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AN APPROACH TO COASTAL RESOURCE UTILIZATION: THE NATURE AND ROLE OF SUSTAINABLE DEVELOPMENT IN EAST KALIMANTAN COASTAL ZONE, INDONESIA

by

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled: "An Approach to Coastal Resource Utilization: The Nature and Role of Sustainable Development in East Kalimantan Coastal Zone, Indonesia"

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ABSTRACT

The thesis identifies sustainable development principles as they are emerging within Indonesia and translates these into practical planning and decision-making criteria and processes for coastal resource development, using East Kalimantan as a case study.

The ARC/INFO GIS (Geographic Information System) is used to indicate coastal areas that are ecologically suitable and available for 14 development activities, ranging from wetland rice to tambak (brackishwater shrimp/fish pond). An integrated economic-ecological model provides a framework for examining the trade-off between economic gains and environmental degradation of multiple-resource uses over time. Four major development activities (oil, LNG, fertilizer, and tambak) are analyzed in the model. The model demonstrates the contribution of each activity as a share of total profit and as environmental costs in the form of coastal water pollution and mangrove degradation. The greatest potential environmental costs appear to be associated with direct population effects through coastal land opening and domestic sewage. Since oil and gas reserves deplete, tambak will be the greatest contributor to the social benefit in the long-run.

Drawing on the insights gained from the spatial planning and the economic-ecological modelling analyses, and other analyses pertaining to the cultural, socioeconomic and institutional setting, a management framework is offered for sustainable coastal development.

ACRONYMS AND ABBREVIATIONS

APBD	Anggaran Pendapatan dan Belanja Daerah (regional government development funds)
APBN	Anggaran Pendapatan dan Belanja Negara (national government development funds/national budget)
ASEAN	Association of South East Asia Nations
BAPPEDA	Badan Perencanaan Pembangunan Daerah (Regional Development Planning Agency)
BKLH	Biro Kependudukan dan Lingkungan Hidup (Provincial Population and Environment Bureau)
BKPMD	Badan Koordinasi Penanaman Modal Daerah (Provincial Investment Co-ordinating Board)
BLK	Balai Latihan Ketrampilan Kerja (Vocational Training Centre of the Ministry of Manpower)
BOD	Biological Oxygen Demand
CRM	Coastal Resource Management
CSR	Centre for Soil Research
Dati I	Daerah Tingkat I (Province)
DIP	Daftar Isian Proyek (list of projects with budget requests which are proposed for funding through the APBN)
DIPDA	Daftar Isian Proyek Daerah (list of projects with budget requests which are proposed for funding through APBD)
DPR	Dewan Perwakilan Rakyat (National Assembly)
DUPDA	Daftar Usulan Proyek Daerah (list of project proposals prepared for possible funding through the APBD)
EIA	Environmental Impact Assessment

EPA	Environmental Protection Agency (USA)
ESRI	Environmental System Research Institute
FAO	Food and Agriculture Organization
FMG	Bay of Fundy/Gulf of Maine/Georges Bank
GBHN	Garis-garis Besar Haluan Negara (State Policy Guidelines)
GIS/RS	Geographic Information Systems/Remote Sensing
GIS	Geographic Information Systems
GNP	Gross National Product
GOI	Government of Indonesia
GPS	Geographic Positioning Satellite
Humas	Hubungan Masyarakat (Human Relations)
ICRM	Integrated Coastal Resource Management
ITCZ	Intertropical Convergence Zone
IUCN	International Union for Conservation of Nature
KUD	Koperasi Unit Desa (government-supported village Co-operative)
Lemhanas	Lembaga Pertahanan Nasional (National Defence Agency)
LNG	Liquified Natural Gas
LRDC	Land Resources Development Centre
MPR	Majelis Permusyawaratan Rakyat (People's Consultative Assembly/Congress)
MSY	Maximum Sustainable Yield
MTPSP	Medium Term Planning Support Project
NGO	Non Governmental Organization
OPEC	Organization of Petroleum Exporting Countries

