the scale values and the correlation coefficients of the rankings among respondents with these different characteristics were significant (α = 0.05) (Appendix III). Nevertheless, the Kruskal-Wallis test suggested that the scale values of some resource losses and activities differed among certain groups of respondents with different gender, education and years lived in the area (Appendix IV). Age was the only characteristic of the respondents that did not produce significant differences in the scale values.

Table 5.22 summarises the resource losses and activities whose scale values differed among groups of respondents, based on Kruskal-Wallis test. In Ban Don Bay, the

Table 5.22 Pairs of respondent groups whose rankings differed significantly at alpha level 0.05 (Kruskal-Wallis test).

Ban Don Bay, resource losses

Clear-cutting of mangrove forests (MF2)

No. of years	0 year < 6 yrs	vs.	11-20 yrs

Phangnga Bay, resource losses

Partial damage to sandy beaches (SB1)

Gender	male formal	vs.	female lay male lay
Education	doctoral bachelor diploma	vs.	grade 4
No. of years	< 6 yrs	vs.	> 30 yrs

Severe damage to sandy beaches (SB2)

Gender	female formal	vs.	female lay male lay
Education	doctoral diploma	vs.	grade 4
No. of years	< 6 yrs	vs.	> 30 yrs

Severe damage to seagrass beds (SG2)

Gender	male formal	vs.	female lay

Table 5.22 (Continued)

Ban Don Bay, activities

Shrimp farming, 25 rai, no clear-cut (SHRIMP1)

Gender	male formal	vs.	female lay
			male lay
Education	bachelor	vs.	junior high
			grade 4
	diploma	vs.	grade 4
No. of years	< 6 yrs	vs.	11-20 yrs
		vs.	> 30 yrs
	6- 10 yrs	vs.	11-20 yrs

Shrimp farming, 100 rai, no clear-cut (SHRIMP2)

Education	bachelor	vs.	junior high
No. of years	< 6 yrs	vs.	22-30 yrs
	6-10 yrs	vs.	22-30 yrs

Housing, 100 units, no clear-cut (HOUSE2)

Gender	male formal	vs.	female lay
			male lay
Education	bachelor	vs.	junior high
			grade 4

Housing, 100 units, clear-cut (HOUSE3)

Gender	male formal	vs.	female lay
			male lay
Education	bachelor	vs.	junior high
No. of years	6- 10 yrs	vs.	11-20 yrs

Phangnga Bay, activities

Shrimp farming, 50 rai, clear-cut (SHRIMP3)

Education	master	vs.	grade 4

Hotel, 75 units, sewage, no clear-cut (HOTEL1)

Education	bachelor	vs.	grade 4

Oil spill, 200,000 litre (OIL2)

Gender	male formal	vs.	male lay
Education	master	vs.	high school
			junior high
			grade 4

significant difference in the scale values occurred between respondents who either did not live in the area (scale value 84.87) or who lived in the area for no more than 5 years (scale value 79.37) and those who lived there for 11 to 20 years (scale value 58.04).

Different results were found in Phangnga Bay where scale values of resource losses of relatively small importance, such as the partial and severe damage to sandy beaches, differed among respondents with different gender, education and number of years lived in the area (table 5.22). Female and male formal experts generally agreed in the rankings of the importance of resource losses in Phangnga Bay. A similar result was found between female and male layexperts. However, both female and male formal experts differed in their judgments from female and male layexperts. The scale values for the damages to sandy beaches given by female and male formal experts were generally lower than those indicated by female and male layexperts (Appendix II A).

Education also played a role in the rankings of resource losses in Phangnga Bay where respondents with four years of education differed significantly from those with higher education. In the two loss scenarios related to sandy beaches, the scale values assigned by layexperts with grade 4 level of education were higher than those given by respondents of higher education (Appendix II B).

The number of years lived in the area seemed to affect the scale values for the damages to sandy beaches in Phangnga Bay. Respondents who had been living in the area for less than six years considered these damages to be of lower importance than those who lived in the area for more than 30 years (Appendix II C).

The degree of disagreement in the scale values was greatest in the case of impacting activities in Ban Don Bay. The disparity in the scale values were found in the two shrimp farming activities in Ban Don Bay that involved no clear-cutting of mangrove forests (SHRIMP1, SHRIMP2), as well as in the two housing activities (HOUSE 2, HOUSE 3). The difference was related to gender, education and number of years lived in the area (table 5.22). The scale values given to the two shrimp farming activities given by male formal experts were lower than those indicated by both female and male layexperts. The opposite was found when considering the two housing activities, HOUSE 2 and HOUSE 3 (Appendix II A). The pattern of disparity between the scale values of these four activities given by respondents with bachelor's degree and those with no more than junior high school, was the same as in the case of gender difference. In general, those who lived in the area longer tended to put a higher importance to the impact of shrimp farming activities that involved no clear-cutting. On the contrary, those who lived in the area for a shorter period of time indicated a higher scale value for housing project involving clear-cutting than those who had lived there for a longer amount of time.

The difference in the scale values of impacting activities in Phangnga Bay involved shrimp farming with clear-cutting (SHRIMP3), hotel development with sewage and no clear-cutting (HOTEL1) and 200,000 litre oil spills (OIL2) (table 5.22). While male formal experts considered oil spills to be most important, male layexperts ranked that type of event below hotel development and shrimp farming activities that involved clear-cutting. Education seemed to be another attribute contributing to the difference in the scale values. The level of importance that the respondents with four years of education assigned to shrimp farming with clear-cutting was higher than that given by respondents with master degrees. However, they indicated a higher scale value to HOTEL 1 than respondents with bachelor's degree. As for oil spill, while respondents with M. Sc. degrees considered such incidents to be of high importance, respondents with lower education levels put significantly lower importance to the events.

In conclusion, some disparity was observed in the judgments of the importance of resource losses and activities provided by respondents with different gender, education level and number of years lived in the study areas. However, these findings did not present a problem in terms of the reliability of the scales of relative importance based on all respondents. Rather, they implied that certain additional considerations might be required when dealing with some of the resources and activities in which respondents differed in their judgments.

5.6 The intensity of importance and the interval scale of impacting activities

The analysis of paired comparison data by Dunn-Rankin's method, as used in this study, relied on the linear transformation of ordinal measurement of importance of objects into an interval scale ranging from 0 to 100 (Dunn-Rankin, 1983). The zero point on the scale is an arbitrary origin, as in the zero point on the Celsius scale, and not the true zero point of a ratio scale. However, the ordering of the objects is preserved with this transformation, and thus no information on the relationship among objects is lost.

On this interval scale, object *A* with a scale value of 80 is considered to be more important than object *B* with a scale value of 40. Similarly, object *B* is considered to be more important than object *C* with a scale value of 20. While it is not possible to conclude that object *A* is twice as important as object *B*, or object *B* is twice as important as object *C*, it can be stated that the difference in the scale value between *A* and *B* (40) is twice as large as the difference between *B* and *C* (20). In other words, the level of intensity of importance can be indirectly determined.

Alternatively, the level of intensity of importance may be obtained from the responses to an additional question. As in Part III of the questionnaire, apart from choosing which activity was more important, respondents were asked to indicate how much more important that chosen activity was, in comparison to the other one in the pair. This section explores the possibility of incorporating this additional information into the importance scales of activities already constructed for Ban Don Bay and Phangnga Bay.

5.6.1 Theoretical background

In this study, the respondents were asked to indicate how much more important the selected activity was, by choosing one of four levels, i.e. nearly equally important, slightly more important, more important, and much more important. These levels were converted into numerical values and scale values were developed using the framework of a scaling method called Analytic Hierarchy Process or AHP (Saaty and Kearns, 1985).

The Analytic Hierarchy Process is a procedure for dealing with complex technological, economic, and socio-political problems, using a systematic procedure for representing the elements of such problems in form of a hierarchy (Saaty and Vargas, 1991; Saaty and Kearns, 1985). It utilises the paired comparison method in presenting alternatives to decision-makers who express their judgments in terms of relative importance. These judgments are translated into numbers, then synthesised to provide preference weights for each alternative.

Unlike the general use of AHP in multi-criteria decision analysis, the application of AHP in this study was limited to only one decision level, where the objective was to select the most important alternatives (in this case, coastal activities). No information about the criteria or the decision modes used to produce the judgments was considered. Thus, only the description of the method pertaining to this study, as well as its adaptation to the current work, is discussed.

The AHP uses a scale of 1 to 9 to represent the intensity level of relative importance. '1' refers to equal importance and '9' means extreme importance. Instead of using the numerical scale, the study used words (nearly equal, slightly more, more and much more important). The first task was therefore to convert these verbal scales into numerical scales. Two sets of scales were arbitrary chosen in this study and later tested for their appropriateness, i.e. (1) 1.5, 3, 5 and 7 and (2) 2, 4, 6 and 8, to represent nearly equal, slightly more, more and much more important, respectively.

Data obtained from the paired comparison questions were entered in a judgment matrix similar to the Dunn-Rankin method. For example, when an activity *A* was considered to be 'slightly more important' than activity *B*, the intensity level 3 (based on the first scale) was recorded in the column activity *A* preferred to the row activity *B* (table 5.23). Note that the corresponding cell (column *B*, row *A*) took a reciprocal value (1/3), instead of 0 as in Dunn-Rankin's method. In the comparison between *B* and *C*, in this example, *C* was considered to be 'slightly more important' than *B*, '1/3' was thus entered in that cell (column *B* row *C*),

Table 5.23 Example of analysis of paired comparison data using AHP framework.

Pairs		Preference	Intensity
A	*B*	*A*	slightly more important
A	*C*	*A*	nearly equal
A	*D*	*A*	more important
B	C	*C*	slightly more important
B	*D*	*B*	much more important
C	*D*	*C*	slightly more important

	A	*B*	*C*	*D*
A	1	1/3	1/1.5	1/5
B	3	1	3	1/7
C	1.5	1/3	1	1/3
D	5	7	3	1
Geometric mean	2.178	0.939	1.565	0.312
Priority weights	0.436	0.188	0.313	0.063

λ_{max} = 4.295
C.I. = 0.098
CR = 0.109

and '3' was the value in the corresponding cell. The diagonal value was '1', representing the equality of an item in its self-comparison.

From this square reciprocal matrix, the geometric mean was calculated as an approximation of the priority vectors (Saaty and Kearns, 1985). This was done by first multiplying the elements in each column and taking their k^{th} root where k was the number of elements (e.g. k = 4 in table 5.23). The normalisation of this result, which gave the estimate of a vector of local priorities, was obtained by dividing each component of the geometric mean by its sum. In this study, these priorities directly indicated the importance weightings of each item in the paired comparisons given by an individual respondent.

Consistency of the local priorities can be assessed using a consistency index (Saaty and Kearns, 1985). This index was calculated by first multiplying the sum of the first row in the judgment matrix by the value of the first component of the normalised priority vector. The same multiplication was taken of the second row by the second component and so on. The resulting numbers were added up to yield a value denoted by λ_{max}. The consistency index (*C.I.*) was thus:

$$C.I. = (\lambda_{max} - k) / (k - 1) \qquad (5.1)$$

where k was the number of elements or objects in the comparisons.

This value was compared with average consistency that could occur at random for any paired comparison choices. The consistency index was divided by the random consistency number for the same size matrix to obtain the inconsistency ratio. The acceptable value of this ratio should be less than 20% and preferably less than 10% (Saaty and Kearns, 1985).

When more than one respondent was involved in the decision making process, their responses to paired comparison questions could also be aggregated by the geometric mean. These mean values were then used to represent the judgment for the whole group of respondents and the analysis was performed as in the case of one individual described above.

5.6.2 The level of intensity of importance based on the analysis of data using AHP

Only the responses from formal experts of Ban Don Bay and Phangnga Bay are presented here, as they were more complete than the responses from layexperts. The analysis showed that the priority weights from the two scales were similar and the ranking of the activities was identical (table 5.24). As the deviation from consistency obtained when using scale 1.5, 3. 5, and 7 was smaller than when using the other scale (smaller inconsistency ratio), the priority weights calculated using this set of scales was selected to develop the AHP scale of relative importance.

The priority weights were used to construct the scale value of relative importance of activities for Ban Don Bay and Phangnga Bay, as seen in table 5.24. The activity with the highest interval scale value was used as a reference point of conversion of other subsequent activities. The AHP scale values were highly correlated with the scale values obtained from Dunn-Rankin's method (correlation coefficient equalled 0.9594 for Ban Don

Table 5.24 Priority weights of activities in Ban Don Bay and Phangnga Bay based on responses from formal experts.

Ban Don Bay

Activity	Priority weights				Dunn-Rankin***		AHP	
	Scale 1*	Rank	Scale 2**	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	0.033	8	0.028	8	12.62	8	10.70	8
Shrimp farming , 100 rai, no clear-cut	0.066	6	0.061	6	36.88	6	21.40	6
Shrimp farming , 100 rai, clear-cut	0.249	1	0.256	1	80.73	1	80.73	1
Housing, 50 units, no clear-cut	0.049	7	0.043	7	26.25	7	15.89	7
Housing, 100 units, no clear-cut	0.086	4	0.084	4	47.51	5	27.88	4
Housing, 100 units, clear-cut	0.224	2	0.232	2	77.08	2	72.63	2
Oil spill, 20,000 litre	0.084	5	0.078	5	48.17	4	27.23	5
Oil spill, 200,000 litre	0.210	3	0.219	3	70.76	3	68.09	3
Inconsistency ratio	0.058		0.078					

Phangnga Bay

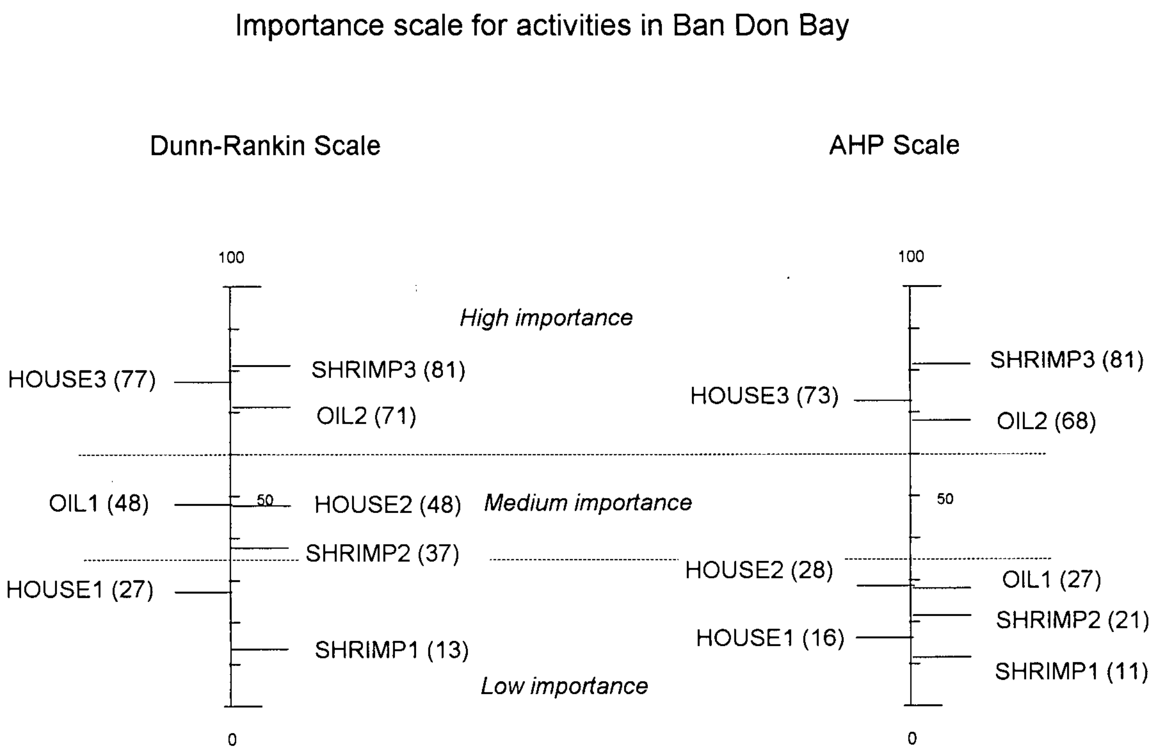
Activity	Priority weights				Dunn-Rankin***		AHP	
	Scale 1*	Rank	Scale 2**	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	0.041	7	0.035	7	18.68	7	12.04	7
Shrimp farming , 50 rai, no clear-cut	0.062	6	0.058	6	35.71	6	18.20	6
Shrimp farming , 50 rai, clear-cut	0.171	3	0.170	3	71.15	3	50.20	3
Hotel, 75 units, sewage, no clear-cut	0.029	8	0.025	8	9.62	8	8.51	8
Hotel, 75 units, no sewage, no clear-cut	0.077	5	0.072	5	43.41	5	22.60	5
Hotel, 75 units, no sewage, clear-cut	0.214	2	0.224	2	79.40	2	62.82	2
Oil spill, 20,000 litre	0.114	4	0.111	4	56.32	4	33.46	4
Oil spill, 200,000 litre	0.292	1	0.306	1	85.71	1	85.71	1
Inconsistency ratio	0.057		0.073					

* nearly equal =1.5, slightly more important = 3, more important = 5, much more important = 7
** nearly equal = 2, slightly more important = 4, more important = 6, much more important = 8
*** Dunn-Rankin (a) is the interval scale values adjusted by the ratio scale

Bay and 0.9438 for Phangnga Bay). Gorter (1997) also reported high correlation coefficient between the AHP scale and the Dunn-Rankin's scale in his study of various environmental losses.

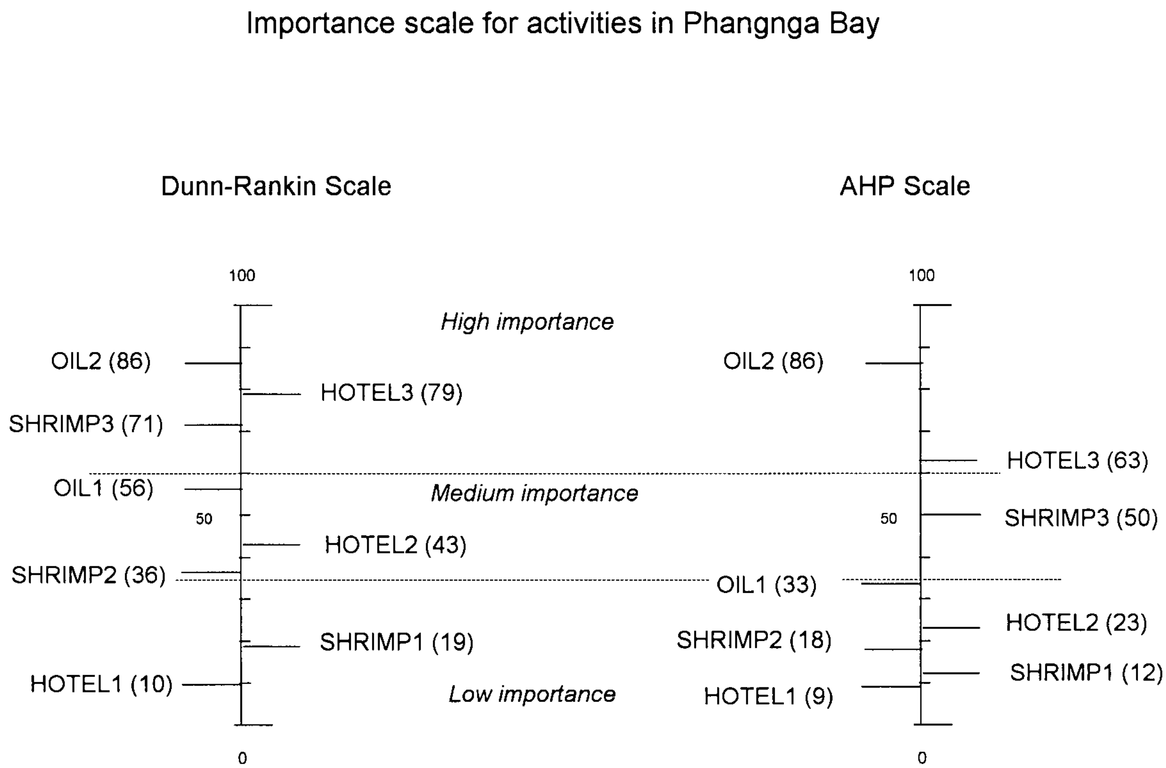
Despite the high correlation, there were some remarkable differences between these two sets of scale values, as observed when constructing the scale of relative importance. As seen in figure 5.6, the top three important activities in Ban Don Bay were comparable in the two scales. However, the rest of the activities in the AHP scale were with very low scale values. The largest change in the scale value was for housing, 100 unit, with no clear-cut (HOUSE2), whose scale value was 48 in Dunn-Rankin's scale and was only 28 in the AHP scale. In Phangnga Bay, the largest difference in the two scales was in the scale value of hotel, 75 units, with no sewage, involving clear-cutting (HOTEL3) (79 using Dunn-Rankin's method and 63 using AHP) (figure 5.7).

It cannot be concluded in this study which interval scale of importance was more reliable. In theory, the AHP scale should provide a more accurate indication of relative importance of activities, as it was developed based on direct responses about the magnitude of importance. However, the derivation of the AHP scale in this study was subject to some constraints, such as the arbitrary application of the numerical scale (1.5, 3, 5, 7), the use of four levels of intensity instead of nine and the restriction on tied observations.