Pelita	Pembangunan Lima Tahun (Five-year Development)
PT	Perseroan Terbatas (Company Limited)
Repelita	Rencana Pembangunan Lima Tahun (Five-year National Development Plan)
Repelitada	Rencana Pembangunan Lima Tahun Daerah (Five-year Regional Development Plan)
Repetada	Rencana Pembangunan Tahunan Daerah (Annual Regional Development Plan)
RGDP	Regional Gross Domestic Product
UNOCAL	Union California
UTM	Universal Transverse Mercator
WCED	World Commission for Environment and Development
WRI	World Resources Institute

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I. INTRODUCTION

1.1. RATIONALE OF THE STUDY

Indonesia, a developing nation, has been striving to improve its wellbeing since the initiation of the First Five Year Development Plan (REPELITA I) in 1969/1970. Through a systematic economic development planning process, the nation has produced some remarkable achievements. Basic human needs (i.e. food, clothing, housing, health and educational services), which used to be a privilege for only a few, are now accessible to the majority of the population.

According to Walton (1990), in 1970 those who lived under the poverty line amounted to about 58 % of the population (67.9 million), while in 1987 the number has decreased to 30 million (17% of the population). A psychologically important success of the national development endeavour has been the shift from being the largest rice importer in the world to becoming self sufficient in rice since 1986. Not surprisingly, Indonesia's economic position in the world also has moved from being a poor-income country to a middle-income one (Wardhana, 1987).

Without doubt the sustained success of this economic development has relied heavily on the nation's wealth in natural resources, both renewable (e.g. forests, agricultural land and fisheries) and non renewable (e.g. oil and gas, tin, coal, bauxite and iron ores). Most of these resources are found within the country's coastal zone (Canada/Indonesia MTPSP, 1988).

Yet, many of these resource bases have been depleted and their sustainability is threatened by incompatible development activities. Oil and gas, which contribute more than 50 % of the country GNP, are expected to be exhausted by the year 2020 (Lemhanas, 1989). Deforestation through both commercial logging and shifting cultivation has reached a level that harms the sustainable capacity of forest resources as the second largest contributor to the country's economy. Soil erosion and indiscriminate conversion of agricultural lands to other purposes, including Java where the most fertile soil occurs, have generated the most challenging assignment for agricultural planners in maintaining the country's rice self-sufficiency. Furthermore, several coastal waters close to major population concentrations, like the North Coast of Java and Malacca Strait, already experience overfishing and polluted conditions (Sujastani, 1981; Burbridge et al., 1988).

Given that poverty is still lingering in a considerable fraction of the population, the nation has to increase its economic development. As a corollary, more natural resources will have to be harnessed and pollution levels in populated areas may also be magnified. Unless development policies and programs are designed prudently with full environmental considerations, more resource bases will be in jeopardy and thereby threaten the sustainability of economic development itself.

Although considerable efforts have been made to shift the country's economic reliance to the secondary sector (industry and manufacturing) and the tertiary sector (trade and services), the primary base economy (the extraction of natural resources) will still be the dominant sector at least until "the take-off period"[1] which is assumed to be started by the year 2000. In addition, experiences from developed countries such as North America, Western Europe and Japan have shown that no matter how advanced the industrialization of a country is, the integrity of the environment with its embodied resources remains an essential ingredient for sustained economic development as well as for the welfare of the people (Brown, 1981; WCED, 1987; and Starke, 1990).

The challenge for the Indonesian government is then how to best utilize its valuable natural resources while maintaining an ecological and social-economic balance. In other words, it is the question of how to implement sustainable principles, which have gained popular acceptance since the publication of "Our Common Future" by the World Commission on Environment and Development in 1987, into practical development policies and actions.

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[1]According to Rostow (1961), a nation in its economic dimensions may be lying within one of five development stages: the traditional society, the precondition for take-off, the take-off period, the drive to maturity, and the age of high mass consumption.

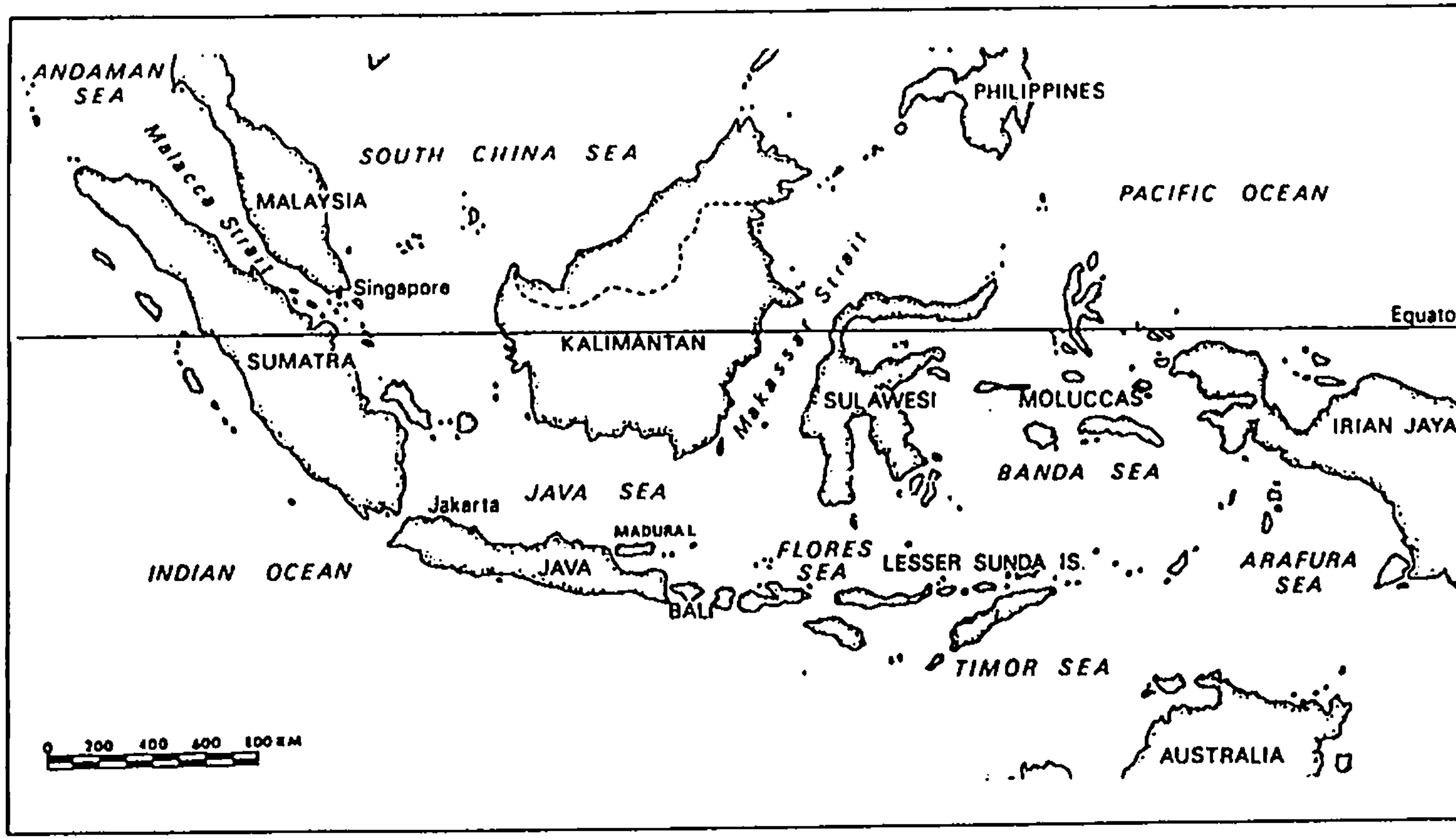


Figure 1.1. Map of Indonesia (The Marine and Coastal Sector Definition Mission, 1987)

Indonesia is an archipelagic state, consisting of about 14,000 islands (Figure 1.1), with the second longest coastline in the world after Canada, at an estimated total length of 81,000 km (Borgese and Ginsburg, 1982 and Soegiarto and Polunin, 1982). The coastal zone is endowed with various valuable natural resources, ranging from non-living resources like oil, gas and other minerals to living resources such as fish, crustaceans, and seaweeds. The productive and varied life of the coastal areas has been a traditional major food supply, especially animal protein, for the Indonesian population for centuries. More recently, oil and other mineral resources have been tapped to support economic development. Apart from providing these resources, the coastal areas of Indonesia have many other functions such as providing for waterborne transport and port development, waste reception from both ocean and land-based human activities, cooling water sites for industries, centres for recreation and tourism, and agribusiness development. As a result of the many activities which are based upon the coastal resources, the majority of the population (more than 60 %) currently resides in the coastal areas (Koesoebiono et al., 1982).