SHRIMP1 = Shrimp farming, 25 rai, no clear-cut
SHRIMP2 = Shrimp farming, 100 rai, no clear-cut
SHRIMP3 = Shrimp farming, 100 rai, clear-cut
HOUSE1 = Housing, 50 units, no cut
HOUSE2 = Housing, 100 units, no cut
HOUSE3 = Housing, 100 units, clear-cut
OIL1 = Oil spill, 20,000 litre
OIL2 = Oil spill, 200,000 litre

Figure 5.6 Activity scale for Ban Don Bay based on the scale values from Dunn-Rankin's method and AHP procedure



SHRIMP1 = Shrimp farming, 25 rai, no clear-cut
SHRIMP2 = Shrimp farming, 50 rai, no clear-cut
SHRIMP3 = Shrimp farming, 50 rai, clear-cut
HOTEL1 = Hotel, 75 units, sewage, no cut
HOTEL2 = Hotel, 75 units, no sewage, no cut
HOTEL3 = Hotel, 75 units, no sewage, clear-cut
OIL1 = Oil spill, 20,000 litre
OIL2 = Oil spill, 200,000 litre

Figure 5.7 Activity scale for Phangnga Bay based on the scale values from Dunn-Rankin's method and AHP procedure

CHAPTER 6

Discussion of the Damage Schedule Approach

Since this study provided the first test of the damage schedule approach in an actual field situation, dealing with its validity, reliability and its usefulness for policymaking is important. This chapter addresses some of the major concerns in developing the approach and provides a critical assessment of the method. The discussion on the appropriateness of using the damage schedule in the management of natural resources and environmental assets is covered in Chapter 8.

6.1 Paired comparison method and questionnaire design

The paired comparison method was used in this study as a simple and straightforward instrument to obtain the relative importance of natural resources and environmental assets. As suggested by David (1988), the method is appropriate when it is not possible to make absolute measurements in order to decide which of the two items is preferable. Respondents were asked to provide subjective judgments on the relative importance of the losses and activities under consideration. This task was less demanding than asking them to indicate the importance using a specified unit of measurement. In particular, when the choices were complicated and less familiar to some respondents, presenting them in pairs minimised the effort in making the judgments, as respondents considered only two items at a time. As noted by Nunnally and Bernstein (1994), people are better, or more consistent, at making comparative responses than absolute responses. The ease in making paired comparisons, as opposed to giving more precise responses, was also acknowledged by Magat et al. (1988).

Although the method of paired comparison may be appropriate in a study involving natural resources and environmental assets, many studies have shown that the choice of method used to elicit preference can influence the values indicated by respondents (Magat et al., 1988, Tversky et al. 1988, Gregory et al., 1993, Sunstein, in press). Apart from the paired comparison method, other methods such as contingent valuation (CV) and contingent ranking may be used. In this study, a similar approach to contingent valuation was used in Part II of the questionnaire, as detailed in Chapter 7. Contingent ranking was not used because it is more difficult to compare simultaneously several alternatives than to perform a series of pair-wise comparisons (Magat et al., 1988).

For all respondents, it was the first time they were asked to complete a questionnaire containing paired comparison questions. This could bring about both positive and negative effects. Many respondents felt it was privilege to be among the 'selected few' to complete such an extraordinary questionnaire. They put an obvious amount of effort into answering the questions, despite the length and complexity of the questionnaire. One drawback was that the respondents were not familiar with this type of questionnaire and found it more complicated to answer than a common form of questionnaire. Respondents spent on average 45 minutes completing the questionnaire and some reported difficulty maintaining their concentration for this length of time.

As with CV methods, formulating the questionnaire using the method of paired comparison opens the results to certain biases, such as strategic bias and hypothetical bias. The questionnaire was revised several times during pretests as an attempt to minimise contextual effects. The aim was to ensure that the questions appeared to be neutral and did not lead the respondents to think that the enumerators were looking for particular answers. The fact that there was no presupposed hypothesis about which resource loss or which activity should be considered most important helped minimise the bias in formulating the questions. Furthermore, the use of all possible pairs for comparisons and the random ordering of the pairs and of each item in the pairs (left and right position) generated a sense of equality in the importance to all the choices presented. Rosenberger and Peterson (unpublished) support the notion that randomisation should result in independence of choices and that no framing or anchoring biases should occur.

In Part IV of the questionnaire, respondents were asked to express their opinion about the status of the coastal resources. The majority of the respondents (at least 80% of total) agreed that coastal resources of Thailand were heavily exploited and degraded (Appendix V). The results suggested that most respondents were aware of the problems relating to the resources in the study areas. The awareness of respondents on these issues could stem from personal experiences and knowledge or could be influenced by media coverage or by information from local non-governmental organisations. Some biases may occur if the judgments were based on inaccurate information or misleading personal experiences, as noted by Slovic (1987).

The relationship between mangrove forests and shrimp farming very well demonstrates this point. During the past few years, mangrove forests were destroyed for different purposes, such as shrimp farming, coastal aquaculture, and urban development. However, shrimp farming activity received the strongest criticism, both by local conservation groups and worldwide. Reforestration of mangrove forests was promoted in many coastal areas and the general awareness of conservation of natural resources has increased (S. Ratanasermpong, pers. com.). It was possible that the respondents expressed their judgment based on the social and political movement at the time, to avoid appearing ignorant or uncaring. In such cases, the interpretation of the results should be based on the fact that the responses, although they reflected people's real judgments and values, may be influenced by media coverage and information provided by different interest groups.

However, when comparing the resulting importance scales of the two study areas, it appeared that media coverage did not have any significant effect on the responses relating to mangrove forests and shrimp farming. While the respondents in both coastal areas were exposed to the same media coverage about the importance of mangrove forests and the impacts of shrimp farming on the ecosystem, only the respondents in Ban Don Bay considered shrimp farming involving clear-cutting of mangrove forests to be the most impacting activity. Phangnga Bay respondents, although considering the loss of mangrove forests to be very important, ranked hotel development that involved clear-cutting of mangrove forests to be more important than shrimp farming.

As the respondents were asked to complete the questionnaire on their own, instead of being interviewed, there was less incentive to misrepresent a response in an attempt to make a more favourable impression on an enumerator. The enumerators were present during the survey only to provide explanations as needed. The completed questionnaires were collected and immediately sealed in an envelope. Respondents should have felt reasonably comfortable in expressing their judgments and opinions as their identities were kept anonymous and no sensitive questions, such as income level, were asked.

The resource loss and the activity scenarios were hypothetical but realistic. Clear-cutting of mangrove forests occured in the study areas, as well as damages to other coastal resources. Respondents were familiar with the activities presented in the questionnaire and could relate to them on pragmatic grounds. The resource losses and activities were not framed such as to suggest any preference for one over another and thus contextual effects should be minimal.

The major concern in using the questionnaire as an instrument in this study is related to the amount of information provided to respondents and the description of the items to be compared (information bias). As shown by Carson (1991), the amount of information provided to respondents does influence the responses. To ensure that the respondents made informed judgments, they were provided with a table summarising the resources, their general importance as habitats, and some possible causes of damages to these resources. Moreover, for each resource loss, information about the level of productivity and the recovery period were given (see Appendix I). This information was presented to convey to all respondents the same understanding of the items under consideration. The level of productivity as a result of partial damage and severe damage to a resource was explicitly stated. Thus the respondents did not have to make their own interpretation of the word 'partial' or 'severe'. Recovery periods, based on scientific findings, were added for clarification to the extent of seriousness of each loss. The pretests showed that adding this information was useful in explanation of the kind of losses referred to in the study.

The term 'importance' was chosen as a generic word in this study merely to represent a measurement unit of the losses and activities. The direct translation of the Thai word used in the questionnaire was 'severity' for the losses and 'great impact' for the activities. The explanation and the sample questions at the beginning of the questionnaire were precise and adequate that no semantic confusion should have occurred.

The final point about the use of the paired comparison method and the questionnaire design is related to the allowing of ties in the choices. In this study, the respondents were asked to choose one item even if they felt that the two items were very close. As noted by Rosenberger and Peterson (unpublished), forcing a choice maximises discernment of difference while revealing indifference stochastically. Although the respondents were not allowed to declare a tie, the indifference in the choices appeared as equal preference scores for items, as in the case of intransitive responses.

The design of the questionnaire in a form of a half-sheet booklet was considered to be effective, especially the number of pairs was minimised, with only one pair on each page. Nevertheless, the questionnaire was demanding in terms of time and concentration. An alternative design is to use photographs as stimuli, which may provide a higher degree of cooperation from respondents and more consistent results (Collier, 1957 in Peterson et al. (1973)).

Two methods were used to conduct the survey: on-the-spot survey and drop-off questionnaires. Using two different methods would unavoidably cast some doubts on the reliability of the results, especially since the identity of the person who actually completed the questionnaire was unknown in the case of the drop-off survey. However, It was not possible to control this factor because of time limitations. The only layexperts for which the drop-off method was used were those involved in tourism in Phangnga Bay. The study shows, however, that this group of layexperts did not differ significantly from the rest (tables 5.9, 5.10, 5.13 and 5.14). The drop-off method was also used for all formal experts. It was less likely, however, that the formal experts would pass the questionnaire to someone else. Although not tested, it seems possible that the results of the paired comparison data would not change significantly if formal experts were asked to complete the questionnaire on the spot. Giving formal experts more time to answer the questions should not affect the answers since it was assumed that they already had sufficient amount of knowledge to provide subjective judgments.

6.2 Intransitivity issue

It is well recognised that intransitivity could occur in the paired comparison study. David (1988) suggested that when people were asked to make a choice between two items, they mentally constructed some function of the relevant characteristics and used it as a basis for comparison. When the function is vague, it is possible that it may change from one paired comparison to the next. Moreover, when different pairs are compared, the judges may focus their attention on different features of the objects (David, 1988). Although in this study, intransitivity was considered to have very little impact on the rankings and the scale values of the relative importance of the resource losses and activities, it is still desirable to try to minimise the number of intransitive responses.

In this study, the specification of resource losses seemed to play an important role concerning intransitivity. In Ban Don Bay, a higher percentage of intransitive choices was observed, when compared to Phangnga Bay (table 5.2). Most of the intransitive choices were associated with the comparisons involving mangrove forests. It was found during the survey of Ban Don Bay that some respondents were confused about the meaning of the word 'clear-cutting'. They considered it to be less important than severe damage to mangrove forests because they felt that clear-cutting involved the use of the forests and thus certain benefits were obtained. In Phangnga Bay study, the description of clear-cutting of mangrove forests was rephrased to emphasise the actual loss that occurred and, as a result, the number of intransitive responses decreased.

Another common cause for intransitive choices is the similarity of the objects for comparisons. When two objects are very similar, it is possible that one is preferred to another in one instance, but the opposite may be found in another. This is likely to be the case in Ban Don Bay, but not in Phangnga Bay. As shown in figures 5.2 and 5.3, the spread of the eight resource losses was wider in Phangnga Bay than in Ban Don Bay. This suggests that the resource losses presented for comparisons in Ban Don Bay were more similar than in Phangnga Bay, as is supported by the results of the critical range analysis. Consequently, there were higher percentages of intransitive choices in Ban Don Bay. Another possible explanation for a higher degree of intransitivity in Ban Don Bay was that the four resources selected could be considered to have overlapping boundaries. For example, shellfish culture grounds can be perceived to be part of the mudflats. On the contrary, there was a clear geographical boundary between sandy beaches and coral reefs in Phangnga Bay.

The familiarity of choices for comparisons is another factor affecting transitivity of the responses. This can be seen in the difference in the number of intransitive choices between Part I and Part III (table 5.2). In general, respondents made fewer inconsistent choices when comparing activities with which they were familiar and could easily relate to, than when comparing resource losses.

It is not possible, in this study, to determine whether intransitive responses occurred because of simple errors by respondents. By using a paired comparison software to conduct and analyse the survey, some errors could be detected and avoided, as shown by Peterson and Brown (in press) and Rosenberger and Peterson (unpublished). Both studies allowed respondents to change their answers if they were found to be inconsistent. The software also randomly selected some consistent and inconsistent pairs for respondents to repeat to see if there was a switch in preferences. Peterson and Brown (in press) found that intransitivities were not systematic and most of them were due to simple mistakes. About 61% of the inconsistent choices were switched on repeat choices and 9% of consistent choices were switched in repeat choices. The use of computers was not an option in this field study since most layexperts were not computer literate.

Intransitivity is sometimes viewed as an error of judgment or reasoning. The study by Tversky (1969) revealed that people believed they should be transitive and thus would modify their choices according to the transitivity principle. In actual decisions, intransitivity may not be encountered because a choice is normally eliminated as the decision is made. For example, if y is preferred over x and z over y, a person is typically committed to z, without comparing it to x.

In short, it is not irrational to be intransitive. Intransitivity could be attributed to momentary fluctuations or random variability, as suggested by Tversky (1969). People could be indifferent to choices because they feel that it does not seem meaningful to compare them in the way presented (Fishburn, 1970). Or they may find the choices comparable but do not feel that one is clearly more preferable to the other, based on their experience and information. Because of the non-systematic nature of intransitivity, intransitive responses were kept to preserve the random variation in data set, as also done in Rosenberger and Peterson (unpublished).

The issue of intransitivity relates closely to the way people make judgments, choices or state their preferences. Classical theory of preference assumes that each individual has a well-defined preference order (or a utility function) and that different methods of elicitation produce the same ordering of options, a so-called procedure invariance (Tversky et al., 1988). Studies have shown, however, that it is neither generally true that people have a well-defined preference order nor it is necessary to satisfy the invariance requirement (Tversky et al., 1988; Kahneman and Tversky, 1984). Preferences can be a product of procedure, description, and context at the time of a choice and can depend on the choice set within which they are presented (Tversky et al. 1988).

When faced with complex multidimensional alternatives as in this study, it is extremely difficult to properly utilise all available information. Instead, it may be that people employ various approximation methods that enable them to process the relevant information in making a decision (Tversky, 1969). For example, they could be selecting an option that is superior on the more important attribute (Tversky et al., 1988).

Nunnally and Bernstein (1994) suggested that when making judgments, it could be assumed that there was a correct response and judgments tended to be cognitive, involving 'knowing'. On the contrary, choices involve preferences and feeling, which cover personal reactions, interests, attitudes, values, likes and dislikes (Nunnally and Bernstein, 1994). The main purpose of this study was to obtain judgments since it required some 'knowing' about the items being considered. However, in making their judgment, it was possible that respondents expressed also their preferences and feelings. Thus, the study could be considered as a combination of both judgments and choices, which could be intransitive but yet rational.

6.3 Choice of respondents: formal experts or layexperts?

In a study of a complex natural resource system, it is important that respondents of the paired comparison questions have a good understanding of the system. Thus, formal experts are usually asked to provide rankings based on their expertise and experiences. This study, however, included layexperts as respondents, based on the belief that layexperts' judgments on the relative importance of resources reflected community values which should be taken into account in management decisions and in the design of policy responses.

In this study, a test of discrepancy in the rankings and the scale values between formal experts and layexperts was performed. The results showed that layexperts were able to provide consistent rankings, which were the equal of those of formal experts, despite the concern that they may not have enough information to make such judgments. Layexperts also agreed among themselves as much as the formal experts did, as shown by the significant Kendall u values. More importantly, the rankings of relative importance of resource losses and impacting activities of formal experts and layexperts were highly correlated (rank order correlation coefficient, Kendall T, was highly significant at $\alpha = 0.01$, tables 5.8, 5.10, 5.12 and 5.14).

A slight difference in the judgments between formal experts and layexperts was revealed by the Kruskal-Wallis test. For Ban Don Bay, the two groups were in agreement in the rankings of the relative importance of resource losses, but not so concerning shrimp farming and housing development activities (table 5.18). The opposite was found in Phangnga Bay where they agreed more about the activities but less in the ranking of importance of damages to sandy beaches and seagrass beds (table 5.16).

In Ban Don Bay, formal experts and fishers, in particular, differed in their judgment about the two shrimp farming activities that did not involve clear-cutting of mangrove forests (SHRIMP1, SHRIMP2), and in the two housing activities (HOUSE2, HOUSE3) (table 5.18). In general, shrimp farming activities were considered to be more important to layexperts than to formal experts, while housing development activities were considered to be more important to formal experts than to layexperts. One possible explanation of this divergence is the difference in the familiarity and the understanding of the actual impact of each activity. Formal experts were well equipped with scientific findings that could lead them to consider shrimp farming to be less impacting than housing development. It is also possible that some of the formal experts might have been involved in promoting shrimp farming and thus were not willing to accept the impact of such activity, though there was no indication of this.

Layexperts could consider shrimp farming to be highly important based on their own experience of the impact of such activity in their coastal water. Their judgments may reflect their personal conflicts with such activities, if they were fishers, or shellfish culturers. At the same time, they could be influenced by the media coverage of shrimp farming. On the other hand, housing development would appear to them to be of a lesser concern, as their impacts might not seem as obvious.

Differences in the rankings of damages to sandy beaches in Phangnga Bay were found between formal experts and layexperts (table 5.16). Although both groups agreed that partial damage to sandy beaches was the least important loss, the scale value of this loss was much lower for formal experts (scale value 6.16) than for layexperts (scale value 17.23) (table 5.9). Layexperts also ranked severe damage to sandy beaches higher in terms of importance than severe damage of seagrass beds, while formal experts did the reverse. As in Ban Don Bay, while layexperts may not possess the scientific information about the importance of seagrass beds, they were very familiar with the sandy beaches as they obtained direct benefits from using the resources.

Another point of concern is related to the general opinion that respondents from different occupation groups may give rankings that reflect their own self-interest, rather than reflecting the values to the community as a whole. The results from the rank correlation and critical range analysis showed that, in general, the difference in occupation and personal interests did not influence their judgments. For example, fishers in Ban Don Bay did not rank damages to fishing grounds to be more important than to mangrove forests, although those damages had direct impact on their livelihood (table 5.7). Similarly, shellfish culturers did not consider shellfish culture grounds to be more important than fishing grounds. Examples in Phangnga Bay related to the importance rankings by people in tourism. Rather than giving higher ranks to the resources directly beneficial to their occupation, such as coral reefs and sandy beaches, respondents in tourism considered mangrove forests to be more important than coral reefs, and seagrass beds to be more important than sandy beaches (table 5.9).

In terms of activities, shrimp farmers may be expected to provide judgments in favour of their activities. The results showed that shrimp farmers of Ban Don Bay agreed with the rest of the respondents that shrimp farming with clear-cutting was the most important impacting activity in the area (table 5.11). The rankings based on total respondents indicated that the three levels of shrimp farming activities were considered to be more important than the three levels of housing development. In contrast, the responses from shrimp farmers, which were equivalent to those of formal experts, differed. To shrimp farmers and formal experts, even if no clear-cutting was involved, housing development was considered to be more important than shrimp farming. The judgments from shrimp farmers may have partially indicated their personal self-interest, but not to the extent that the final results were directed in their favour.

Shrimp farmers in Phangnga Bay responded consistently with the other layexpert groups. In fact, the scale value of importance of shrimp farming with clear-cutting was higher than any other groups, except fishers (table 5.13). The rankings of the three hotel activities in Phangnga Bay by people in tourism were also the same as the majority of the respondents.

It can be concluded that both formal experts and layexperts performed equally well in providing the scales of relative importance of different resource losses and impacting activities. This is contrary to what most people expected, including formal experts themselves who tended to believe that they were better judges of scientific research.

When judgments were based on more than 'scientific research', as in this study, informal knowledge from the resource users may become very useful.

Nevertheless, the slight observed difference might be important. It might be necessary to further investigate why those differences exist and how they may affect management decisions. For example, more information about the resources could be provided if the amount of information is suspected to be liable for the disparity. However, it should be noted that the judgments of formal experts could be prone to many of the same biases as those of the general public. This is particularly true when judgments are related to complicated issues, such as environmental values where data are limited. Formal experts, as much as layexperts, may have to rely on their intuition to provide judgments (Slovic, 1987).

Based on this finding, the choice of whether to use formal experts or layexperts or both could thus depend on other factors, such as time and money constraints. Nonetheless, it may be more preferable to include both groups for several reasons. First, the matching of the results from both groups could be used to check for reliability of the data. Second, formal experts may well leave out certain aspects of the issues in consideration, which may be important to the wider community. Finally, it is important to incorporate layexperts in this kind of study, as community involvement is a key aspect to successful management of coastal resources. The inclusion of layexperts is in accord with the use of stakeholder groups in decision analysis (Gregory et al., 1993).

6.4 Reliability and validity of the scales of relative importance

As only relative importance of different losses and activities were obtained in the study, there was no standardised measure that could be used to indicate if the same criteria were employed when respondents were making choices. Respondents may be using different bases to form their judgments and it may not be possible to directly compare their responses. It is therefore difficult to establish any rigorous reliability test on the results. However, the comparative investigation of the two study sites may provide some useful indication of reliability and validity of the damage schedule approach.