To meet the needs of an ever-increasing population expected to reach 215 million by the year 2000 and because upland resources are becoming scarce, it is apparent that the coastal zone with its resources will be a primary target for further Indonesian economic development.

Unfortunately, as side effects of development, the quality and productivity of many coastal ecosystems are gradually threatened by unwise development activities either within the coastal zone or from adjacent upland and open sea areas. Increasing pollution of coastal waters, particularly near coastal cities (e.g. Surabaya, Balikpapan, Jakarta and Medan); massive fish kills in Jakarta Bay (Tempo, August 16, 1986); recent pathogenic outbreaks that have resulted in significant failures of fashionable brackishwater shrimp (tambak) production sites along the North Coast of Java; and the degradation of critical habitats like mangroves and coral reefs indicate this threatened condition. Unless serious efforts are made to improve the management of coastal resources, the sustainable potential of these critically valuable resources cannot fully be utilized in the future.

Recognizing the importance of coastal resources for sustainable economic development, the Government of Indonesia (GOI) has taken several initiatives to better manage the use of these resources. This awareness is reflected in the State Policy Guidelines (GBHN) which clearly indicates that the goals of national development encompass not only economic growth, income distribution and employment opportunity aspects but also the conservation of the environment and natural resources.

Initial steps have been undertaken in the Third REPELITA (1981/1982 - 1986/1987) to strengthen the application of sustainable development concept in the real development policies. These include the enactment of the Government Act No. 4/1982 concerning the Basic Provisions for the Management of the Living Environment, the introduction of environmental impact analysis requirements for any development project that is assumed to have significant environmental impacts (Government Act No. 29/1986), Spatial Planning Law (Presidential Decree No. 59/1989), and the Government Act No. 5/1990 regarding the conservation of living resources and their ecosystems.

Furthermore, a number of steps that specifically address marine and coastal development issues also have been taken. Among others are (Canada/Indonesia MTPSP, 1988):(1) the Environmental Sector Review (1984), which formed part of the pre-REPELITA IV planning process, and which identified the importance and fragility of coastal resource systems; (2) a handbook on coastal zone management that has been prepared for use all over the country; (3) seven marine reserves that have been established to protect critical ecosystems; and (4) marine and coastal zone planning studies that are underway in various localities such as Cilacap, Jakarta Bay and Lampung.

Most of these initiatives, however, are not fully operative due to a lack of appropriate responses from the public as well as relevant government agencies at both national and regional levels. The task of implementing sustainable principles in coastal resource development is complex. Nevertheless, three major concerns can be identified. First, existing guidelines and recommendations for the management of coastal resources based on the sustainable development concept are impractical. Second, there is at present no single or a coordinating institution responsible for safeguarding the proper management of the coastal zone. Third, there is no working model which demonstrates that the application of sustainable development concept over a given region does make development and the environment go hand in hand, finally resulting in the improved wellbeing of the people.

Among those three factors, the third is probably the most prominent one. Because human beings are "homo sapiens" as well as "homo economicus", they seldom adopt any innovation unless there is evidence that the innovation will directly be beneficial to their interests. This point is especially valid in the Indonesian context in which more development programs to increase the living standard of the people are still required. Consequently, decision makers often either deliberately or unintentionally approve environmentally unsound development projects.

It is in this spirit that this dissertation is developed. Using coastal Kutai and Samarinda of the Province of East Kalimantan as a study area, the dissertation offers a framework and creates a generic model, as well as methods, for coastal resource management and planning based upon sustainable development principles.

A coastal zone of East Kalimantan has been deliberately chosen as a study area for three main reasons. First, there are multiple use activities such as oil and gas production, agriculture, aquaculture, forestry and transportation occurring in the same area of the coastal zone, and this presents a situation which is typical of most coastal areas in the country. Secondly, this "frontier" province provides a high potential to be a demonstration project for applying the sustainable development concept in other coastal provinces. Lastly, while Java and Sumatra are considered by Indonesian to be the islands of the past and the present, Kalimantan and the eastern islands are thought to be those of the future.