Ban Don Bay and Phangnga Bay represented different characteristics of coastal areas. In general, Ban Don Bay is more urbanised and is facing rapid population growth. It is the major area where early development of shrimp farming took place. In the early phase of the activity, shrimp farms were constructed closer to the coastline and mostly involved conversion of mangrove forest areas. Shrimp farming has rapidly expanded during the last 20 years (table 4.1), and has taken over 50% of mangrove forest areas (Rattakul, 1995). At present, conversion of mangrove forests for shrimp farming is no longer a practice for many reasons. First, there are no suitable mangrove forest areas remaining that could be used for such purposes. Second, shrimp farming has been shifted upland (into rubber and oil palm plantations) to avoid crowding and disease outbreak. Finally, non-government organisations and other conservation groups actively criticised shrimp farming as a major cause of mangrove forest destruction. Residents of Ban Don Bay had witnessed the rise and fall of the industry, with small operators being forced out of the business while large investors remained. They became highly aware of the potential impacts of shrimp farming on the coastal environment. This appeared to be reflected in their judgments of the importance of the loss or damage of mangrove forests and the severity of shrimp farming activities.

On the contrary, Phangnga Bay has been developed into a tourist destination, with white sandy beaches and beautiful coral reefs. Coral reefs in Phangnga Bay are considered to be one of the most pristine reefs in the region. Ecotourism also plays a major role in the economy of the area. Tourists are taken in canoes to mangrove forests for nature viewing. The importance of mangrove forests as well as other resources attracting tourism, such as coral reefs, were thus well recognised and were reflected in the importance scale for resource losses.

Shrimp farming exists in Phangnga Bay but on a very small scale compared to Ban Don Bay. In 1993, the total shrimp farm area in Krabi Province, Phangnga Bay was 6,665 rai, about one-sixth that of Ban Don Bay (Charuppat and Ongsomwang, 1995). It seemed natural then for respondents in Phangnga Bay to consider hotel development, which is directly related to tourism activities, to be more important than shrimp farming.

The above analysis demonstrates that the scales of relative importance appear to successfully capture the difference in the characteristics of the study areas. The reliability of these scales is examined based on several sensitivity analyses performed on the paired comparison data. In general, the scale values and the rankings of resource losses and activities did not differ significantly at $\alpha = 0.05$ when comparing across respondents with different attributes, such as gender, education, the number of years lived in the area and age (Appendix II). The robustness of the scales of relative importance shows a high degree of reliability of the approach that it is not contingent on the characteristics of respondents.

Although it is not possible to externally validate the resulting importance scales, several observations could be made that might give further credence to the use of this approach. The study included two levels of each resource losses and three levels of activities (except oil spills with only two levels). Respondents were able to rank the relative importance of these losses and activities consistently with the level of damages. That is, partial damage was considered to be less important than severe damage in all cases of the resource losses. Similarly, smaller size activities were ranked lower in terms of their impacts than larger size activities.

In this study, loss (or consequence) and activity (or cause) were independently evaluated. This is based on the assumption that the importance of a loss should be independent from the causes, or as stated under CERCLA, cause of a damage is irrelevant in legal terms. However, Slovic et al. (1979) showed that people's perception of seriousness of deaths varied with different causes. For example death from nuclear power accidents was considered to be more serious than death from smoking. Gregory et al. (1993) also supposed that individual's willingness to pay to restore a damaged habitat would be affected by the source of the damage. Although not explicitly stated, it is possible that respondents in this study related the loss of the resources to particular causes when making their judgments.

Nevertheless, the results of the study showed that the above assumption, that the loss and activity could be independently evaluated, was valid. As shown in Chapter 5, the two activities in Ban Don Bay and Phangnga Bay involving clear-cutting of mangrove forests were ranked high on the activity schedule and corresponded with the high importance of the loss of mangrove forests. In this case, it did not seem to matter what caused the loss of mangrove forests. Any activity involving clear-cutting would always be considered as having a great impact on the coastal environment. It is notable that respondents must be considering each loss and each activity in its own context of relative importance in order to provide consistent rankings and associated loss and activity schedules.

6.5 Advantages and limitations of the damage schedule approach

The damage schedule approach was presented in this study as an alternative method for capturing the importance of natural resources and environment, without attempting to measure their monetary values. It is simple, straightforward and is flexible in changing circumstances. The initial scales of importance would include a reasonable range of resource losses and activities. Based on these scales, new information could be added to the scales without having to reconstruct them. For example, a new type of loss or the same loss of different magnitude could be incorporated on to the loss scale by interpolating or extrapolating from the existing points. If the new loss *C* is considered to be more important than loss *A* on the scale, but not as important as loss *B* on the scale, it should be placed somewhere between *A* and *B*. The actual position of *C*, in most cases, is not crucial, especially if the distance between *A* and *B* is insignificant according to a critical range analysis. Similar policy responses may be applied to these three resource losses if they are in the same region of importance. The scales of relative importance would become more comprehensive as subsequent losses or activities are incorporated onto the scales.

The damage schedule approach offers a low cost option for policymakers since the decisions could be made based on these schedules rather than through new assessments. The scales of relative importance could be constructed relatively quickly and inexpensively and thus could be revised as often as needed.

The versatile nature of the approach is also found in the use of both formal experts and layexperts as key informants. Because the formal experts and layexperts perform equally well in ranking the importance of the resources, they could both provide information needed for the formulation of the damage schedules. This feature is advantageous when the number of formal experts is limited. At the same time, involving layexperts in this decision-making process increases the potential success of implementation of a resource management programme.

The damage schedule approach relies on the ability of respondents to provide consistent judgments about the relative importance of resources. The study does not engage people in a task that exceeds their capabilities, i.e., it does not ask them to consider unfamiliar and complex issues such as natural resources and environment in quantitative terms, and especially in monetary terms. On the other hand, the choices presented in the questionnaire involved several attributes of resource losses and activities, all of which were relevant to the choices made by respondents. There is no way to determine if respondents considered the importance of the losses based on the specified reduction in the level of productivity or on the recovery period or the combination of both and other considerations. Methods such as multiattribute utility theory (MAUT) and decision analysis try to achieve that.

Gregory et al. (1993) presented an approach, refereed to as MAUT/CV, as a basis for an improved contingent valuation (CV) method. The approach was based on multiattribute utility theory and decision analysis which are systematic procedures designed to assist people in making choices in the presence of conflicting objectives and uncertainty. Similar to the damage schedule, the MAUT/CV uses affected people (or focus groups or stakeholders) to provide the values. Only a small number of people is needed for the study, compared to a typical CV study. Another feature that the damage approach shares with the MAUT/CV is in avoiding willingness to pay as a measure of value. Both approaches ask the right question: how valuable is this? The MAUT/CV differs from the damage schedule in its use of value scale to assess utilities and to calculate the total utility. The approach explicitly lists all attributes of a good or activity that they want to evaluate while the damage schedule approach integrates all attributes into a single dimension of the measurement of importance. The application of the damage schedule approach may thus be limited especially when it is important to maintain all detailed information about the problems. Nonetheless, the damage schedule approach provides a simple framework for the understanding of a complex issue and could complement other sophisticated methods in further investigation of the problem.

As only subjective judgments are obtained using this approach, a careful interpretation of the results is needed. Other factors that might influence people's judgments should be considered, such as people's perceptions concerning the resources, cultural background, and possibly other economic considerations. For example, the responses to Part IV of the questionnaire in this study showed that formal experts and layexperts agreed that nonuse values of resources, such as aesthetic value and option value, were important considerations in resource management. Yet, they differed in their opinion about the resource allocation issues. While most formal experts (about 65%) did not think that priority should be given to activities with the greatest economic returns, about half of layexperts (51% in Ban Don Bay and 45% in Phangnga Bay) agreed that economic return should be used as a basis for resource allocation (Appendix V).

The damage schedules of the coastal environment developed in the present study show potential application in assessing other natural resource and environmental problems. The results of this study, however, do not provide a means to measure whether people's judgments of the importance of the loss and implementation of damage schedule approach would lead to economic efficiency in the allocation of environmental resources. Instead, it offers an alternative that seems likely to provide desired incentives that are consistent with community objectives (Rutherford et al., 1998). In this regard, the damage schedules could be viewed as a useful tool in implementing successful management of natural resources, as will be discussed in the final chapter.

CHAPTER 7

Monetary Estimates of Resource Losses Using the Paired Comparison Method

The paired comparison questions used in this study thus far involved two similar items for comparison, such as two resource losses or two activities. It may be possible, however, to use the method of paired comparisons to obtain judgments about two separate items. Part II of the questionnaire used in this study explored that possibility, by asking respondents to make a choice between a resource loss and a loss of money. The objective was to examine the ability of people to provide this type of judgment, the consistency of their choices, and the agreement of monetary estimates with the scale values.

The chapter first describes the construction of the questionnaire containing the monetary losses, and the method used to analyse the data. The results of the study are reported in the next section, followed by the discussion and the interpretation of the monetary estimates obtained in the study.

7.1 Paired comparison of resource loss and monetary loss

The paired comparison question involving monetary losses is similar to a dichotomous choice contingent valuation question, in its use of monetary amount as a means to indicate the importance of the resource. The difference lies, however, in the structure of the question and the response mode. Rather than addressing respondents with a willingness to pay question, the paired comparison question simply asks them to make a choice between a loss of resource and a loss of money. Therefore, the responses from this study are not directly comparable with the willingness to pay amount obtained from a CV study. The estimated monetary amounts are simply indicative of the relative importance of the resource losses in question.

As in the general usage of the paired comparison method, the number of total possible pairs can be calculated using equation 3.1. However, when monetary values are presented in the comparisons, it is not necessary to include the comparisons between two monetary values. That is, it can be assumed that losing a larger amount of money is always worse than losing a smaller amount.

As described in Chapter 4, the paired comparison questions in this part of the study involved four resource losses and four monetary losses. The total number of pairs that could have been included was 28. After removing the six obvious pairs between the four monetary losses, the number of pairs was reduced to 22. A further reduction was possible as the paired comparisons of the four resource losses were already conducted in Part I of the questionnaire. The final number of paired comparisons was therefore 16.

The four resource losses included in the study of Ban Don Bay were severe damage to mangrove forests, clear-cutting of mangrove forests, partial damage to mudflats and severe damage to mudflats. The two losses involving mangrove forests were also included in Phangnga Bay. The other two resource losses for Phangnga Bay were partial and severe damages to sandy beaches. In both study areas, the four amounts of money for comparisons were 300, 700, 1500 and 3000 Baht. These amounts of money were selected after the pre-tests showed that over this range about half of the respondents chose the money loss over the resource loss while the other half chose the resource loss over the range of money loss included in the questionnaire. The list of the four resource losses and the four monetary losses used in the study, as well as the example of paired comparison questions, are shown in Appendix I.

7.2 Analysis of paired comparison data of resource losses and monetary losses

A slightly different analysis is performed for this set of paired comparison data. Suppose there are four objects, *A, B, C* and *D*, for comparison with four amounts of money, 100, 200, 300 and 400 Baht. Assuming that the four objects have already been compared and the monetary amounts are not to be compared among themselves, the number of pairs for comparisons is therefore 16. These pairs are *A vs 100, A vs 200, A vs 300, A vs 400, B vs 100, B vs 200, B vs 300, B vs 400, C vs 100, C vs 200, C vs 300, C vs 400, D vs 100, D vs 200, D vs 300 and D vs 400.* The results can be tabulated into a square array of a reduced form, as seen in table 7.1. As in the general analysis, when object *A* is preferred to 100 Baht, a count for the column object A and the row money 100 is 1. The corresponding count for the column money 100 and the row object *B* is also 0, although not shown in this table.

Once the data are tabulated, a check of consistency of responses can be done. Based on the responses from one individual in table 7.1 (a), the respondent makes consistent choices in all 16 pairs. For example, when *A* is considered to be more important than 400 Baht (indicating by the count of 1 at column *A*, row 400), for the choices to be consistent, *A* must also be considered more important than 300, 200 and 100 Baht. In other words, the whole column object *A* would have a count of 1. When *B* is considered to be less important than 400 Baht, a count of 0 is put for column *B*, row 400. But when *B* is considered more important than 300, it is also considered more important than 200 and 100 Baht (thus, a count of 1 for column *B*, except at the last row). The responses of these types are

Table 7.1 Examples of a matrix for the analysis of paired comparison data of resource losses and monetary losses.

a) Consistent responses

Baht	*A*	*B*	*C*	*D*
100	1	1	1	1
200	1	1	1	0
300	1	1	0	0
400	1	0	0	0

b) Inconsistent responses

Baht	*A*	*B*	*C*	*D*
100	0	1	1	0
200	0	0	1	1
300	0	1	0	1
400	1	0	1	0

c) 'No-trade' responses

Baht	*A*	*B*	*C*	*D*
100	1	1	1	1
200	1	1	1	1
300	1	1	1	1
400	1	1	1	1

considered to be consistent. The same consistency check is used for *C* and *D* and the responses to these two objects, according to table 7.1 (a), are also consistent.

Inconsistent choices occur, for example in table 7.1 (b), when *A* is considered more important than 400, but less important than 300, 200 and 100. The count of column *A* from top to bottom is therefore 0, 0, 0, 1. Another example for the count of column *B*, which reads from top to bottom, 1,0,1,0, shows that there is a degree of inconsistency in the responses. Using this method, inconsistent choices can be observed.

It is possible that respondents consider all objects to be more important than any amount of money, at least over the range provided. That is, they are not willing to make any trade-off between the objects and the money. In such case, the count in the whole table is thus 1, as in table 7.1 (c). Respondents with this kind of responses are referred to as "no-trade" respondents.

For each respondent, a matrix like those in table 7.1 is constructed. The respondents are categorised according to the consistency of their responses, into three groups, i.e. consistent, inconsistent and no-trade. Counts of preferences are aggregated across respondents in each consistency group to yield aggregated preference scores. Table 7.2 is constructed based on hypothetical responses from 10 respondents. The preference scores in table 7.2 (a) are converted to proportions of total respondents, indicating the number of respondents choosing the objects to be more important than the money (table 7.2 b).

In order to estimate the monetary value of the objects, median values are determined from these proportions using graphic representation. The proportions are plotted against the

Table 7.2 Determination of the median value of resource losses.

a) Aggregated preference scores of responses to comparisons between resource losses and monetary losses

Baht	*A*	*B*	*C*	*D*
100	9	8	5	6
200	9	6	3	4
300	6	4	3	2
400	6	2	1	1

b) Proportions of respondents considering the resource losses to be more important than monetary losses

Baht	*A*	*B*	*C*	*D*
100	.90	.80	.50	.60
200	.90	.60	.30	.40
300	.60	.40	.30	.20
400	.60	.20	.10	.10

monetary value and the median values are obtained by linear interpolation of the proportions. The median point is used here as a value acceptable to at least 50% of the sample (Peterson and Brown, in press). According to Rosenberger and Peterson (unpublished), the procedure of reading off the median value from the aggregated proportion curve to obtain monetary estimates was acceptable.

Based on the hypothetical data in table 7.2 (b), the estimated monetary values for A is unidentified since at the largest amount of money (400 Baht), the proportion of respondents is 0.6, which is greater than the median point 0.5. For object B, C, and D, the median point is equivalent to the monetary value of 250, 100 and 150 Baht, respectively.

7.3 Monetary estimates of the resource losses in Ban Don Bay and Phangnga Bay

A total of 208 people in Ban Don Bay and another 220 people in Phangnga Bay responded to Part II of the questionnaire. These respondents were divided into three groups based on their responses: consistent, inconsistent and no-trade, as described above. The number of respondents in each consistency group, categorised also into five expert groups, is shown in table 7.3. Almost half of all respondents (49%) in Ban Don Bay were in the no-trade group while the other half were split almost evenly between the consistent (25%) and the inconsistent group (26%). The distribution of respondents in the three groups was more even in Phangnga Bay (i.e. about one-third of respondents in each consistent group). When compared with layexperts, formal experts formed the largest percentage of respondents in the consistent group, both in Ban Don Bay (29%) and in Phangnga Bay (37%).

Table 7.3 Number of respondents, by expert groups, for Part II of the questionnaire, Ban Don Bay and Phangnga Bay (numbers in parenthesis are percentages within the consistency group).

Ban Don Bay

Expert group	Consistent Number	Consistent % within expert group	Inconsistent Number	Inconsistent % within expert group	No trade Number	No trade % within expert group	Total
Formal experts	15 (28.9)	35.7	7 (12.7)	16.7	20 (19.8)	47.6	42
Fishers	10 (19.2)	21.3	19 (34.6)	40.4	18 (17.8)	38.3	47
Shrimp farmers	9 (17.3)	22.5	8 (14.6)	20.0	23 (22.8)	57.5	40
Shellfish culturers	10 (19.2)	22.7	8 (14.6)	18.2	26 (25.7)	59.1	44
Others	8 (15.4)	22.9	13 (23.6)	37.1	14 (13.9)	40.0	35
Total	52		55		101		208
% Total	25.0		26.4		48.6		100.0

Phangnga Bay

Expert group	Consistent Number	Consistent % within expert group	Inconsistent Number	Inconsistent % within expert group	No trade Number	No trade % within expert group	Total
Formal experts	26 (37.1)	50.0	12 (16.4)	23.1	14 (18:2)	26.9	52
Fishers	11 (15.7)	24.4	18 (24.7)	40.0	16 (20.8)	35.6	45
Shrimp farmers	9 (12.9)	23.7	14 (19.2)	36.8	15 (19.5)	39.5	38
Tourism	10 (14.3)	25.6	10 (13.7)	25.6	19 (24.7)	48.7	39
Others	14 (20.0)	30.4	19 (26.0)	41.3	13 (16.9)	28.3	46
Total	70		73		77		220
% Total	31.8		33.2		35.0		100.0

A good number of respondents in Ban Don Bay were in the no-trade group (48% of formal experts, 58% of shrimp farmers, 59% of shellfish culturers, and 40% of respondents in other occupations). An exception were the fishers, whose number in the inconsistent group (40%) was slightly higher than that in no-trade group (38%). In Phangnga Bay, about 50% of formal experts were in the consistent group. However, a good proportion of fishers (40%) and other respondents (41%) in Phangnga Bay were found in the inconsistent group. The other two groups (shrimp farmers and tourism-related business) followed the same pattern as in Ban Don Bay, i.e. the largest part of respondents was in the no-trade group.

The observed proportion of respondents considering the resource loss to be more important than the specified amount of money was calculated for consistent respondents, consistent and inconsistent combined, and for all three groups (consistent, inconsistent and no-trade). Another set of calculations was performed, excluding responses from formal experts, to test their effects on the monetary estimates. Tables 7.4 and 7.5 summarise these proportions which were used to estimate the median values indicating the importance of resource losses in consideration for Ban Don Bay and Phangnga Bay, respectively.

For severe damage to mangrove forests and clear-cutting, more than half of the consistent respondents both in Ban Don Bay and Phangnga Bay considered these two losses to be more important than the highest amount of money (3,000 Baht). The median value was therefore not estimated for these resource losses. When adding inconsistent respondents to the group of consistent respondents, the proportion of those rejecting the money increased. The trend continued when combining the no-trade respondents, resulting in the proportion being greater than 0.5 in all cases. Only a small variation in the proportion was observed when taking the formal experts out of the consistent group of respondents. The

Table 7.4 Proportions of Ban Don Bay respondents considering resource loss to be more important than monetary loss (in Thai Baht).

Consistent

	Proportion				
Total (52)	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.808	0.788	0.731	0.654
Clear-cutting of mangrove forests	1.000	0.885	0.827	0.788	0.692
Partial damage to mudflats	1.000	0.731	0.596	0.365	0.038
Severe damage to mudflats	1.000	0.846	0.788	0.615	0.442

Total without formal experts (37)	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.811	0.811	0.757	0.703
Clear-cutting of mangrove forests	1.000	0.892	0.811	0.811	0.730
Partial damage to mudflats	1.000	0.730	0.568	0.324	0.027
Severe damage to mudflats	1.000	0.838	0.811	0.595	0.459

Consistent + Inconsistent

	Proportion				
Total (107)	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.897	0.876	0.825	0.835
Clear-cutting of mangrove forests	1.000	0.931	0.832	0.782	0.782
Partial damage to mudflats	1.000	0.844	0.688	0.458	0.302
Severe damage to mudflats	1.000	0.911	0.889	0.733	0.622

Total without formal experts (85)	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.908	0.895	0.868	0.882
Clear-cutting of mangrove forests	1.000	0.949	0.823	0.797	0.835
Partial damage to mudflats	1.000	0.865	0.689	0.446	0.324
Severe damage to mudflats	1.000	0.912	0.941	0.750	0.676

Consistent + Inconsistent + No-trade

	Proportion				
Total (208)	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.949	0.939	0.914	0.919
Clear-cutting of mangrove forests	1.000	0.965	0.916	0.891	0.891
Partial damage to mudflats	1.000	0.924	0.848	0.736	0.660
Severe damage to mudflats	1.000	0.958	0.948	0.874	0.822

Total without formal experts (166)	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.955	0.949	0.936	0.943
Clear-cutting of mangrove forests	1.000	0.975	0.913	0.900	0.919
Partial damage to mudflats	1.000	0.935	0.852	0.735	0.677
Severe damage to mudflats	1.000	0.960	0.973	0.886	0.852

Table 7.5 Proportions of Phangnga Bay respondents considering resource loss to be more important than monetary loss (in Thai Baht)

Consistent

	Proportion				
Total (70)	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.614	0.443	0.214	0.029
Severe damage to sandy beaches	1.000	0.800	0.729	0.600	0.386
Severe damage to mangrove forests	1.000	0.871	0.800	0.671	0.557
Clear-cutting of mangrove forests	1.000	0.914	0.871	0.814	0.686

Total without formal experts (44)	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.545	0.455	0.205	0.023
Severe damage to sandy beaches	1.000	0.795	0.705	0.523	0.364
Severe damage to mangrove forests	1.000	0.841	0.795	0.750	0.614
Clear-cutting of mangrove forests	1.000	0.909	0.841	0.818	0.705

Consistent + Inconsistent

	Proportion				
Total (143)	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.786	0.524	0.349	0.238
Severe damage to sandy beaches	1.000	0.889	0.841	0.690	0.484
Severe damage to mangrove forests	1.000	0.931	0.855	0.733	0.672
Clear-cutting of mangrove forests	1.000	0.956	0.876	0.861	0.693

Total without formal experts (105)	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.778	0.556	0.367	0.289
Severe damage to sandy beaches	1.000	0.900	0.867	0.689	0.500
Severe damage to mangrove forests	1.000	0.926	0.862	0.777	0.734
Clear-cutting of mangrove forests	1.000	0.960	0.870	0.860	0.700

Consistent + Inconsistent + No-trade

	Proportion				
Total (220)	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.867	0.704	0.596	0.527
Severe damage to sandy beaches	1.000	0.931	0.901	0.808	0.680
Severe damage to mangrove forests	1.000	0.957	0.909	0.832	0.793
Clear-cutting of mangrove forests	1.000	0.972	0.921	0.911	0.804

Total without formal experts (168)	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.869	0.739	0.627	0.582
Severe damage to sandy beaches	1.000	0.941	0.922	0.817	0.706
Severe damage to mangrove forests	1.000	0.955	0.917	0.866	0.841
Clear-cutting of mangrove forests	1.000	0.975	0.920	0.914	0.816

effect of formal experts to the median values was therefore considered to be insignificant. Overall, the median values were estimated only for the damages to mudflats in Ban Don Bay and the damages to sandy beaches in Phangnga Bay, using responses from the consistent group alone and from the combination of consistent and inconsistent groups.

Median values were estimated graphically as the point where the proportion of respondents rejecting the money was 0.5. The value based on consistent respondents of partial damage to mudflats in Ban Don Bay was found to be about 1,050 Baht and about 2,500 Baht for severe damage to mudflats (figure 7.1). The estimate increased to about 1,350 Baht in the first case, and greater than 3,000 Baht in the latter, when including inconsistent respondents. In Phangnga Bay, the median values were obtained for partial damage and severe damage to sandy beaches, for both consistent respondents and consistent with inconsistent respondents. Figure 7.2 shows the median value for each case. Similar to Ban Don Bay, the median value increased when including inconsistent respondents, and also when considering all cases. The median value when including inconsistent responses increased from 550 to 850 Baht for partial damage to sandy beaches, and from 2,200 to 2,850 Baht for severe damage to sandy beaches.

7.4 Discussion of monetary estimates

When the comparisons involved two different items, as in this part of the study, a small percentage of respondents were able to provide consistent choices (25% in Ban Don Bay and 32% in Phangnga Bay). The rest of the respondents were either inconsistent in their choices or were not willing to make any trade-off. These findings are comparable to the

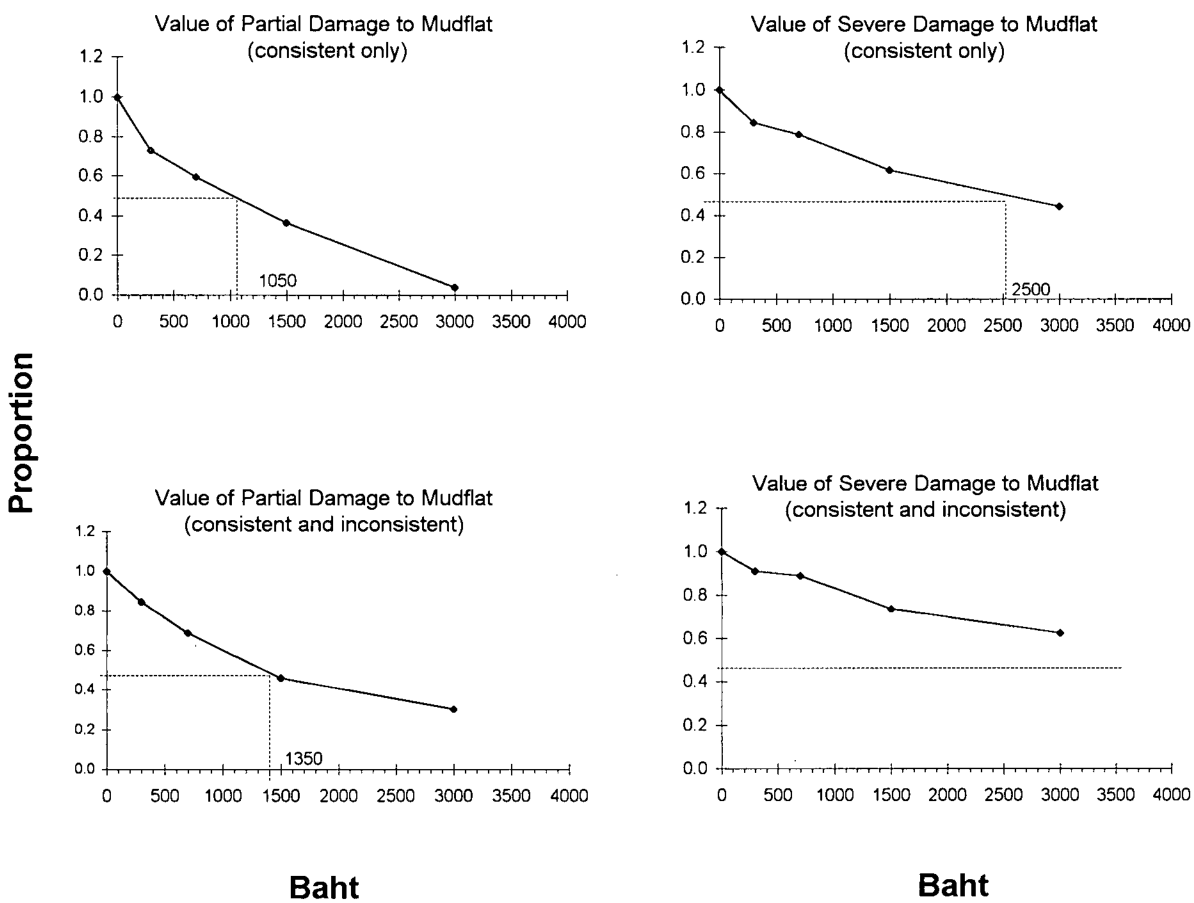


Figure 7.1 Median values of resource losses in Ban Don Bay.

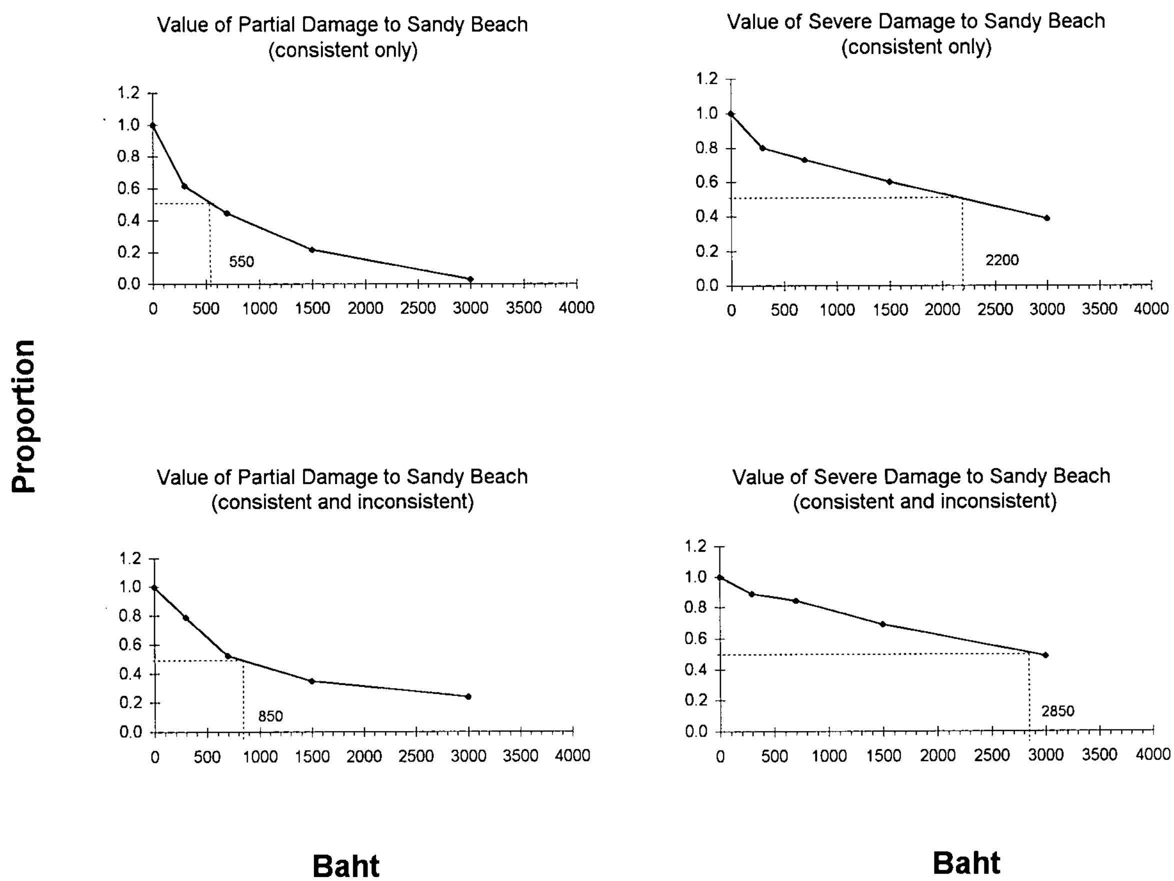


Figure 7.2 Median values of resource losses in Phangnga Bay.

percentage of respondents with no intransitive response in Part I and Part III of the questionnaire, where the comparisons involved no monetary amount (table 5.2).

While intransitivity did not pose any problems to the resulting scale values, the inconsistent and the no-trade responses cause some difficulty in the estimation of monetary values. As shown in tables 7.4 and 7.5, when including the respondents with inconsistent choices and no-trade in the calculation, the proportions of respondents rejecting the money increased, in most cases, to the point where median values were not found.

Inconsistent choices could be due to simple mistakes, or because respondents were uncertain about their preferences. It was also possible that respondents changed their minds because they learned more about the values as they went through the exercise. The order in which the pairs were presented might cause inconsistency, similar to what Tversky (1969) suggested about intransitive responses. This hypothesis may be tested by observing the pattern of the ordering of the pairs presented to the respondents with inconsistent responses.

The findings indicated that there was no difference between the judgment of formal experts and layexperts. The proportion of respondents rejecting the money, with or without formal experts, did not differ greatly (tables 7.4 and 7.5). However, one might suggest that this could be because the number of formal experts was small in relation to the number of layexperts. Formal experts (both with consistent and inconsistent choices) comprised about 21% and 27% of total respondents in Ban Don Bay and Phangnga Bay respectively. This is clearly not the case since further analysis on individual expert group showed that median values of formal experts fell in the same range as those of the other four layexperts groups of comparable sample size (Appendix VI).

One of the problems associated with the comparisons of resource losses and monetary losses conducted in this study was the large number of no-trade responses. Although the pretests showed that the range of money used in the questionnaire was appropriate, respondents still refused to choose the monetary amount within that given range. Three possible extensions could be pursued to explain this difference in the result. First, it could mean that the amounts of money presented in the comparisons were too low. This could be tested using an additional survey question. After the respondents have rejected all the given choices, they could be asked to state the amount of money loss that would be more important than the resource loss. Alternatively, open-ended questions could be used in the pretest to provide an appropriate range of money that could again be tested before use in the survey.

It was also possible that the no-trade choices represented protest responses, similar to the protest bids in CV studies. Respondents may consider the resource losses to be much greater than any amount of money, and thus may refuse to make a choice between the two losses. Another explanation for the no-trade incidence is that people may not be willing to, or were not able to, value the resource losses in monetary terms. A refusal to make a trade-off could be attributed to the fact that the two choices were incommensurable, a belief that some things cannot be directly compared, at least on a linear scale. It is beyond the scope of this study, however, to explore the existence and the extent of incommensurability of resource and environmental values in this context.

7.5 Interpretation of the monetary estimates

Within the context of this study, the observed monetary values for resource losses were in accord with the relative importance of such losses indicated by the importance scales. In Ban Don Bay, partial damage to mudflats, which was considered to be the least important loss, had a median value between 1,050 to 1,350 Baht (the lower value was based on consistent respondents alone and the upper value was obtained when including inconsistent respondents). When severe damage to mudflats was compared to the loss of money, the value increased from 2,500 to greater than 3,000 Baht. In Phangnga Bay, the value for partial damage to sandy beaches was between 550 to 850 Baht, and the value for severe damage to sandy beaches was between 2,200 to 2,850 Baht.

Both partial damage to mudflats in Ban Don Bay and partial damage to sandy beaches in Phangnga Bay had low scale values, while severe damage to those resources were in the region of medium important on the scales (figures 5.2, 5.3). The difference between the two monetary values on the importance scales of each study area was roughly the same (i.e. 1,450 for Ban Don Bay and 1,650 for Phangnga Bay, based on consistent responses). Correspondingly, the difference between the scales of the two resource losses was almost identical in the two study areas (i.e. 27 points for Ban Don Bay and 25 points for Phangnga Bay). These findings showed that the monetary estimates obtained in this study were consistent with the scale values in terms of being ranked in similar order.

Several studies have attempted to provide monetary values of some of the resources included in this study, using various valuation methods. The most recent study by Sathirathai (1997) gave estimates of direct use value of mangrove forests in Surat Thani (where Ban Don Bay is located) to be about 4,240 Baht per rai per year. This value could, at most, represent a minimum value for clear-cutting of mangrove forest in Ban Don Bay. Without the values of mangrove to the offshore fishery, or to indirect use values, such as storm protection and nonuse values, it is difficult to use the estimate in Sathirathai's study to indicate the total value of mangrove forests.

Another study by Costanza et al. (1997) reported, on a global basis, the value of ecosystem services of mangrove forests at US $9,990 per ha per year, which is equivalent to about 64,000 Baht per rai per year (an approximate of 40 Thai Baht to 1 US Dollar is used). Ecosystem services of coral reefs were also estimated in the same study to be about 39,000 Baht per rai per year. These estimates have the same order of ranking as in the scale of the relative importance of these resources developed for Phangnga Bay. On the other hand, the estimate for seagrass beds was roughly 122,000 Baht per rai per year, which is much higher than both mangrove forests and coral reefs and thus contradicted the rankings on the schedule. Almost all of the value for seagrass beds was from nutrient cycling services which were not reported for mangrove forests or coral reefs (Costanza et al., 1997). It is thus possible that once value for such environmental service is included for mangrove forests and coral reefs, the ranking of the relative importance of the three resources could be the same as that reported in this study.

In conclusion, the estimation of monetary values performed in this study served merely as a demonstration on how these values might be obtained using the method of paired comparisons. The results showed that the respondents had some difficulty in making choices between the resource losses and the monetary losses, as observed by the high percentage of inconsistent and no-trade responses. The monetary estimates obtained based on the consistent respondents were in rough agreement with the importance of the resources indicated by the importance scales.

Although it may seem desirable to obtain accurate monetary values, it should be recognised that the estimation is difficult especially when dealing with the complexity and multidimensionality of environmental resources. The scales of relative importance and the resulting damage schedules are informative even without incorporating the monetary values. Therefore, the damage schedule approach offers a tool that could be useful for policymakers particularly when accurate monetary estimates are lacking.

CHAPTER 8

Policy Implications and Future Research Needs

8.1 Application of the damage schedule approach in policymaking

As stated in Chapter 1, this study is an empirical test of the feasibility of developing damage schedules based on people's judgments of the relative importance of natural resources and environmental assets. The damage schedule approach is a non-valuation procedure that could provide a comprehensive understanding of the importance of the environmental resources, when accurate monetary valuations may be difficult, or impossible, to estimate. The approach offers an alternative tool for policymakers in resource allocation and assessment of environmental damage awards, especially when faced with constraints on information, time and/or finances.

In this study, the damage schedule approach was applied to a complex resource system of coastal areas of Thailand, where environmental damages and their monetary values are difficult to quantify. The study suggested a proper application of the method since Thailand, similar to other developing countries, faces problems of limitations of information, financial and personnel resources. The results showed that experts (both formal and lay) could provide reliable scale values and consistent rankings that could be used to construct meaningful damage schedules. As stated by Rutherford, et al. (1998), "*...if consistent judgments of environmental importance can be elicited directly from the public, a damage schedule based on those judgments might provide more accurate and acceptable signals of community values*" (Rutherford, et al., 1998, p. 81).

The damage schedule approach has broad implications in policymaking and management of environmental resources. For several decades, decision-makers have been relying on the translation of ecosystem functions into economic values, and on the quantification of the many benefits of environmental functions in monetary terms for economic planning and for approval of development projects (de Groot, 1992). These processes of translation and quantification are, however, rather difficult and unreliable. The damage schedule approach provides decision-makers with a tool that takes into account the importance of natural resources and environment without having to express them in monetary units.

Acknowledging the complexity of the resource system in question, the damage schedule approach draws on the knowledge and experiences of both formal experts and layexperts to freely express their judgments about the resources. The approach does not limit the respondents to consider certain aspects of the resource nor does it guide them through their judgments. Rather, it allows them to use any criteria they deem appropriate in making their decisions and any method to arrive to their conclusion. The outcome from this process is taken as a true reflection of the societal values of the resource system. Decisions made on these importance scales could produce resource allocations more in accord with public values. As Hausman and McPherson (1994) suggested, Pareto efficiency may be achieved if social decision making was based on people's preferences and beliefs. The approach is particularly useful, when the society has other goals apart from economic efficiency, such as income distribution, development of cultural values, the promotion of healthy life style or improving the safety of working conditions (Hufschmidt et al., 1983).

As shown in this study, the scales of relative importance obtained based on experts' judgment could serve as a foundation for construction of the damage schedules. Policy makers can then direct their effort to the resources and activities that are considered most important on the schedules, instead of having to deal with all of them concurrently.

The damage schedules can be used to prohibit, restrict or discourage development projects that endanger, or are considered to be a greater threat to, the health of more important ecosystems. By attaching greater damage compensation, or other more severe sanctions, to the use of resources with higher relative importance on the schedules, policymakers are more consistent with the accounting of the resource users.

Figures 8.1 and 8.2 show how the damage schedules could be developed based on the importance scales obtained from the Phangnga Bay study. Two schedules could be constructed: the loss schedule, based on the scale of relative importance of losses, and the activity schedule, based on the scale of relative importance of activities. A range of policy responses could be assigned to different levels of importance of resource losses or activities. Following the groupings of resource losses and activities on the importance scales (figures 5.2, 5.3, 5.4 and 5.5), the damage schedules could be divided into three regions of importance: high, medium and low. Rigorous sanctions could be applied to prevent resource losses in the high importance region or to deter high impact activities. Moderate policies could be used for the losses and activities in the middle region of importance, while less stringent disincentives could be applied to those at the bottom end of the schedules.