Once the application of sustainable development principles in the development and management of coastal resources in this province starts to give successful results, it is hoped that the consideration of these three characteristics will hasten and encourage the adoption of the model by the other coastal provinces of the country.

1.2. GOALS AND OBJECTIVES

Based upon the above background, which essentially reflects the objectives of national development as well as issues specific to coastal resources, the dissertation is intended to achieve the following goals and objectives:

(1) To identify sustainable development principles and define an analytical framework that facilitates planning and decision-making processes for optimal and sustainable coastal resource development.

(2) To develop a working model of coastal resource planning and management based on sustainable development principles in East Kalimantan, which hopefully can be applied in other coastal areas of the country.

1.3. OPERATING ASSUMPTIONS

The aforementioned goals and objectives generated the following operating assumptions (hypotheses) which directed the methodology employed in the dissertation.

(1) The sustainable development of the coastal zone and its natural resources can only be achieved if each development activity is located on biophysically suitable sites within the coastal zone.

(2) The achievement of sustainable development of coastal resources is dependent on the ability to determine a mosaic combination of various development activities, occurring at appropriate rates, in harmony with the overall capacity and resilience of the coastal zone.

(3) The successful implementation of any CRM framework will depend on whether it is designed based upon the existing socioeconomic and sociocultural conditions as well as institutional arrangements of the coastal zone.

II. SUSTAINABLE DEVELOPMENT AND COASTAL RESOURCE MANAGEMENT

This Chapter explores the relevance of the sustainable development concept for the management of coastal resource utilization and describes some basic approaches for implementing sustainable development principles in coastal resource management. It explains the need for sustainable development as an alternative to current development strategies and policies that have led to unsustainable economic development paths in most parts of the world.

The chapter then analyzes the nature of sustainable development in terms of its meaning and definitions, focusing on its multifaceted dimensions ranging from biophysical to ethical perspectives. Based upon this understanding of the nature of sustainable development, the Chapter sets out the ways of incorporating the sustainable development concept into practical planning and decision-making process in coastal resource management.

2.1. THE NEED FOR SUSTAINABLE DEVELOPMENT

Since the initiation of the Marshall Plan in 1940s, the development paradigm, which emphasizes economic growth (the increase in per capita income) through capital-intensive industrialization strategies, has indeed brought about a variety of improvements in human welfare. From macroeconomic indicators, this achievement has been reflected in expansion of the global economy by a factor of 20, the increase in industrial production by a factor of 50, and growth in the consumption of fossil fuels by a factor of 30 (MacNeill, 1990). Moreover, the living standards of the human population (as measured by the attainment of basic needs, educational status, and life expectancy) is also improving (WCED, 1987).

The benefits of this development strategy driven mainly by neo-classical economics, however, have been enjoyed only by a small fraction of the world society particularly in developed nations such as North America, Western Europe and Japan as well as by the upper-class elite in developing countries (Ruddle and Rondinelli, 1983). The vast majority of the world's population, especially in Africa, Latin America and most of Asia, remains in a struggle to obtain basic human needs at a subsistence level. Even more relevant to the context of this dissertation is the fact that this dualistic outcome of the current development paradigm has also persistently degraded the quality and carrying capacity of the natural systems of the planet, on which economic development and the very existence of human beings depend.

The environment and its embodied natural resources are basic economic assets, which in most countries are being utilized at a rate greater than their renewable capacity. Furthermore, various wastes as a by-product of development activities have been discharged into the land, water, and atmospheric environment at a rate that has exceeded the environmental assimilative capacity.

With the above problems as a backdrop, the future can be envisioned as one of ever-increasing environmental degradation and poverty. In other words, the development path that has been taken by mankind is, so far, not leading to sustainable development. This can easily be understood on the basis of both theoretical explanations and empirical evidence.