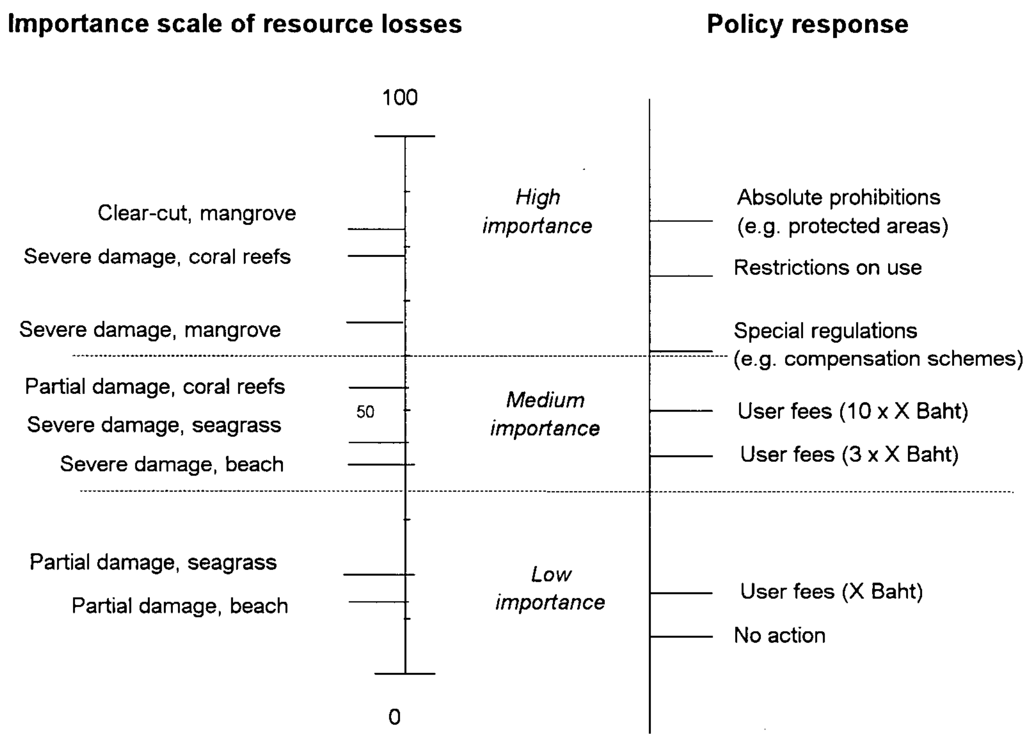


Figure 8.1 Loss damage schedule of Phangnga Bay

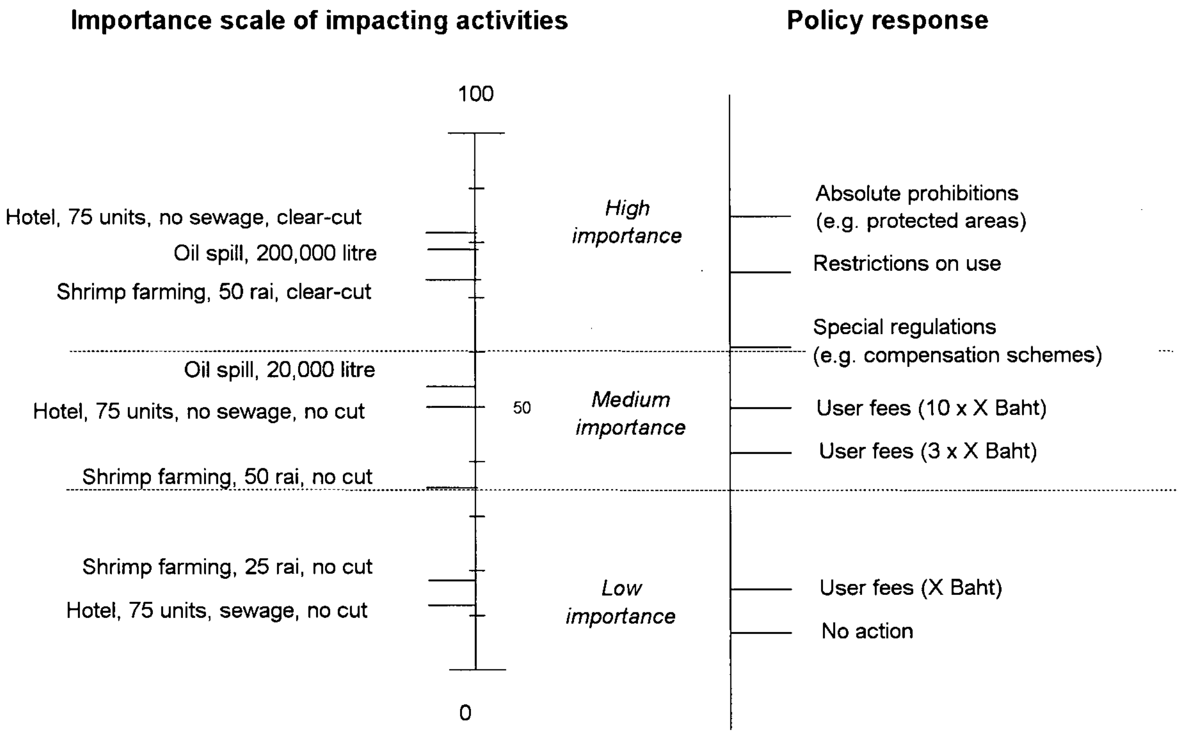


Figure 8.2 Activity damage schedule of Phangnga Bay

For example, based on the loss schedule of Phangnga Bay, mangrove forests might justifiably receive greater degree of protection, such as absolute prohibition from clear-cutting (figure 8.1). Other activities in the mangrove forest areas that may cause severe damages may be similarly restricted but to varying degrees. Boundaries may be placed around sensitive coral reef areas to protect them from severe damages. User fees might be imposed to discourage any activities that could cause severe damages to seagrass beds and sandy beaches. A smaller user fee could be charged, or no action taken, for partial damages of the resources at the bottom part of the loss schedule, to reflect what the community regards as being of relatively low importance.

Using the activity schedule, similar policies to those for the top part of the loss schedule could be applied to the activities within the high importance region. A prohibition policy could be developed to prevent activities involving clear-cutting of mangrove forests, such as hotel development and shrimp farming, from taking place in Phangnga Bay (figure 8.2). Certain restrictions may be applied to other activities that could severely damage coral reefs. In the case of oil spills, other regulations, such as compensation schemes or damage payments, may be needed. User fees could be charged for other activities not involving clear-cutting of mangrove forests, depending on the level of importance on the schedule. For instance, a higher fee could be imposed on hotel development with no sewage system, than on shrimp farming of 50 rai. At the bottom end of the scale, policy makers could apply less stringent restrictions or sanctions to reflect the lower impact of the activities.

The damage schedule approach has a further practical implication for the management policies for coastal resources of Thailand. For instance, because of the complexity of the resource system, there has long been a debate on the biophysical relationship between mangrove forests and coastal fisheries and between mangrove forests and aquaculture. The socio-economic impacts of this activity on the community and their interactions are not well defined. The Royal Forestry Department has authority in mangrove forest management, including giving official logging concessions to private firms. This is commonly done with limited regard to the impact on coastal fisheries and aquaculture (White and Suphapodok, 1988). The Department of Fisheries, on the other hand, promotes the shrimp farming industry without sufficient consideration of its impacts on the coastal environment and on mangrove forest areas. The damage schedule does not determine if having mangrove forests is better than having shrimp farms. However, it indicates that, according to the public's judgment, clear-cutting of mangrove forests and shrimp farming activities involving clear-cutting are considered to be of high importance. In this case, the policy might be to prohibit clear-cutting of mangrove forests for shrimp farming, and to apply a user fee for shrimp farming that does not involve the clear-cutting of mangrove forests.

The two kinds of schedules could be used independently or complementarily, as demonstrated above. It might be easier to use the activity schedule since no measurement of specific losses resulting from an event is needed. The activity schedule directly indicates the level of damage payment or user fee that could be applied to a certain activity that has already taken place or is about to begin. In contrast, some field measurements may be required to determine the level of damages before using the loss schedule. However, it might not be necessary to have an exact measurement, as suggested by Rutherford et al. (1998). As seen in this study, having two levels of damages (partial and severe), despite their seeming arbitrariness, serves as good anchoring points on a schedule that could then accommodate other losses as they are incurred.

For activities whose impacts are agreed upon to undoubtedly be of high importance or of low importance, the activity schedule could be used without any consideration of the level of the losses. However, for activities in the middle of the schedule where the levels of severity are less distinct and could be sensitive to the characteristics of respondents, it might be necessary to incorporate the loss schedule in the decision making process.

The assignment of policy responses on the importance scales, whether in the form of regulations or involving monetary payments, is subject to decision-makers' judgments. The schedules obtained at this initial stage, referred to as being 'interim' by Rutherford et al. (1998), could be fine-tuned using new information, knowledge and experience and could be adjusted in accordance with shifting social values. Notwithstanding this initial disposition, the damage schedules based on relative values would ensure that losses considered to be more important are given more compensation than those that are considered to be less important (Rutherford, et al., 1998). Likewise, a higher fee or stricter regulation would be applied to the activities that are considered to have greater impacts on coastal environment than those of lower impacts.

8.2 Further research needs

This study takes an initial step in testing the applicability of the damage schedule approach to an actual field situation. Despite the encouraging results that meaningful scales of relative importance of resource losses and impacting activities can be obtained based on people's judgments, further research is needed to improve the reliability, validity and credibility of the method.

In general, a great amount of effort could be put in the design of the questionnaire to reduce the number of inconsistent choices and to minimise the biases associated with the questionnaire and the survey method used. As previously emphasised, information bias is one of the most important factors affecting the reliability in this type of study. Different tests could be performed to check the sensitivity of the responses to variations in the amount and the kind of information provided to respondents, as well as to the format in which they are presented in the questionnaire. The description of losses and activities could be varied to find out how they influence the results. The word 'importance' could be replaced with alternative phrases to assess semantic effects.

Alternative formats of presenting the questionnaire and conducting the survey could be explored. For example, the administration of questionnaires could be computer-assisted. Respondents could be interviewed instead of being asked to complete the questionnaire on their own. A group interview or open group discussion could be tested to see if it provides more consistent responses.

This study chose the paired comparison method to provide rankings of relative importance of resource losses and activities. Other elicitation methods such as contingent ranking, multiattribute utility theory and decision analysis could be investigated to see if they result in different scale values. A test could also be performed to see how differently people who are not directly related or affected by the environmental damages in consideration would respond to the questionnaire.

There are two main approaches in validating the results of the study: internal and external validation. Internal validation is based on the approval of the damage schedules from policy makers, experts, resource users, stakeholders and other interest groups. After the damage schedules have been developed, a workshop could be held with participants representating each of the interest groups. The invited participants could be asked to complete the same questionnaire before they are informed of the resulting damage schedules obtained from the survey. This would make it more difficult for some participants in the workshop to try to impose their preferences over the study's findings of community preferences, as their own preferences might turn out to be similar to the findings. The objectives of the workshop would be to acquire feedback on the proposed damage schedules and to discuss any diversity in the importance considerations of different groups. Any necessary adjustments to the damage schedules would be made if agreed upon by all parties. This workshop would aim also at facilitating conversation among various interest groups, which could eventually help lead to successful management.

External validation is done by implementation of more studies. The exercise should be repeated in other geographical areas with different resource characteristics. Other kinds of natural resources and other environmental problems should be included in such studies. For example, a study could be conducted to study the importance of recreational areas and the impacts of tourism using the damage schedule approach.

The next important research step that should be taken after the damage schedule approach has been well developed is to test its applicability in real policy settings. Unless the damage schedules are being used by policy makers as a tool that could aid them in their decisions about environmental resources, the usefulness of the approach would remain doubtful.

8.3 Conclusion

The loss schedule and the activity schedule were successfully developed for Ban Don Bay and Phangnga Bay. The schedules reflected people's judgments of the relative importance of resource losses and impacting activities. The questionnaire containing paired comparison questions was an effective instrument in this survey study. The analysis of paired comparison data using the Dunn-Rankin's variance stable rank method provided scale values that were highly correlated with those obtained from Thurstone's case V method and the scale produced by the analytical hierarchy process method.

Intransitivities had little impact on the final scales of relative importance. Both formal and layexperts were able to provide consistent scale values and rankings. Layexperts of different occupation groups were also found to be consistent in their judgments. The characteristics of the respondents such as gender, education, number of years lived in the area and age did not seem to have a significant effect on the scale values. The scale values based on all respondents were appropriate as inputs to construct the damage schedules for the two study areas.

The association and the small differences observed in the damage schedules of the two study areas indicated that they were constructed in accord with the existing and potential development of the areas, and they reflected community values of the resources. The damage schedules provided a comprehensive understanding of the importance of resources in a complex natural system.

The damage schedule approach can have direct implications for the management of natural resources and environmental assets. The damage schedules can be used to aid policy makers in designing appropriate policies to protect the resources that are considered to be of high importance, as well as to discourage activities that are considered to have high impact on the environment. The damage schedule approach, being relatively easy and inexpensive to develop, is a promising method that could provide information necessary for improving management of environmental resources.

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Appendix I A: Ban Don Bay's Questionnaire

Notes:

1. This appendix includes the first 7 pages of the questionnaire, including explanation and instruction given to respondents.
2. The examples of the actual paired comparisons are attached for Part I, Part II and Part III of questionnaire.
3. The actual presentation of the paired comparison is the half-sheet format. In this appendix, two pairs are put on one page.
4. The complete Part IV for layexperts is included in this appendix.
5. Only the first 2 half-sheets of Part IV for formal experts are included. The rest of Part IV for formal experts is the same as that of layexperts.

Questionnaire

Relative importance of resource losses in Ban Don Bay

(Research project in cooperation with the Faculty of Fisheries, Kasetsart University)

This questionnaire consists of pairs of losses or damages to resources in Ban Don Bay. For each of these pairs, we want you to choose the one that you think is more important, not only to you and your family, but to the environment, the economic and social values of the community and the future of the area.

For example, a pair of losses might be: **(1)** ***loss of 20% of coral reefs*** or **(2)** ***loss of 50% of coral reefs***. In this case, nearly all people would choose the 50% loss as being more important or more severe than the 20% loss.

However, another pair might be; **(1)** ***loss of 50% of coral reefs*** or **(2)** ***loss of 50% of seagrass beds***. In this case, some people might feel that the loss of 50% of coral reefs is more important and others might feel that the loss of 50% of seagrass beds is more important.

There are no right or wrong answers, the choices that you make should depend entirely on your own personal judgment of which one you feel is more important.

Because the sampling design takes into account the level of familiarity with the resources of Ban Don Bay of every person we survey, it is important that you complete this questionnaire personally. Please do not ask others to complete the questionnaire even if you feel they may be more knowledgeable.

The questionnaire consists of FOUR parts which should be done in order from 1 to 4.

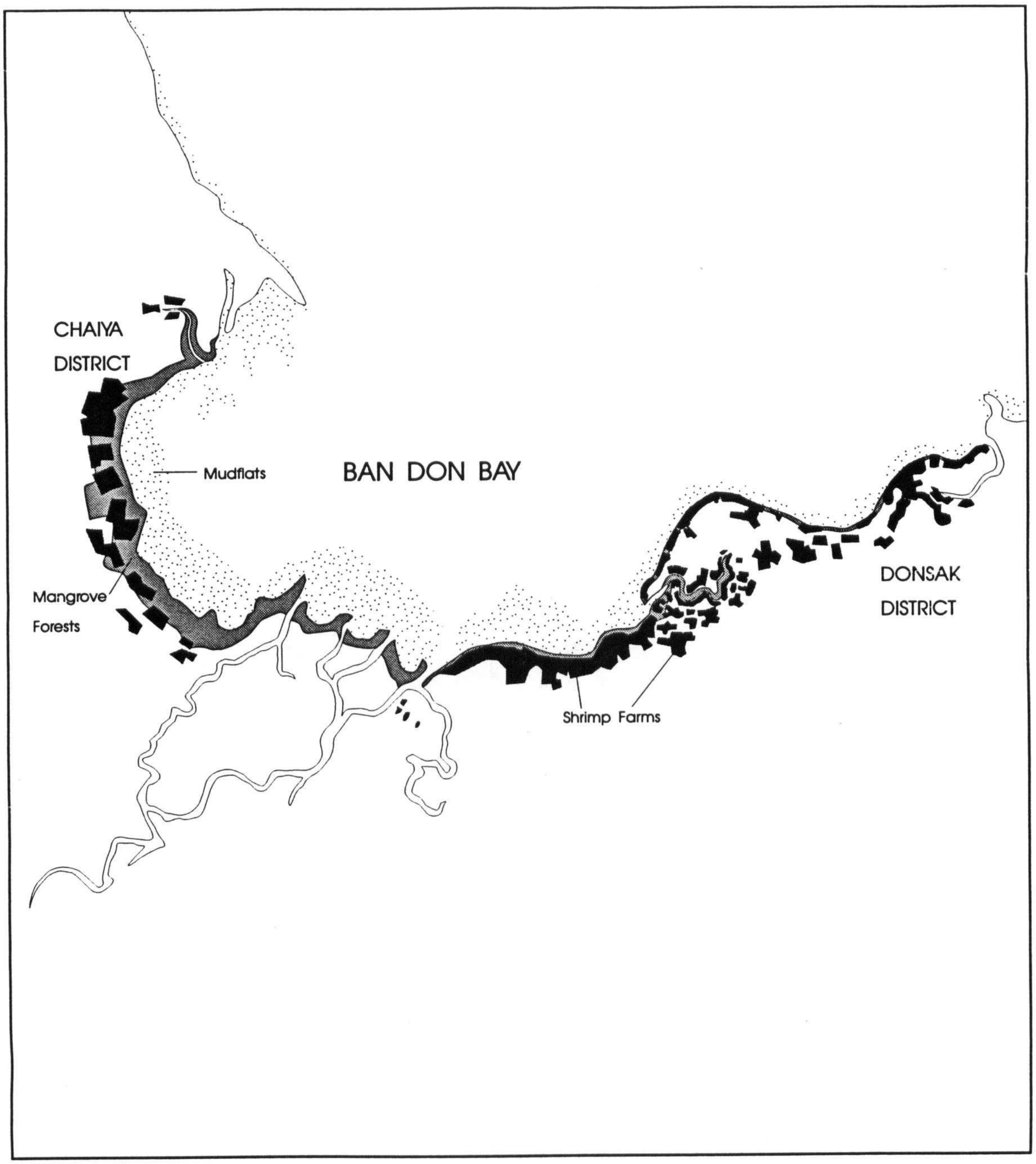
The completed questionnaire should be returned to:

Rattana (Ying) Chuenpagdee, Project Investigator
Department of Fishery Management,
Faculty of Fisheries, Kasetsart University
Chatuchak, Bangkok 10900

Thank you for your cooperation and your assistance.

Boundary of study area

In this study, Ban Don Bay refers to the coastal areas of Surat Thani Province, from Chaiya District to Don Sak District. The coastal areas cover the land area to about 5 km from shoreline (landward direction), the interface between land and sea, and extend seaward to about 5 km.



Part 1

In **Part 1**, you will be given several pairs of specific losses. For each pair, you will select the loss you feel is more important. (Select one loss as more important even if you feel they are almost equally important.) All of these different losses would be the result of human activities, not natural causes. The affected resources would gradually recover, reaching their prior level, in a specified period of time.

In this part, you will compare different losses of:

1) Mangrove forests

There are 19,500 rai of mangrove forests in Ban Don Bay. About 7,000 rai are in economic zone B where tree cutting may be allowed. Mangrove forests of Ban Don Bay serve as nursery and feeding grounds for marine organisms including fish, shellfish, and crabs. They also help prevent coastal soil erosion and provide protection from storms. Damage to mangrove forests could be caused by pollution and coastal development, while loss to mangrove forests are a result of clear-cutting.

2) Intertidal mudflats

Mudflats in Ban Don Bay cover a large band of about 1 to 2 km of the intertidal areas along the coastline. These intertidal mudflats provide habitats for shorebirds, many crabs, and shellfish, such as cockles. Damages could result from pollution, coastal development and dredging.

3) Shellfish culture areas

Shellfish culture areas of Ban Don Bay extend along the coast, from intertidal area to about 3 km into the sea. These areas serve as culture grounds for many shellfish such as short-necked clams, mussels and, especially, oysters. Damages to suitable shellfish culture areas could result from pollution and coastal development.

4) Marine fishing grounds

Fishing in Ban Don Bay takes place both within the 3 km from shoreline and beyond. Many fish species, squid and shrimps are caught in these areas. Damages to marine fishing grounds could result from pollution and oil spills.

Table 1. Resources of Ban Don Bay and different levels of losses for comparisons in Part I

Resource	Level of losses	Level of productivity	Recovery period
Mangrove forests	1) severe damage 2) loss	1) reduced to almost nothing 2) no longer productive	1) 10 - 15 yrs 2) no recovery
Mudflats	1) partial damage 2) severe damage	1) reduced by half 2) reduced to almost nothing	1) 6 mos - 1 yr 2) 1 - 2 yrs
Shellfish culture areas	1) partial damage 2) severe damage	1) reduced by half 2) reduced to almost nothing	1) 1 - 2 yrs 2) 3 - 5 yrs
Marine fishing grounds	1) partial damage 2) severe damage	1) reduced by half 2) reduced to almost nothing	1) 1 - 2 yrs 2) 3 - 5 yrs

Part 2

In **Part 2**, you will be given several pairs of specific losses. For each pair, you will select the loss you feel is more important. In each pair, one loss would be a resource loss, the other would be a one-time loss of money from you and every household in Ban Don Bay area.

The money lost to you and all of the other households would not be used to eliminate or reduce the resource loss and it would not be used for any purpose in the Ban Don Bay area.

Table 2. Loss of resources and loss of money for comparisons in Part II

Resource	Level of losses	Amount of money (Baht)
Mangrove forests	1) Severe damage 2) Loss	1) 300 Baht 2) 700 Baht 3) 1,500 Baht 4) 3,000 Baht
Mudflats	1) Partial damage 2) Severe damage	1) 300 Baht 2) 700 Baht 3) 1,500 Baht 4) 3,000 Baht

Part 3

In **Part 3**, you will be given several pairs of specific activities that may take place in Ban Don Bay and may result in resource losses. For each pair, first select the activity you feel is more important in terms of potential impacts on coastal resources of Ban Don Bay. Second, indicate the level of importance you attach to the selected activity.

The activities you will compare in this part are:

1) Black tiger shrimp farming

Black tiger shrimp farming in Ban Don Bay often takes place in the coastal area, involving conversion of deteriorated farm land, and damaged forest areas, old rubber plantations and paddy fields. Shrimp farming is often in conflict with other coastal activities in terms of land use and freshwater consumption, and possible saltwater seepage from shrimp farms into surrounding land. Because of the lack of waste water treatment systems, effluent from the farms that is released to the sea might contain organic matters and chemicals that could have negative impacts on coastal water and coastal environments.

2) Housing projects

The rapid development of Surat Thani is increasing the demand for housing in the area. Because of the lack of suffient sewage and waste water treatment systems, the development of housing areas contribute to the environmental pollution problem in Ban Don Bay.

3) Oil spills

The oil loading activity at the proposed deep sea port in Khanom District, Nakon Srithammarat Province could increase the chance of crude oil spills. About 10% of any spilled oil could be washed up on shore and damage mangrove forests, fish and shellfish habitats and pollute the beaches in Ban Don Bay.

Table 3. Coastal activity scenarios in Ban Don Bay for comparisons in Part III

Activities	Size of operation	Clear-cutting of mangrove
Shrimp farming	1) 25 rai 2) 100 rai 3) 100 rai	1) No 2) No 3) Yes, 40 rai
Housing project	1) 50 units 2) 100 units 3) 100 units	1) No 2) No 3) Yes, 20 rai
Crude oil spills	1) 20,000 litre 2) 200,000 litre	- -

Examples of Part I paired comparison questions:

BDB 1- 07

Which of the two losses is more important, **A** or **B** (circle one)?

A	**B**
Severe damage to 25% of marine fishing grounds in Ban Don Bay. Productivity in these areas would be **almost all reduced**. Recovery would take 3 to 5 years.	**Severe damage** to 40 rai of **mangrove forests** in economic zone B in Ban Don Bay. Productivity in these areas would be **almost all reduced**. Recovery would take 10 to 15 years.

BDB 1- 08

Which of the two losses is more important, **A** or **B** (circle one)?

A	**B**
Partial damage to 25% of the **intertidal mudflat** areas in Ban Don Bay. Productivity in these areas would be **reduced by half**. Recovery would take 6 months to 1 year.	**Loss** of 40 rai of **mangrove forests** in economic zone B in Ban Don Bay. All functions of the clear-cut mangrove forests would be lost.

Examples of Part II paired comparison questions:

BDB 2- 01

Which of the two losses is more important, **A** or **B** (circle one)?

A	B
Severe damage to 40 rai of **mangrove forests** in economic zone B in Ban Don Bay. Productivity in these areas would be **almost all reduced**. Recovery would take 10 to 15 years.	A one-time loss of **300 Baht** to you and every household in Ban Don Bay area.

A **B**

BDB 2- 02

Which of the two losses is more important, **A** or **B** (circle one)?

A	B
A one time loss of **700 Bath** to you and every household in Ban Don Bay area.	**Severe damage** to 40 rai of **mangrove forests** in economic zone B in Ban Don Bay. Productivity in these areas would be **almost all reduced**. Recovery would take 10 to 15 years.

A **B**

Examples of Part III paired comparison questions:

BDB 3 - 01

Which one of the two activities is more important, **A** or **B**? Circle one.

A	B
Construction of a new **shrimp farm** of **25 rai** in the coastal area of Ban Don Bay, with **no cutting** of mangrove forests.	Construction of a new **shrimp farm** of **100 rai** in the coastal area of Ban Don Bay. **No mangrove forests** would be **cut**.

Then, indicate the level of importance of the selected activity, in comparison to the other one, by putting a '□' in the appropriate box.

Much more important	More important	Slightly more important	Nearly equal
□	□	□	□

BDB 3 - 02

Which one of the two activities is more important, **A** or **B**? Circle one.

A	B
Construction of a new **shrimp farm** of **25 rai** in the coastal area of Ban Don Bay, with **no cutting** of mangrove forests.	Construction of a new **shrimp farm** of **100 rai** in the coastal area of Ban Don Bay. About **40 rai** of **mangrove forests** in economic zone B would be **clear-cut**.

Then, indicate the level of importance of the selected activity, in comparison to the other one, by putting a '□' in the appropriate box.

Much more important	More important	Slightly more important	Nearly equal
□	□	□	□

Complete Part IV of the questionaire (for layexperts):

BDB 4L - 01

What is your MAIN occupation (choose only ONE occupation that you spend most of your time with)?

_____ 1) agricultural farmer
_____ 2) labour / trading
_____ 3) small-scale fisher (major gear used ....)
_____ 4) commercial fisher (major gear used ....)
_____ 5) shrimp farmer
_____ 6) fish cage / shellfish culturer
_____ 7) private business
_____ 8) fish processor / fish wholesaler
_____ 9) hotel / resort / bungalow
_____ 10) tour operator / guide / tour company
_____ 11) restaurant / food stall / gift shop
_____ 12) others (please specify ....)

What is your MINOR occupation? ....

BDB 4L - 02

Do you live in Ban Don Bay area?

_____ 1) Yes. Subdistrict .... District..........................
For how long have you lived in the area? .... years

_____ 2) No.
How many times a year do you visit Ban Don Bay? ....

Your age ....years

Gender: _____ 1) Male _____ 2) Female

Highest education: ....

Have you ever been involved in management / policy and planning of coastal resources?
_____ 1) Yes _____ 2) No

BDB 4L - 03

Do you agree or disagree with the following statements?
(Put a '✓' in one of the boxes provided).

	Strongly agree	Agree	Disagree	Strongly disagree	No Opinion
Coastal resources of Thailand, in general, are being degraded.	☐	☐	☐	☐	☐
Coastal resources of Thailand are being heavily exploited for various purposes.	☐	☐	☐	☐	☐
Coastal resource management policies of Thailand are effective.	☐	☐	☐	☐	☐
Management of coastal resources is the sole responsibility of the government.	☐	☐	☐	☐	☐

BDB 4L - 04

Do you agree or disagree with the following statements?
(Put a '✓' in one of the boxes provided).

	Strongly agree	Agree	Disagree	Strongly disagree	No Opinion
Resource users should be involved in the management of resources.	☐	☐	☐	☐	☐
Non-government organizations (NGOs) play an important role in the management of Thai coastal resources.	☐	☐	☐	☐	☐
It is difficult to get stakeholders to collaborate with the government in resource management.	☐	☐	☐	☐	☐

BDB 4L - 05

Do you agree or disagree with the following statements?
(Put a '✓' in one of the boxes provided).

	Strongly agree	Agree	Disagree	Strongly disagree	No Opinion
Resources are to be used now, not to keep for future generations.	☐	☐	☐	☐	☐
There is no need to consider scenic values in the management of coastal resources.	☐	☐	☐	☐	☐
Priority in resource allocation should be given to activities that create greatest economic returns.	☐	☐	☐	☐	☐

The first two pages of Part IV questionnaire for formal experts:

BDB 4F - 01

What is your area of specialization / expertise? (If more than one, please put '1' to indicate the area of your highest expertise, and 2, 3, ..., etc. for the lesser ones).

_____ 1) land use / GIS mapping
_____ 2) mangrove forests
_____ 3) coastal resources
_____ 4) marine biology
_____ 5) coral reefs
_____ 6) seagrass beds
_____ 7) physical / chemical oceanography
_____ 8) fishery biology / fishery management
_____ 9) environmental impact assessment
_____ 10) coastal aquaculture
_____ 11) agriculture and resource economics
_____ 12) social science / socio-economics
_____ 13) others (please specify ....)

Your employer ....
Your position ....
Number of years in this occupation ....

BDB 4F - 02

Do you work or have you worked in Ban Don Bay area?
_____ 1) Yes, for how long? ....

_____ 2) No.
Have you visited the area (job-related)?
_____ 1) Yes, how many times a year? ....
_____ 2) Never

Have you ever been involved in management / policy / planning of coastal resources or other natural resources?
_____ 1) Yes
_____ 2) No

Your age ....years
Gender _____ 1) female _____ 2) male
Highest education: ....

Appendix I B: Phangnga Bay's Questionnaire

Notes:

Only the first 7 pages of the questionnaire are included in this appendix. The actual pairs used in the survey are not included. Part IV of Phangnga Bay is the same as that of Ban Don Bay.

Questionnaire

Relative importance of resource losses in Phangnga Bay

(Research project in cooperation with the Faculty of Fisheries, Kasetsart University)

This questionnaire consists of pairs of losses or damages to resources in Phangnga Bay. For each of these pairs, we want you to choose the one that you think is more important, not only to you and your family, but to the environment, the economic and social values of the community and the future of the area.

> For example, a pair of losses might be: **(1)** ***loss of 20% of sea turtles*** or **(2)** ***loss of 50% of sea turtles***. In this case, nearly all people would choose the 50% loss as being more important or more severe than the 20% loss.
>
> However, another pair might be: **(1)** ***loss of 50% of sea turtles*** or **(2)** ***loss of 50% of dugongs***. In this case, some people might feel that the loss of 50% of sea turtles is more important and others might feel that the loss of 50% of dugongs is more important.

There are no right or wrong answers, the choices that you make should depend entirely on your own personal judgment of what you feel is more important.

Because the sampling design takes into account the level of familiarity with the resources of Phangnga Bay of every person we survey, it is important that you complete this questionnaire personally. Please do not ask others to complete the questionnaire even if you feel they may be more knowledgeable.

The questionnaire consists of FOUR parts which should be done in order from 1 to 4.

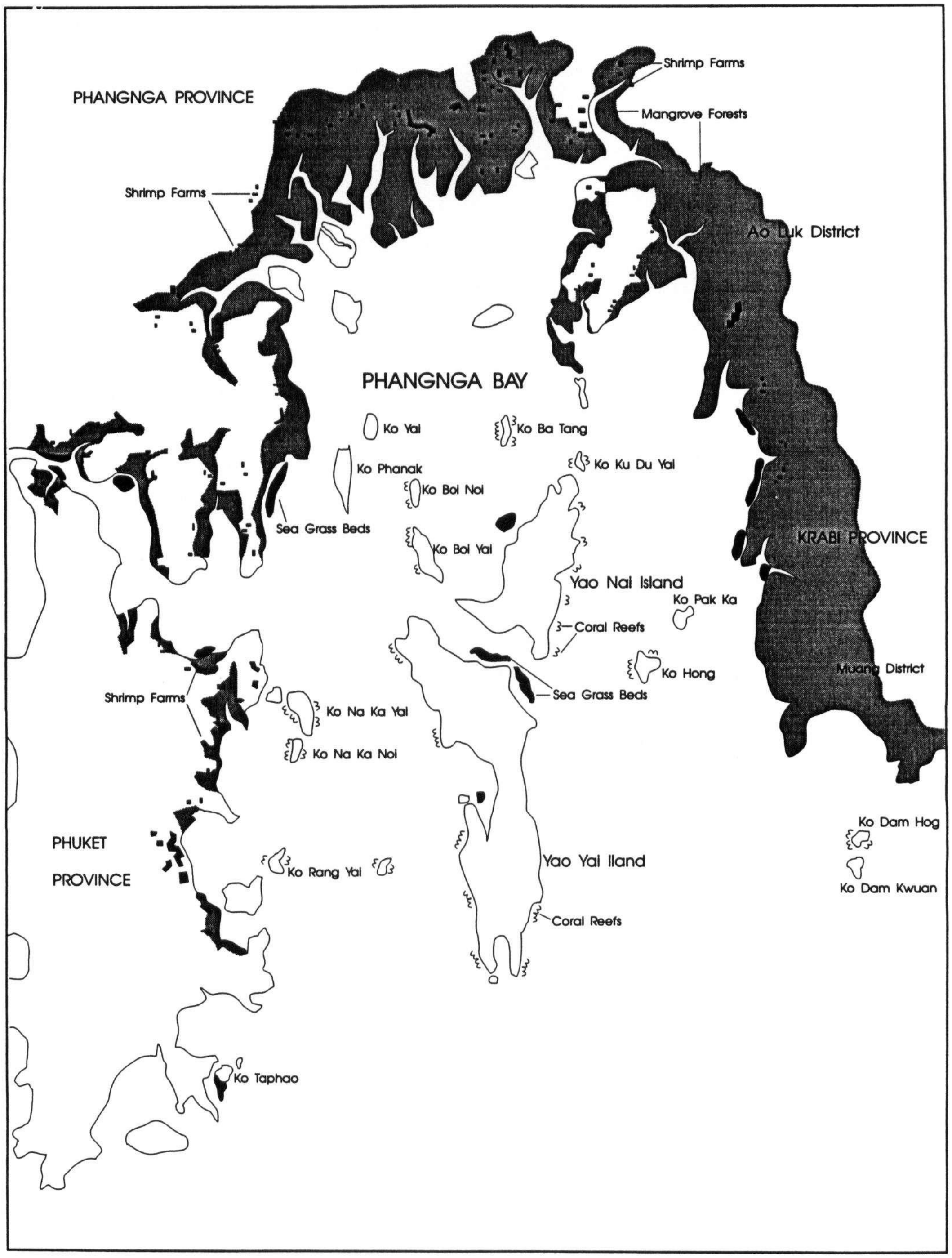
The completed questionnaire should be returned to:

Rattana (Ying) Chuenpagdee, Project Investigator
Department of Fishery Management,
Faculty of Fisheries, Kasetsart University
Chatuchak, Bangkok 10900

Thank you for your cooperation and your assistance.

Boundary of study area

In this study, Phangnga Bay refers to the coastal areas in the east of Phuket Province, the inner bay area adjacent to Phangnga and Krabi Provinces. The coastal areas cover the land area to about 5 km from shoreline (landward direction), the interface between land and sea, and extend seaward to about 5 km.



Part 1

In **Part 1**, you will be given several pairs of specific losses. For each pair, you will select the loss you feel is more important. (Select one loss as more important even if you feel they are almost equally important.) All of these different losses would be the result of human activities, not natural causes. The affected resources would gradually recover, reaching their prior level, in a specified period of time.

In this part, you will compare different losses of:

1) Sandy beaches

Sandy beaches of Phangnga Bay provide recreational opportunities and natural beauty. Losses could result from pollution and coastal development.

2) Mangrove forests

There are 178,000 rai of mangrove forests in Krabi Province. About 3,500 rai are in economic zone B where tree cutting may be allowed. Mangrove forests of Phangnga Bay serve as nursery and feeding grounds for marine organisms including fish, shellfish, and crabs. They also help prevent coastal soil erosion and provide protection from storms. Damage to mangrove forests could be caused by pollution and coastal development, while loss to mangrove forests are a result of clear-cutting.

3) Seagrass beds

Seagrass beds of Phangnga Bay provide habitats for marine organisms including fish, shellfish, sea cucumber, shrimps and dugongs. Dugongs also depend on seagrass for food. Seagrass beds in Phangnga Bay are found around Ko Yao Yai, and along the northern coast of Muang Distrcit, Krabi Province, for example. Losses could result from pollution and sedimentation from coastal development.

4) Coral reefs

Coral reefs of Phangnga Bay provide habitats for marine organisms including fish and shellfish. They also provide recreational opportunities and natural beauty. Coral reefs in Phangnga Bay are found around Ko Hong, Ko Dam Hok and Ko Yao Noi, for example. Losses could result from pollution, sedimentation, boat anchoring, discarded fishing nets and tourists activities.

Table 1. Resources of Phangnga Bay and different levels of losses for comparisons in Part I

Resource	Level of losses	Level of productivity	Recovery period
Nopparat Thara Beach	1) partial damage 2) severe damage	1) number of visitors is reduced by half 2) no more visitors	1) 6 mo - 1 yr 2) 1 - 2 yrs
Mangrove forests	1) severe damage 2) loss (clear-cut)	1) reduced to almost nothing 2) no longer productive	1) 10 - 15 yrs 2) no recovery
Seagrass beds	1) partial damage 2) severe damage	1) reduced by half 2) reduced to almost nothing	1) 6 mo - 1 yr 2) 1 - 2 yrs
Coral reefs	1) partial damage 2) severe damage	1) reduced by half 2) reduced to almost nothing	1) 6 - 10 yrs 2) 12 - 15 yrs

Part 2

In **Part 2**, you will be given several pairs of specific losses. For each pair, you will select the loss you feel is more important. In each pair, one loss would be a resource loss, the other would be a one-time loss of money from you and every household in Ao Luk District and Muang District of Krabi Province, which are adjacent to Phangnga Bay.

The money lost to you and all of the other households would not be used to eliminate or reduce the resource loss and it would not be used for any purpose in Krabi Province or in Phangnga Bay area.

Table 2. Loss of resources and loss of money for comparisons in Part II

Resource	Level of losses	Amount of money (Baht)
Nopparat Thara Beach	1) Partial damage 2) Severe damage	1) 300 Baht 2) 700 Baht 3) 1,500 Baht 4) 3,000 Baht
Mangrove forests	1) Severe damage 2) Loss	1) 300 Baht 2) 700 Baht 3) 1,500 Baht 4) 3,000 Baht

Part 3

In **Part 3**, you will be given several pairs of specific activities that may take place in the coastal area of Krabi Province and may result in resource losses in Phangnga Bay. For each pair, first select the activity you feel is more important in terms of potential impacts on coastal resources of Phangnga Bay. Second, indicate the level of importance you attach to the selected activity.

The activities you will compare in this part are:

1) Black tiger shrimp farming

Black tiger shrimp farming in Phangnga Bay often takes place in the coastal area, involving conversion of deteriorated farm land and damaged forest areas, old rubber plantations and paddy fields. Shrimp farming is often in conflict with other coastal activities in terms of land use and freshwater consumption, and possible saltwater seepage from shrimp farms into surrounding land. Because of the lack of waste water treatment systems, effluent from the farms that is released to the sea might contain organic matters and chemicals that could have negative impacts on coastal water and coastal environments.

2) Hotel development

Many new hotels are being built along the shoreline in Krabi Province to support the rapid growth in tourism. Although hotels of more than 80 rooms are required to install waste water treatment systems, more hotels often result in greater pollution to the coastal water. Related tourist development may have further impacts on coastal resources.

3) Oil spills

The oil loading activity at the proposed deep sea port in Krabi Province could increase the chance of crude oil spills. About 10% of any spilled oil could be washed up on shore and damage mangrove forests, fish and shellfish habitats and pollute the beaches in Phangnga Bay.

Table 3. Coastal activity scenarios in Phangnga Bay for comparisons in Part III.

Activity	Size of operation	Waste water treatment	Clear-cutting of mangrove
Shrimp farming	1) 25 rai 2) 50 rai 3) 50 rai	1) No 2) No 3) No	1) No 2) No 3) Yes, 20 rai
Hotel development	1) 75 rooms 2) 75 room 3) 75 room	1) Yes 2) No 3) No	1) No 2) No 3) Yes, 20 rai
Crude oil spills	1) 20,000 litre 2) 200,000 litre	- -	- -

Appendix II A. Scale values and rankings of resource losses and activities based on respondents in different gender groups.