In the last two decades, there has been an increasingly strong theoretical foundation showing that natural systems (the environment) and human systems (the economy) are indeed two sides of the same coin, in the sense that they are highly interdependent so that they influence each other (e.g. Boulding, 1966; Ehrlich and Ehrlich, 1970; Meadows et al, 1972; Daly, 1977; IUCN, 1982; WCED, 1987; Pearce et al, 1990). The interdependencies of these two systems will be elucidated in Section 2.2. At this point, it suffices to say that in order for economic development to be sustainable, the sustainable capacity of environmental systems on which the development based must be safeguarded.

Empirical evidence also clearly demonstrates that the pursuit of indiscriminate economic growth has eventually been constrained by the carrying capacity of environmental systems in providing living space and raw materials (natural resources), and in absorbing wastes (residuals) generated by human activities (Brown et al., 1991). Probably the most telling illustration of this evidence is the decade of the oil embargo by OPEC (the Organization of Petroleum Exporting Country) of the 1970's. This was a period, particularly in developed countries, in which the era of major economic growth following the end of World War II was slowing, if not ending (Zucchectto and Jansson, 1985). Yet, it is also the period of exceedingly rapid economic growth for Southeast Asian countries (Todaro, 1981; Gillis et al., 1987).

Recent concern about the potential global warming phenomena (Rosenberg, 1989; Flavin, 1990; Graedel and Crutzen, 1990; Schneider, 1990) and species extinction that threats the world's biological diversity (Ehrlich, 1988; Wilson, 1990) also present obvious signals from the earth regarding its inability to support the indiscriminate economic growth.

2.2. THE NATURE OF SUSTAINABLE DEVELOPMENT

The preceding section apparently shows that human activities during the last two decades have resulted in system-wide disruptions of the biosphere. In addition, the feedback mechanisms from the biosphere have, in turn, disrupted economic activities themselves. Over this time period, the effects of environmental problems (e.g. overfishing, deforestation, pollution, acid rain, global warming, and reduction in biological diversity) have become ever more obvious.

The publication of the Brundtland Commission's Report in 1987 (WCED, 1987) has awakened public awareness regarding interdependency between nature and economy, and prompted governments in various parts of the world to adopt the notion of sustainable development into their economic development effort. However, sustainable development is a very broad concept encompassing multifaceted aspects of the dynamic interactions between economic development and the environment. Consequently, it is subject to a variety of interpretations, and sometimes misconceptions. This is particularly true when one tries to implement the concept into a specific resource development and management context like coastal resource management. To operationalize the concept of sustainable development appropriately, the proper meaning of sustainable development and its dimensions should first of all be understood as clearly as possible.

2.2.1. The Meaning of Sustainable Development

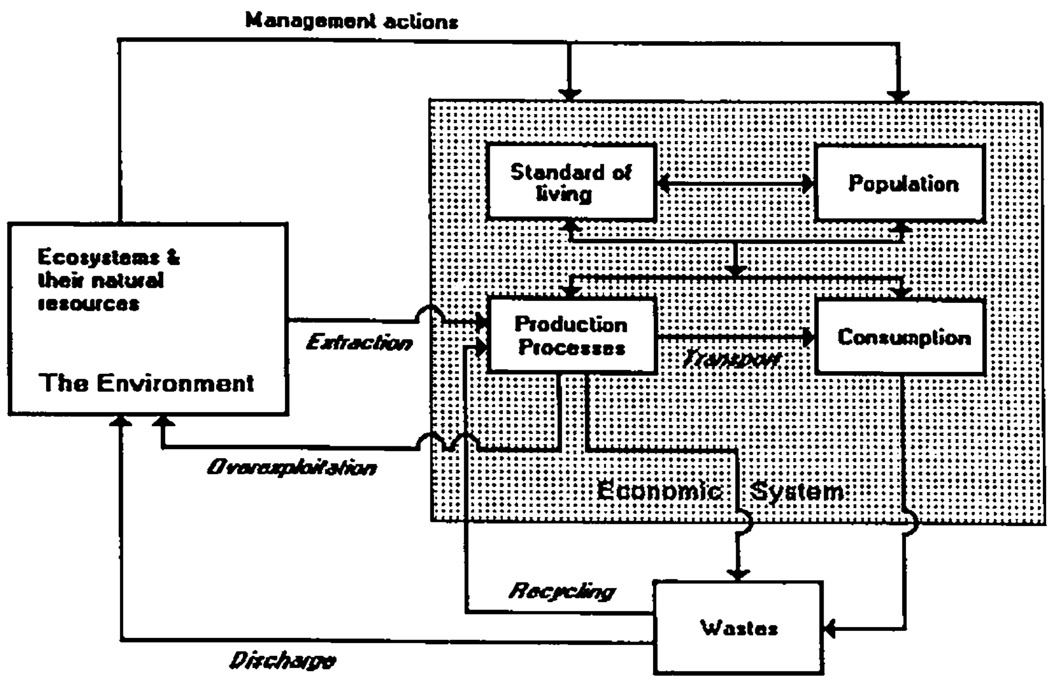
As society develops, from primitive to more modern stages, the needs and aspirations that shape developmental goals will also increase in terms of both quantity and quality. Changes in the goal of development can be traced through the chronology of economic development policy from 1940 to the present (Ruddle and Rondinelli, 1983; WCED, 1987; ADB, 1990). In the early 1940s and the late 1950s, the goal of economic development was primarily to achieve maximum economic growth, industrial output and export production through capital-intensive investment strategies without due regard to equity. This approach assumed that benefits would trickle down to poor groups and to poor countries.