Ban Don Bay, Part I

Resource	Female experts		Male experts		Female formal experts		Female lay experts		Male formal experts		Male layexperts	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Severe damage to mangrove forests	73.14	2	68.42	2	74.60	2	72.82	1	66.96	2	68.82	2
Clear-cutting of mangrove forests	75.14	1	72.69	1	88.89	1	72.13	2	70.98	1	73.17	1
Partial damage to mudflats	17.71	8	25.27	8	19.05	7	17.42	8	25.89	7	25.09	8
Severe damage to mudflats	48.86	5	50.63	5	50.79	4	48.43	5	50.00	5	50.81	5
Partial damage to shellfish culture grounds	25.14	7	26.72	7	9.52	8	28.57	7	24.55	8	27.33	7
Severe damage to shellfish culture grounds	51.71	4	54.32	4	47.62	5	52.61	4	56.70	4	53.66	4
Partial damage to fishing grounds	39.71	6	37.03	6	34.92	6	40.77	6	37.95	6	36.77	6
Severe damage to fishing grounds	68.86	3	64.92	3	74.60	2	67.60	3	66.96	2	64.35	3
N		50		147		9		41		32		115
Kendall u		0.3648		0.2620		0.5357		0.3352		0.2480		0.2627

Phangnga Bay, Part I

Resource	Female experts		Male experts		Female formal experts		Female lay experts		Male formal experts		Male layexperts	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Partial damage to sandy beach	15.57	8	14.18	8	5.10	8	18.33	7	6.56	8	16.90	8
Severe damage to sandy beach	40.30	6	39.72	6	22.45	7	45.01	5	33.59	6	41.90	6
Severe damage to mangrove forests	66.95	3	65.05	3	64.29	3	67.65	3	60.62	3	66.62	3
Clear-cutting of mangrove forests	87.42	1	81.46	1	88.78	1	87.06	1	83.01	2	80.91	1
Partial damage to seagrass beds	18.76	7	20.97	7	28.57	6	16.17	8	22.78	7	20.33	7
Severe damage to seagrass beds	41.79	5	45.69	5	53.06	5	38.81	6	50.19	5	44.09	5
Partial damage to coral reefs	51.39	4	55.32	4	55.10	4	50.40	4	59.85	4	53.71	4
Severe damage to coral reefs	78.04	2	77.61	2	82.65	2	76.82	2	83.40	1	75.55	2
N		67		141		14		53		37		104
Kendall u		0.4962		0.4586		0.6036		0.4858		0.5347		0.4379

Appendix II A (Continued)

Ban Don Bay, Part III

	Female experts		Male experts		Female formal experts		Female lay experts		Male formal experts		Male layexperts	
Activitiy	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	21.57	7	21.63	7	11.11	8	23.93	7	10.71	8	24.81	7
Shrimp farming , 100 rai, no clear-cut	44.90	5	41.95	5	38.10	6	46.43	5	35.27	6	43.90	5
Shrimp farming , 100 rai, clear-cut	83.67	1	81.99	1	88.89	1	82.50	1	77.23	2	83.38	1
Housing, 50 units, no clear-cut	19.24	8	21.13	8	17.46	7	19.64	8	28.57	7	18.96	8
Housing, 100 units, no clear-cut	33.24	6	39.03	6	41.27	5	31.43	6	49.55	4	35.97	6
Housing, 100 units, clear-cut	66.47	3	70.32	3	66.67	3	66.43	3	80.80	1	67.27	3
Oil spill, 20,000 litre	55.98	4	52.11	4	53.97	4	56.43	4	48.21	5	53.25	4
Oil spill, 200,000 litre	74.93	2	71.83	2	82.54	2	73.21	2	69.64	3	72.47	2
N		49		142		9		40		32		110
Kendall u		0.4088		0.3813		0.5675		0.3812		0.4423		0.3803

Phangnga Bay, Part III

	Female experts		Male experts		Female formal experts		Female lay experts		Male formal experts		Male layexperts	
Activitiy	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	18.68	7	17.46	7	20.41	7	18.21	7	17.76	7	17.35	7
Shrimp farming , 50 rai, no clear-cut	36.70	6	34.71	6	37.76	6	36.41	6	35.14	6	34.55	6
Shrimp farming , 50 rai, clear-cut	74.29	3	74.29	3	75.51	3	73.95	3	69.88	3	75.95	2
Hotel, 75 units, sewage, no clear-cut	13.63	8	9.74	8	9.18	8	14.85	8	9.27	8	9.91	8
Hotel, 75 units, no sewage, no clear-cut	46.15	5	47.72	5	46.94	5	45.94	5	41.31	5	50.15	5
Hotel, 75 units, no sewage, clear-cut	83.08	1	81.69	1	82.65	1	83.19	1	77.99	2	83.09	1
Oil spill, 20,000 litre	50.99	4	55.45	4	50.00	4	51.26	4	60.23	4	53.64	4
Oil spill, 200,000 litre	77.14	2	78.94	2	77.55	2	77.03	2	88.42	1	75.36	3
N		65		135		14		51		37		98
Kendall u		0.4903		0.5272		0.4694		0.4884		0.5556		0.5251

Appendix II B. Scale values and rankings of resource losses and activities based on respondents in different education groups.

Ban Don Bay, Part I

	Doctoral		Master		Bachelor		Diploma		High school		Middle school		Grade 4	
Resource	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Severe damage to mangrove forests	71.43	3	69.64	2	72.43	2	70.07	2	75.13	2	64.29	3	66.75	2
Clear-cutting of mangrove forests	85.71	1	83.93	1	73.09	1	65.99	3	77.78	1	70.41	1	71.43	1
Partial damage to mudflats	13.10	8	17.86	8	27.24	7	21.77	8	21.69	8	28.57	7	20.78	8
Severe damage to mudflats	40.48	6	37.50	5	54.82	4	40.82	6	51.85	4	52.55	4	49.35	5
Partial damage to shellfish culture grounds	19.05	7	28.57	7	23.26	8	28.57	7	24.87	7	28.06	8	28.05	7
Severe damage to shellfish culture grounds	51.19	4	62.50	4	53.16	5	52.38	4	51.85	4	46.94	5	60.26	4
Partial damage to fishing grounds	44.05	5	30.36	6	33.89	6	46.94	5	35.98	6	39.29	6	38.18	6
Severe damage to fishing grounds	75.00	2	69.64	2	62.13	3	74.15	1	60.85	3	69.90	2	65.19	3
N		12		8		43		21		27		28		55
Kendall u		0.4892		0.367		0.2897		0.2748		0.3183		0.2281		0.2746

Phangnga Bay, Part I

	Doctoral		Master		Bachelor		Diploma		High school		Middle school		Grade 4	
Resource	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Partial damage to sandy beach	4.08	8	8.04	8	8.12	8	11.33	8	17.37	7	18.63	8	22.36	7
Severe damage to sandy beach	22.45	7	33.04	6	34.74	6	32.02	6	47.49	5	40.37	5	47.20	5
Severe damage to mangrove forests	63.27	3	63.39	3	64.61	3	64.04	3	59.07	3	69.57	3	71.43	2
Clear-cutting of mangrove forests	85.71	1	82.14	1	86.04	1	75.86	2	81.08	1	83.23	1	86.02	1
Partial damage to seagrass beds	32.65	6	22.32	7	22.08	7	23.65	7	17.37	7	24.22	7	15.22	8
Severe damage to seagrass beds	48.98	5	55.36	4	48.70	5	47.78	5	40.93	6	40.99	5	39.44	6
Partial damage to coral reefs	57.14	4	55.36	4	55.19	4	62.07	4	57.92	4	47.83	4	47.52	4
Severe damage to coral reefs	85.71	1	80.36	2	80.84	2	83.25	1	78.76	2	75.16	2	70.81	3
N		7		16		44		29		37		23		46
Kendall u		0.5918		0.498		0.5311		0.4951		0.4412		0.4094		0.4663

Appendix II B (Continued)

Ban Don Bay, Part III

	Doctoral		Master		Bachelor		Diploma		High school		Middle school		Grade 4	
Activitiy	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	11.90	8	12.50	7	12.93	8	21.09	8	17.58	7	31.63	6	28.85	7
Shrimp farming , 100 rai, no clear-cut	34.52	6	39.29	5	37.76	6	40.14	6	41.76	5	53.06	4	45.94	5
Shrimp farming , 100 rai, clear-cut	84.52	1	80.36	2	80.95	1	76.87	1	83.52	1	83.67	1	82.63	1
Housing, 50 units, no clear-cut	23.81	7	12.50	7	25.85	7	22.45	7	15.93	8	22.96	8	19.61	8
Housing, 100 units, no clear-cut	44.05	5	32.14	6	46.60	5	42.18	5	37.91	6	31.12	7	32.77	6
Housing, 100 units, clear-cut	75.00	2	69.64	3	77.89	2	69.39	3	71.43	3	60.71	3	65.83	3
Oil spill, 20,000 litre	52.38	4	69.64	3	46.94	4	54.42	4	56.04	4	48.47	5	54.34	4
Oil spill, 200,000 litre	73.81	3	83.93	1	71.09	3	73.47	2	75.82	2	68.37	2	70.03	2
N		12		8		42		21		26		28		51
Kendall u		0.4838		0.5842		0.4266		0.3619		0.4574		0.2868		0.3545

Phangnga Bay, Part III

	Doctoral		Master		Bachelor		Diploma		High school		Middle school		Grade 4	
Activitiy	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	12.24	8	13.39	8	18.60	7	19.39	7	17.23	7	18.18	7	17.46	7
Shrimp farming , 50 rai, no clear-cut	36.73	5	26.79	6	36.88	6	38.27	6	34.87	6	39.61	6	32.70	6
Shrimp farming , 50 rai, clear-cut	67.35	3	62.50	4	72.43	3	72.96	3	74.79	3	77.92	2	79.68	2
Hotel, 75 units, sewage, no clear-cut	18.37	7	14.29	7	4.32	8	8.16	8	10.92	8	14.94	8	13.65	8
Hotel, 75 units, no sewage, no clear-cut	36.73	5	43.75	5	48.50	5	50.51	5	50.00	5	41.56	5	49.52	5
Hotel, 75 units, no sewage, clear-cut	73.47	2	79.46	2	81.40	2	81.12	1	85.71	1	79.22	1	84.44	1
Oil spill, 20,000 litre	57.14	4	66.07	3	55.81	4	50.51	4	50.84	4	55.84	4	51.43	4
Oil spill, 200,000 litre	97.96	1	93.75	1	82.06	1	79.08	2	75.63	2	72.73	3	72.06	3
N		7		16		43		28		34		22		45
Kendall u		0.5170		0.6042		0.5752		0.5017		0.5205		0.4542		0.5189

Appendix II C. Scale values and rankings of resource losses and activities based on respondents with different no. of years lived in the area.

Ban Don Bay, Part I

	Not lived in the area		Less than 6 years		6 to 10 years		11 to 20 years		21 to 30 years		more than 30 years	
Resource	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Severe damage to mangrove forests	73.95	2	71.83	2	65.38	2	63.39	2	74.79	2	69.00	2
Clear-cutting of mangrove forests	84.87	1	79.37	1	64.84	3	58.04	3	77.31	1	75.20	1
Partial damage to mudflats	20.17	8	23.02	7	27.47	8	27.23	8	22.27	8	19.68	8
Severe damage to mudflats	39.50	5	50.00	4	54.40	4	53.13	5	46.22	5	50.40	5
Partial damage to shellfish culture grounds	21.01	7	19.84	8	31.32	7	29.91	7	27.31	7	28.03	7
Severe damage to shellfish culture grounds	55.46	4	48.81	5	51.65	5	56.25	4	52.52	4	57.68	4
Partial damage to fishing grounds	36.13	6	39.68	6	36.81	6	41.52	6	33.61	6	38.81	6
Severe damage to fishing grounds	68.91	3	67.46	3	68.13	1	70.54	1	65.97	3	61.46	3
N		17		36		26		32		34		53
Kendall u		0.4128		0.3704		0.1787		0.2062		0.3313		0.2891

Phangnga Bay, Part I

	Not lived in the area		Less than 6 years		6 to 10 years		11 to 20 years		21 to 30 years		more than 30 years	
Resource	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Partial damage to sandy beach	9.24	8	10.91	8	14.29	8	12.99	8	14.29	8	21.29	7
Severe damage to sandy beach	35.29	6	36.88	6	42.21	6	39.39	6	34.18	6	47.62	4
Severe damage to mangrove forests	60.50	4	63.38	3	61.69	3	62.77	3	72.45	2	69.47	3
Clear-cutting of mangrove forests	85.71	1	84.16	1	73.38	2	80.95	2	91.33	1	83.19	1
Partial damage to seagrass beds	15.13	7	23.12	7	24.68	7	21.65	7	17.86	7	17.65	8
Severe damage to seagrass beds	43.70	5	48.31	5	44.81	5	44.16	5	40.31	5	42.02	6
Partial damage to coral reefs	65.55	3	53.77	4	58.44	4	55.84	4	54.59	4	47.62	4
Severe damage to coral reefs	84.87	2	79.74	2	80.52	1	82.25	1	75.00	3	71.15	2
N		17		55		22		33		28		51
Kendall u		0.6008		0.4935		0.3905		0.4602		0.5729		0.4198

Appendix II C (Continued)

Ban Don Bay, Part III

	Not lived in the area		Less than 6 years		6 to 10 years		11 to 20 years		21 to 30 years		more than 30 years	
Activitiy	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	17.65	7	11.84	8	17.14	8	27.14	7	25.97	7	25.27	7
Shrimp farming , 100 rai, no clear-cut	42.02	5	34.29	6	39.43	6	48.57	5	48.92	4	43.41	5
Shrimp farming , 100 rai, clear-cut	94.12	1	81.22	1	76.00	2	79.52	1	82.68	1	82.69	1
Housing, 50 units, no clear-cut	17.65	7	24.49	7	28.00	7	22.38	8	18.61	8	16.76	8
Housing, 100 units, no clear-cut	35.29	6	44.90	5	42.86	5	34.76	6	38.53	6	33.24	6
Housing, 100 units, clear-cut	75.63	2	71.43	3	77.71	1	64.76	3	67.10	3	65.66	3
Oil spill, 20,000 litre	50.42	4	55.10	4	50.86	4	52.38	4	48.05	5	57.42	4
Oil spill, 200,000 litre	67.23	3	76.73	2	68.00	3	70.48	2	70.13	2	75.55	2
N		17		35		25		30		33		52
Kendall u		0.5252		0.4466		0.3333		0.3030		0.3452		0.4157

Phangnga Bay, Part III

	Not lived in the area		Less than 6 years		6 to 10 years		11 to 20 years		21 to 30 years		more than 30 years	
Activitiy	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	17.65	7	18.60	7	16.88	7	17.51	7	16.84	7	18.24	7
Shrimp farming , 50 rai, no clear-cut	41.18	6	37.47	6	32.47	6	35.48	6	33.16	6	33.13	6
Shrimp farming , 50 rai, clear-cut	75.63	3	73.32	3	71.43	3	70.97	3	73.98	3	77.20	2
Hotel, 75 units, sewage, no clear-cut	9.24	8	7.01	8	12.34	8	13.82	8	13.78	8	11.25	8
Hotel, 75 units, no sewage, no clear-cut	42.02	5	48.25	5	50.65	5	42.40	5	48.47	5	49.24	5
Hotel, 75 units, no sewage, clear-cut	79.83	2	81.94	1	82.47	1	82.03	1	83.67	1	82.37	1
Oil spill, 20,000 litre	48.74	4	54.72	4	53.90	4	57.14	4	55.61	4	53.50	4
Oil spill, 200,000 litre	85.71	1	78.71	2	79.87	2	80.65	2	74.49	2	75.99	3
N		17		53		22		31		28		47
Kendall u		0.5095		0.5322		0.5257		0.5235		0.4788		0.5093

Appendix II D Scale values and rankings of resource losses and activities based on age groups.

Ban Don Bay, Part I

Resource	Less than 21		21 to 30 years		31 to 40 years		41 to 50 years		51 to 60 years		more than 60 years	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Severe damage to mangrove forests	75.00	2	72.91	1	68.49	2	70.43	2	66.07	3	54.76	4
Clear-cutting of mangrove forests	85.71	1	71.18	2	72.80	1	76.41	1	75.00	1	61.90	3
Partial damage to mudflats	25.00	7	23.89	8	23.68	8	22.59	8	19.64	8	19.05	8
Severe damage to mudflats	57.14	3	48.52	5	50.49	5	50.17	5	47.32	5	52.38	5
Partial damage to shellfish culture grounds	21.43	8	27.09	7	27.40	7	24.92	7	22.32	7	30.95	7
Severe damage to shellfish culture grounds	53.57	4	52.71	4	52.84	4	54.15	4	56.25	4	71.43	1
Partial damage to fishing grounds	32.14	6	37.19	6	37.77	6	37.21	6	42.86	6	38.10	6
Severe damage to fishing grounds	50.00	5	66.50	3	66.73	3	64.12	3	70.54	2	71.43	1
N		4		58		73		43		16		6
Kendall u		0.2500		0.2911		0.2669		0.3071		0.3042		0.1857

Phangnga Bay, Part I

Resource	Less than 21		21 to 30 years		31 to 40 years		41 to 50 years		51 to 60 years		more than 60 years	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Partial damage to sandy beach	15.24	8	12.18	8	15.08	8	13.39	8	23.21	7	20.00	7
Severe damage to sandy beach	40.00	5	38.03	6	40.67	6	39.73	6	45.54	5	37.14	6
Severe damage to mangrove forests	64.76	2	63.87	3	69.64	3	60.71	3	64.29	3	71.43	2
Clear-cutting of mangrove forests	88.57	1	84.45	1	81.75	1	81.70	1	82.14	1	91.43	1
Partial damage to seagrass beds	17.14	7	21.85	7	19.44	7	21.43	7	17.86	8	20.00	7
Severe damage to seagrass beds	40.00	5	44.54	5	44.44	5	46.43	5	44.64	6	42.86	5
Partial damage to coral reefs	55.24	4	56.09	4	52.38	4	56.25	4	50.00	4	45.71	4
Severe damage to coral reefs	79.05	2	79.20	2	76.59	2	80.36	2	72.32	2	71.43	2
N		15		68		72		32		16		5
Kendall u		0.4952		0.4945		0.4655		0.4568		0.3714		0.4000

Appendix II D (Continued)

Ban Don Bay, Part III

Activitiy	Less than 21		21 to 30 years		31 to 40 years		41 to 50 years		51 to 60 years		more than 60 years	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	17.86	8	21.82	7	25.64	7	15.31	8	21.90	7	14.29	8
Shrimp farming , 100 rai, no clear-cut	32.14	6	45.71	5	45.79	5	36.05	6	39.05	5	45.71	5
Shrimp farming , 100 rai, clear-cut	89.29	1	85.19	1	81.80	1	79.93	1	79.05	1	82.86	1
Housing, 50 units, no clear-cut	32.14	6	19.74	8	19.37	8	24.49	7	20.00	8	17.14	7
Housing, 100 units, no clear-cut	39.29	5	36.88	6	35.23	6	43.54	5	39.05	5	28.57	6
Housing, 100 units, clear-cut	75.00	2	65.71	3	67.71	3	74.49	2	72.38	3	77.14	2
Oil spill, 20,000 litre	46.43	4	52.73	4	51.66	4	55.44	4	54.29	4	57.14	4
Oil spill, 200,000 litre	67.86	3	72.21	2	72.80	2	70.75	3	74.29	2	77.14	2
N		4		55		73		42		15		5
Kendall u		0.3810		0.3801		0.3756		0.4029		0.3796		0.5000

Phangnga Bay, Part III

Activitiy	Less than 21		21 to 30 years		31 to 40 years		41 to 50 years		51 to 60 years		more than 60 years	
	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank	Scale value	Rank
Shrimp farming , 25 rai, no clear-cut	15.24	7	17.44	7	19.12	7	16.59	7	19.05	7	19.05	8
Shrimp farming , 50 rai, no clear-cut	39.05	5	35.08	6	35.29	6	34.10	6	37.14	6	28.57	6
Shrimp farming , 50 rai, clear-cut	75.24	3	73.53	3	72.90	3	78.80	2	72.38	2	80.95	2
Hotel, 75 units, sewage, no clear-cut	9.52	8	10.71	8	11.34	8	9.68	8	12.38	8	23.81	7
Hotel, 75 units, no sewage, no clear-cut	39.05	5	48.53	5	44.54	5	48.85	5	57.14	4	52.38	4
Hotel, 75 units, no sewage, clear-cut	78.10	2	84.03	1	79.20	2	82.95	1	88.57	1	85.71	1
Oil spill, 20,000 litre	58.10	4	53.36	4	56.93	4	52.53	4	41.90	5	57.14	3
Oil spill, 200,000 litre	85.71	1	77.31	2	81.30	1	76.50	3	71.43	3	52.38	4
N		15		68		68		31		15		3
Kendall u		0.5429		0.5217		0.5076		0.5499		0.4694		0.3810

Appendix III A. Kendall correlation coefficient T of the rankings of resource losses and impacting activities by respondents in different gender groups.

Ban Don Bay Part I

		FALL	MALL	FFOR	MFOR	FLAY	MLAY
Correlation coefficient*	FALL	1.0000					
	MALL	1.0000	1.0000				
	FFOR	0.7857	0.7857	1.0000			
	MFOR	0.8571	0.8571	0.9286	1.0000		
	FLAY	0.9286	0.9286	0.7143	0.7857	1.0000	
	MLAY	1.0000	1.0000	0.7857	0.8571	0.9286	1.0000

Phangnga Bay Part I

		FALL	MALL	FFOR	MFOR	FLAY	MLAY
Correlation coefficient*	FALL	1.0000					
	MALL	1.0000	1.0000				
	FFOR	0.9286	0.9286	1.0000			
	MFOR	0.8571	0.8571	0.7857	1.0000		
	FLAY	0.8571	0.8571	0.7857	0.7143	1.0000	
	MLAY	1.0000	1.0000	0.9286	0.8571	0.8571	1.0000

Ban Don Bay Part III

		FALL	MALL	FFOR	MFOR	FLAY	MLAY
Correlation coefficient*	FALL	1.0000					
	MALL	1.0000	1.0000				
	FFOR	0.8571	0.8571	1.0000			
	MFOR	0.6429	0.6429	0.7857	1.0000		
	FLAY	1.0000	1.0000	0.8571	0.6429	1.0000	
	MLAY	1.0000	1.0000	0.8571	0.6429	1.0000	1.0000

Phangnga Bay Part III

		FALL	MALL	FFOR	MFOR	FLAY	MLAY
Correlation coefficient*	FALL	1.0000					
	MALL	1.0000	1.0000				
	FFOR	1.0000	1.0000	1.0000			
	MFOR	0.9286	0.9286	0.9286	1.0000		
	FLAY	1.0000	1.0000	1.0000	0.9286	1.0000	
	MLAY	0.9286	0.9286	0.9286	0.8571	0.9286	1.0000

* All correlations are significant at the alpha level 0.05.

FALL	All female respondents
MALL	All male respondents
FFOR	Female formal experts
MFOR	Male formal experts
FLAY	Female layexperts
MLAY	Male layexperts

Appendix III B. Kendall correlation coefficient T of the rankings of resource losses and impacting activities by respondents in different education groups.