In the early 1960s to the late 1970s, beside the attainment of economic growth, the goal of development also included such factors as: (1) equitable distribution of wealth, (2) health and nutritional status, (3) educational achievement, (4) access to resources, (5) well-paid employment opportunities, and (6) basic freedoms. From the early 1980s to the present, the need for better environmental quality has also been included in the overall development objectives of most nations in the world.

Thus, development is essentially an evolutionary process carried out by human beings to fulfil their needs and aspirations, individually and collectively, by using the ecological endowment of the biosphere (ADB, 1990). The development process that involves dynamic interactions between economic and ecological systems can diagrammatically be depicted as in Figure 2.1. The driving force of the development process is basically human needs and aspirations for utilizing ecological endowment. They determine the types and rates of consumption and production processes which, in turn, influence the utilization rate of natural resources as well as the discharge rate of wastes into the environment.

Two inherent characteristics of the development process can be identified from Figure 2.1. First, an economic activity in one way or another always involves three processes: taking out natural resources from the environment, discharging wastes to the environment, and altering the spatial configuration of the environment. According to Lee (1982), the nature, magnitude, and location of the flows of both resources and wastes which pass through the economic-environmental links change over time in response to changes within the economic

Figure 2.1. Interrelationships between Economic System and the Environment



system. These are especially affected by changes in: (1) the general level and composition of consumption; (2) the general
system. These are especially affected by changes in: (1) the
level and composition of production; (3) the technology of production; (4) the spatial distribution of production and consumption activities; and (5) the regulations imposed upon withdrawals from and disposals to the environmental systems.

The second characteristic is that the relationships between economic and environmental systems are reciprocal in nature. This means that the extraction of natural resources and disposal of wastes affect the condition of environmental systems which, in turn, alter the future uses that the economic system may make of them. These feedback mechanisms from nature to the economic system, which are not recognized in the frontier economic thinking, could be direct or indirect in nature.

The direct feedback mechanisms take place when the use of the environment with its embodied resources for a certain purpose directly precludes or reduces its value for other uses within the economic system. An example of this is when the allocation of a portion of the coastal zone for industrial estates will foreclose or decrease its availability for aquaculture uses. In the meantime, the indirect feedbacks happen when the direct environmental impacts of an economic activity result in secondary changes within the environmental system which, in turn, affect other types of economic activities. An illustration of this is the use of coastal land for a power plant that discharges thermal wastes (in the form of heated water) which may kill mangrove forests further downstream which, in turn, decreases fisheries productivity of adjacent coastal waters.

Based upon the above discussion on the meaning of the linkages between the environment and economic development, sustainable development is in essence human endeavour, individually or collectively, to utilize the ecological endowment provided by the biosphere or an ecosystem of a given spatial unit on the earth in such a way that its future functioning and capacity to produce benefits for human beings are not impaired. To obtain various perspectives on the meaning of sustainable development, twenty four definitions of sustainable development gathered by Pearce et al (1990) from a wide range of sources should be consulted.