Ban Don Bay Part I

		PHD	MS	BS	DIP	HS	JH	G4
Correlation coefficient*	PHD	1.0000						
	MS	0.9092	1.0000					
	BS	0.6429	0.6910	1.0000				
	DIP	0.8571	0.7638	0.6429	1.0000			
	HS	0.8571	0.9092	0.7857	0.7143	1.0000		
	JH	0.8571	0.9092	0.7857	0.7143	0.8571	1.0000	
	G4	0.8571	0.9092	0.7857	0.7143	1.0000	0.8571	1.0000

Phangnga Bay Part I

		PHD	MS	BS	DIP	HS	JH	G4
Correlation coefficient*	PHD	1.0000						
	MS	0.9092	1.0000					
	BS	0.9286	0.9820	1.0000				
	DIP	0.8571	0.9092	0.9286	1.0000			
	HS	0.6429	0.6910	0.7143	0.7857	1.0000		
	JH	0.8571	0.9092	0.9286	0.8571	0.7857	1.0000	
	G4	0.7143	0.7638	0.7857	0.7143	0.7857	0.8571	1.0000

Ban Don Bay Part III

		PHD	MS	BS	DIP	HS	JH	G4
Correlation coefficient*	PHD	1.0000						
	MS	0.7412	1.0000					
	BS	1.0000	0.7412	1.0000				
	DIP	0.8571	0.8154	0.8571	1.0000			
	HS	0.7857	0.8895	0.7857	0.9286	1.0000		
	JH	0.6429	0.7412	0.6429	0.7857	0.8571	1.0000	
	G4	0.7857	0.8895	0.7857	0.9286	1.0000	0.8571	1.0000

Phangnga Bay Part III

		PHD	MS	BS	DIP	HS	JH	G4
Correlation coefficient*	PHD	1.0000						
	MS	0.9286	1.0000					
	BS	0.9286	0.8571	1.0000				
	DIP	0.8571	0.7857	0.9286	1.0000			
	HS	0.7857	0.7143	0.8571	0.9286	1.0000		
	JH	0.7638	0.6910	0.8365	0.9092	0.8365	1.0000	
	G4	0.7857	0.7143	0.8571	0.9286	0.8571	0.9820	1.0000

* All correlations are significant at the alpha level 0.05.

PHD	Ph.D.
MS	Master's degree
BS	Bachelor's degree
DIP	Diploma
HS	High school
JH	Junior high school
G4	Grade 4

Appendix III C. Kendall correlation coefficient T of the rankings of resource losses and impacting activities by respondents with different number of years lived in the area.

Ban Don Bay Part I

		NA	Y5	Y10	Y20	Y30	YM
Correlation coefficient*	NA	1.0000					
	Y5	0.8571	1.0000				
	Y10	0.7143	0.7143	1.0000			
	Y20	0.7857	0.6429	0.9286	1.0000		
	Y30	1.0000	0.8571	0.7143	0.7857	1.0000	
	YM	1.0000	0.8571	0.7143	0.7857	1.0000	1.0000

Phangnga Bay Part I

		NA	Y5	Y10	Y20	Y30	YM
Correlation coefficient*	NA	1.0000					
	Y5	0.9286	1.0000				
	Y10	0.8571	0.9286	1.0000			
	Y20	0.8571	0.9286	1.0000	1.0000		
	Y30	0.9286	1.0000	0.9286	0.9286	1.0000	
	YM	0.7143	0.7857	0.7143	0.7143	0.7857	1.0000

Ban Don Bay Part III

		NA	Y5	Y10	Y20	Y30	YM
Correlation coefficient*	NA	1.0000					
	Y5	0.8571	1.0000				
	Y10	0.9286	0.9286	1.0000			
	Y20	0.8571	0.8571	0.7857	1.0000		
	Y30	0.7857	0.7857	0.7143	0.9286	1.0000	
	YM	0.8571	0.8571	0.7857	1.0000	0.9286	1.0000

Phangnga Bay Part III

		NA	Y5	Y10	Y20	Y30	YM
Correlation coefficient*	NA	1.0000					
	Y5	0.9286	1.0000				
	Y10	0.9286	1.0000	1.0000			
	Y20	0.9286	1.0000	1.0000	1.0000		
	Y30	0.8571	0.9286	0.9286	0.9286	1.0000	1.0000
	YM	0.8571	0.9286	0.9286	0.9286	1.0000	1.0000

* All correlations are significant at the alpha level 0.05.

NA	Never lived in the area
Y5	Lived there for no more than 5 years
Y10	Lived there for no more than 10 years
Y20	Lived there for no more than 20 years
Y30	Lived there for no more than 30 years
YM	Lived there for more than 30 years

Appendix III D. Kendall correlation coefficient T of the rankings of resource losses and impacting activities by respondents in different age groups.

Ban Don Bay Part I

		A20	A30	A40	A50	A60	AM
Correlation coefficient*	A20	1.0000					
	A30	0.6910	1.0000				
	A40	0.7638	0.9286	1.0000			
	A50	0.7638	0.9286	1.0000	1.0000		
	A60	0.6910	0.8571	0.9286	0.9286	1.0000	
	AM	0.4728	0.6429	0.7143	0.7143	0.7857	1.0000

Phangnga Bay Part I

		A20	A30	A40	A50	A60	AM
Correlation coefficient*	A20	1.0000					
	A30	0.9286	1.0000				
	A40	0.9286	1.0000	1.0000			
	A50	0.9286	1.0000	1.0000	1.0000		
	A60	0.9286	0.8571	0.8571	0.8571	1.0000	
	AM	0.9286	0.8571	0.8571	0.8571	1.0000	1.0000

Ban Don Bay Part III

		A20	A30	A40	A50	A60	AM
Correlation coefficient*	A20	1.0000					
	A30	0.6910	1.0000				
	A40	0.6910	1.0000	1.0000			
	A50	0.9092	0.7857	0.7857	1.0000		
	A60	0.7407	0.9820	0.9820	0.8365	1.0000	
	AM	0.8148	0.9092	0.9092	0.9092	0.9259	1.0000

Phangnga Bay Part III

		A20	A30	A40	A50	A60	AM
Correlation coefficient*	A20	1.0000					
	A30	0.9286	1.0000				
	A40	1.0000	0.9286	1.0000			
	A50	0.8571	0.9286	0.8571	1.0000		
	A60	0.7857	0.8571	0.7857	0.9286	1.0000	
	AM	0.6429	0.7143	0.6429	0.7857	0.7143	1.0000

* All correlations are significant at the alpha level 0.05.

A20	less than 21 years old
A30	between 21-30 years old
A40	between 31-40 years old
A50	between 41-50 years old
A60	between 51-60 years old
AM	more than 60 years old

Appendix IV. Results of Kruskal-Wallis tests of the rankings obtained from respondents with different attributes.

Ban Don Bay

	Chi-square*			
Resource loss	Gender	Educatio	Years	Age
Severe damage to mangrove forests	3.9594	5.8047	5.3378	3.3686
Clear-cutting of mangrove forests	5.4264	7.5275	17.1813*	2.6694
Partial damage to mudflats	5.7622	8.7286	5.713	0.9249
Severe damage to mudflats	0.4644	13.2239	6.5962	1.3599
Partial damage to shellfish culture grounds	6.2874	3.9800	7.0640	0.7819
Severe damage to shellfish culture grounds	1.2593	7.4875	3.3429	4.0909
Partial damage to fishing grounds	1.4576	7.8858	3.1556	1.5311
Severe damage to fishing grounds	2.9320	12.4900	5.8948	3.6638

Ban Don Bay

	Chi-square*			
Impacting activities	Gender	Educatio	Years	Age
Shrimp farming , 25 rai, no clear-cut	15.3608*	27.4534*	15.8463*	8.1553
Shrimp farming , 100 rai, no clear-cut	7.1642	13.5340*	12.6869*	9.7005
Shrimp farming , 100 rai, clear-cut	1.6492	1.4715	9.8325	3.0374
Housing, 50 units, no clear-cut	5.9709	9.2500*	8.772	3.5969
Housing, 100 units, no clear-cut	14.9678*	16.1209*	10.8876	5.6241
Housing, 100 units, clear-cut	15.1383*	15.5348*	12.6390*	8.5026
Oil spill, 20,000 Litre	1.6381	7.2023	3.0998	0.9762
Oil spill, 200,000 Litre	3.3716	4.4368	5.6106	0.8788

Phangnga Bay

	Chi-square*			
Resource loss	Gender	Educatio	Years	Age
Partial damage to sandy beach	19.0897*	25.2216*	13.4409*	7.8401
Severe damage to sandy beach	19.5088*	24.3101*	13.0673*	2.0617
Severe damage to mangrove forests	2.4980	10.2738	7.7391	7.1858
Clear-cutting of mangrove forests	3.2592	4.0663	4.8220	2.3947
Partial damage to seagrass beds	6.9987	15.2276*	6.6624	2.5033
Severe damage to seagrass beds	13.1658*	15.9549*	6.0388	1.7501
Partial damage to coral reefs	5.0400	16.2254*	14.9569*	4.5967
Severe damage to coral reefs	6.4496	11.1611	12.7897*	3.8749

Phangnga Bay

	Chi-square*			
Impacting activities	Gender	Educatio	Years	Age
Shrimp farming , 25 rai, no clear-cut	0.5160	4.3483	0.2278	2.4746
Shrimp farming , 50 rai, no clear-cut	0.7689	10.4400	4.9059	2.7536
Shrimp farming , 50 rai, clear-cut	3.3411	13.6485*	3.3811	3.3096
Hotel, 75 units, sewage, no clear-cut	3.6529	20.3773*	6.5153	2.5900
Hotel, 75 units, no sewage, no clear-cut	5.8039	5.7003	4.8406	8.4723
Hotel, 75 units, no sewage, clear-cut	3.0900	7.9356	0.5086	7.4814
Oil spill, 20,000 Litre	6.0622	10.2676	1.8922	6.2586
Oil spill, 200,000 Litre	12.9364*	28.0982*	4.2105	10.2420

* denotes significantly difference chi-square value at alpha level 0.05; degrees of freedom for gender, education, years and age are 3, 6, 5, 5 respectively.

Appendix V Respondents' opinion on the management of Thai coastal resources.

Ban Don Bay

	Statement	Formal experts					Layexperts				
		strongly agree	agree	disagree	strongly disagree	no opinion	strongly agree	agree	disagree	strongly disagree	no opinion
1	Coastal resources of Thailand, in general, are degrading.	90.24	7.32			2.44	61.88	30.00	2.50	3.13	2.50
2	Coastal resources are being heavily exploited for various purposes.	73.17	24.39			2.44	28.66	52.87	13.38	2.55	2.55
3	Coastal resource management policies of Thailand are effective.	2.44	9.76	56.10	24.39	7.32	16.46	27.85	35.44	13.29	6.96
4	Management of the coastal resources is the sole responsibility of the government.	2.44		34.15	60.98	2.44	8.28	9.55	53.50	25.48	3.18
5	Non-government organizations play an important role in the management of coastal resources.	19.51	46.34	14.63	2.44	17.07	20.25	44.94	15.82	2.53	16.46
6	It is difficult to get stakeholders to collaborate with the government in resource management.	9.76	39.02	36.59	9.76	4.88	14.47	41.51	34.59	3.77	5.66
7	Priority in resource allocation should be given to activities that create greatest economic returns.	9.76	17.07	36.59	36.59		22.01	29.56	31.45	8.81	8.18
8	Resource users should be involved in the management of coastal resources.	58.54	41.46				39.62	53.46	4.40	1.26	1.26
9	There is no need to consider scenic values in the management of coastal resources.	2.44	2.44	58.54	36.59		10.19	18.47	48.41	14.65	8.28
10	Resources are to be used now, not to keep for future generations.	4.88	2.44	21.95	70.73		12.10	8.28	38.22	36.94	4.46

Appendix V (Continued)

Phangnga Bay

	Statement	Formal experts					Layexperts				
		strongly agree	agree	disagree	strongly disagree	no opinion	strongly agree	agree	disagree	strongly disagree	no opinion
1	Coastal resources of Thailand, in general, are degrading.	70.59	29.41				59.62	32.69	3.21	3.21	1.28
2	Coastal resources are being heavily exploited for various purposes.	52.94	45.10	1.96			34.42	47.40	12.34	3.90	1.95
3	Coastal resource management policies of Thailand are effective.	1.96	21.57	43.14	21.57	11.76	16.88	31.82	31.17	5.84	14.29
4	Management of the coastal resources is the sole responsibility of the government.	1.96	1.96	27.45	68.63		4.52	7.74	51.61	31.61	4.52
5	Non-government organizations play an important role in the management of coastal resources.	5.88	52.94	19.61	1.96	19.61	10.97	49.68	11.61	5.81	21.94
6	It is difficult to get stakeholders to collaborate with the government in resource management.	13.73	37.25	41.18	7.84		10.90	46.15	29.49	7.69	5.77
7	Priority in resource allocation should be given to activities that create greatest economic returns.	7.84	17.65	49.02	17.65	7.84	21.29	28.39	34.19	10.32	5.81
8	Resource users should be involved in the management of coastal resources.	66.67	33.33				37.82	55.77	3.21	0.64	2.56
9	There is no need to consider scenic values in the management of coastal resources.		3.92	60.78	33.33	1.96	7.79	12.99	47.40	25.97	5.84
10	Resources are to be used now, not to keep for future generations.		7.84	19.61	72.55		7.69	5.77	37.18	46.15	3.21

Appendix VI Proportions of respondents rejecting money, by expert groups.

Ban Don Bay

Formal experts

Formal experts	Consistent (15)					Consistent + Inconsistent (15+7=22)					Consistent + inconsistent + no trade (22+20=42)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.800	0.733	0.667	0.533	1.000	0.857	0.810	0.667	0.667	1.000	0.927	0.902	0.829	0.829
Clear-cutting of mangrove forests	1.000	0.867	0.867	0.733	0.600	1.000	0.864	0.864	0.727	0.591	1.000	0.929	0.929	0.857	0.786
Partial damage to mudflats	1.000	0.733	0.667	0.467	0.067	1.000	0.773	0.682	0.500	0.227	1.000	0.881	0.833	0.738	0.595
Severe damage to mudflats	1.000	0.867	0.733	0.667	0.400	1.000	0.909	0.727	0.682	0.455	1.000	0.952	0.857	0.833	0.714

Fishers

Fishers	Consistent (10)					Consistent + Inconsistent (10+19=29)					Consistent + inconsistent + no trade (29+18=47)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.700	0.700	0.600	0.500	1.000	0.875	0.875	0.833	0.917	1.000	0.929	0.929	0.905	0.952
Clear-cutting of mangrove forests	1.000	0.900	0.700	0.700	0.500	1.000	0.962	0.769	0.846	0.846	1.000	0.977	0.864	0.909	0.909
Partial damage to mudflats	1.000	0.800	0.600	0.400	0.100	1.000	0.920	0.760	0.560	0.400	1.000	0.953	0.860	0.744	0.651
Severe damage to mudflats	1.000	0.800	0.800	0.600	0.600	1.000	0.923	0.885	0.692	0.692	1.000	0.955	0.932	0.818	0.818

Shrimp farmers

Shrimp farmers	Consistent (9)					Consistent + Inconsistent (9+8=17)					Consistent + inconsistent + no trade (17+23=40)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.889	0.889	0.889	0.889	1.000	0.938	0.938	0.813	0.875	1.000	0.974	0.974	0.923	0.949
Clear-cutting of mangrove forests	1.000	1.000	0.889	0.889	0.889	1.000	1.000	0.938	0.813	0.813	1.000	1.000	0.974	0.923	0.923
Partial damage to mudflats	1.000	0.667	0.667	0.556	0.000	1.000	0.786	0.714	0.571	0.286	1.000	0.919	0.892	0.838	0.730
Severe damage to mudflats	1.000	1.000	0.889	0.667	0.444	1.000	1.000	1.000	0.929	0.786	1.000	1.000	1.000	0.973	0.919

Shellfish culturers

Shellfish culturers	Consistent (10)					Consistent + Inconsistent (10+8=18)					Consistent + inconsistent + no trade (18+26=44)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.800	0.800	0.800	0.700	1.000	0.889	0.778	0.833	0.722	1.000	0.955	0.909	0.932	0.886
Clear-cutting of mangrove forests	1.000	0.800	0.800	0.800	0.800	1.000	0.889	0.778	0.667	0.833	1.000	0.955	0.909	0.864	0.932
Partial damage to mudflats	1.000	0.700	0.600	0.200	0.000	1.000	0.824	0.824	0.353	0.412	1.000	0.930	0.930	0.744	0.767
Severe damage to mudflats	1.000	0.800	0.800	0.600	0.400	1.000	0.867	0.867	0.733	0.600	1.000	0.951	0.951	0.902	0.854

Others

Others	Consistent (8)					Consistent + Inconsistent (8+13=21)					Consistent + inconsistent + no trade (21+14=35)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Severe damage to mangrove forests	1.000	0.875	0.875	0.750	0.750	1.000	0.944	1.000	1.000	1.000	1.000	0.969	1.000	1.000	1.000
Clear-cutting of mangrove forests	1.000	0.875	0.875	0.875	0.750	1.000	0.947	0.842	0.842	0.842	1.000	0.970	0.909	0.909	0.909
Partial damage to mudflats	1.000	0.750	0.375	0.125	0.000	1.000	0.889	0.444	0.278	0.167	1.000	0.938	0.688	0.594	0.531
Severe damage to mudflats	1.000	0.750	0.750	0.500	0.375	1.000	0.846	1.077	0.692	0.615	1.000	0.926	1.037	0.852	0.815

Appendix VI (Continued)

Phangnga Bay

	Consistent choices					**Consistent + inconsistent**					**Consistent + inconsistent + no trade**				
	Formal experts (26)					Formal experts (26+12=38)					Formal experts (38+14=52)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.731	0.423	0.231	0.038	1.000	0.806	0.444	0.306	0.111	1.000	0.860	0.600	0.500	0.360
Severe damage to sandy beaches	1.000	0.808	0.769	0.731	0.423	1.000	0.861	0.778	0.694	0.444	1.000	0.900	0.840	0.780	0.600
Severe damage to mangrove forests	1.000	0.923	0.808	0.538	0.462	1.000	0.946	0.838	0.622	0.514	1.000	0.961	0.882	0.725	0.647
Clear-cutting of mangrove forests	1.000	0.923	0.923	0.808	0.654	1.000	0.946	0.892	0.865	0.676	1.000	0.961	0.922	0.902	0.765
	Fishers (11)					Fishers (11+18=29)					Fishers (29+16=45)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.727	0.636	0.364	0.000	1.000	0.864	0.682	0.500	0.409	1.000	0.921	0.816	0.711	0.658
Severe damage to sandy beaches	1.000	0.818	0.818	0.545	0.455	1.000	0.920	0.960	0.720	0.600	1.000	0.951	0.976	0.829	0.756
Severe damage to mangrove forests	1.000	0.818	0.818	0.727	0.727	1.000	0.913	0.913	0.826	0.870	1.000	0.949	0.949	0.897	0.923
Clear-cutting of mangrove forests	1.000	0.909	0.818	0.818	0.727	1.000	0.962	0.962	0.846	0.808	1.000	0.976	0.976	0.905	0.881
	Shrimp farmers (9-1)					Shrimp farmers (9+14=23)					Shrimp farmers (23+15=38)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.444	0.333	0.111	0.000	1.000	0.762	0.429	0.238	0.190	1.000	0.861	0.667	0.556	0.528
Severe damage to sandy beaches	1.000	0.667	0.444	0.333	0.222	1.000	0.850	0.700	0.700	0.400	1.000	0.914	0.829	0.829	0.657
Severe damage to mangrove forests	1.000	0.667	0.556	0.444	0.333	1.000	0.850	0.700	0.600	0.650	1.000	0.914	0.829	0.771	0.800
Clear-cutting of mangrove forests	1.000	0.778	0.667	0.667	0.444	1.000	0.909	0.727	0.864	0.545	1.000	0.946	0.838	0.919	0.730
	Tourism (10)					Tourism (10+10=20)					Tourism (20+19=39)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.400	0.400	0.300	0.100	1.000	0.647	0.588	0.471	0.235	1.000	0.833	0.806	0.750	0.639
Severe damage to sandy beaches	1.000	0.700	0.700	0.600	0.500	1.000	0.813	0.875	0.688	0.625	1.000	0.914	0.943	0.857	0.829
Severe damage to mangrove forests	1.000	0.900	0.800	0.800	0.400	1.000	0.950	0.850	0.750	0.600	1.000	0.974	0.923	0.872	0.795
Clear-cutting of mangrove forests	1.000	1.000	0.900	0.800	0.600	1.000	1.000	0.895	0.842	0.632	1.000	1.000	0.947	0.921	0.816
	Others (14-1)					Others (14+19=33)					Others (33+13=46)				
	<300	300	700	1500	3000	<300	300	700	1500	3000	<300	300	700	1500	3000
Partial damage to sandy beaches	1.000	0.571	0.429	0.071	0.000	1.000	0.800	0.533	0.300	0.300	1.000	0.860	0.674	0.512	0.512
Severe damage to sandy beaches	1.000	0.929	0.786	0.571	0.286	1.000	0.966	0.897	0.655	0.414	1.000	0.976	0.929	0.762	0.595
Severe damage to mangrove forests	1.000	0.929	0.929	0.929	0.857	1.000	0.968	0.935	0.871	0.774	1.000	0.977	0.955	0.909	0.841
Clear-cutting of mangrove forests	1.000	0.929	0.929	0.929	0.929	1.000	0.970	0.879	0.879	0.758	1.000	0.978	0.913	0.913	0.826