2.2.2. The Dimensions of Sustainable Development

From the meaning of sustainable development as described above, the concept of sustainable development essentially possesses five major dimensions. The success of implementing the concept into practice requires a full consideration and an appropriate inclusion of those dimensions. To date, most initiatives to introduce or to operationalize sustainable development have only touched such dimensions partially. As a consequence, policy makers and planners, let alone the public, are becoming more confused about the concept.

These five main dimensions of sustainable development are: ecological, socioeconomic, legal and political, institutional, and ethical perspectives.

1. Ecological dimensions of sustainable development

Economic development can be sustainable ecologically only if the total demand on the ecological endowments generated by such a development effort does not exceed the ability of the ecosystem to supply them. Any ecosystem, such as the coastal zone, provides four major functions: (1) life support services; (2) amenity services; (3) material inputs (the supplier of natural resources); and (4) waste receptor services (Freeman et al, 1973 in Ortolano, 1984). Life support services include such things that are necessary for human existence as the provision of clean water and air, and space for development activities. Amenity services from natural systems can be found, for instance, in the form of surroundings that people find pleasant, attractive, and renewing. The ecosystem can also supply natural resources which provide input materials for socioeconomic activities, such as food, timber, oil and gas, and other minerals. Waste receptor services offered by ecosystems reflect their ability to transform wastes into harmless substances and dilute them.

Accordingly, in ensuring such a balance between the demand and supply of ecological endowment, four approaches (guidelines) should be taken into account when conducting any development activity: (1) spatial suitability; (2) assimilative capacity; (3) sustainability; and (4) carrying capacity.

The spatial suitability guidelines basically require that each development activity should be located in an area which is biophysically (ecologically) suitable for such a development activity. In other words, the spatial suitability includes integrated information regarding the conditions of the environment, and the types, extent and distribution of its embodied resources that can be used to determine areas (spatial units of the earth) which are suitable for a specific development activity. Any development activity which is put in a biophysically unsuitable area will likely be unsustainable. For example, the development of brackishwater shrimp/ fish ponds in areas with highly sandy-textured soils most likely will be a failure. The land upon which the pond is constructed typically does not have sufficient capability of holding water which is absolutely needed by the fish or shrimps being cultured.

In addition, the spatial suitability also implies the need to arrange all development activities within a certain area in such a way that their cross-sectoral impacts (inter-regional trade-offs) are minimized, and their total impacts (in the form of either wastes or loss of species and landscape alterations) do not surpass the capability of the environment to absorb them i.e. its assimilative capacity.

When treating an ecosystem (e.g. coastal zone, watershed, and land fill) as the receptacle of wastes, it must be ensured that all wastes from development activities both within and beyond its boundaries should not exceed the assimilative capacity of the ecosystem under consideration. Assimilative (accommodative) capacity, in this case, means the ability of an ecosystem to absorb a certain amount of pollutant before there is an unacceptable environmental and health hazards (Krom, 1986).

In the meantime, when considering an ecosystem as a supplier of natural resources, the sustainability criterion for their utilization is that no larger amount of the renewable resources (e.g. fish stocks and forest stands) be extracted than can be either produced or renewed over the same period of time (Clark, 1985). Furthermore, the exploitation of non-renewable (exhaustible) resources of an ecosystem should be undertaken with great care so that the associated impacts do not endanger the environment, and thereby do not preclude other uses of the environment. Another criterion for the extraction of the exhaustible energy (e.g. oil and gas, and coal) is, as pointed out by Goodland and Ledec (1987), that such an extraction rate should be kept slow enough so as to allow an orderly societal transition to renewable energy sources as substitutes.

The carrying capacity of an ecosystem (a particular region with a characteristic community of organisms) is defined as the maximum population of a given species which can be supported on a sustainable basis (indefinitely), allowing for seasonal and random changes, without any degradation of the natural resource base that would diminish this maximum population in the future (Ledec et al., 1985; Munn, 1989). Thus, if the carrying capacity could be accurately assessed, then it would be possible to set the number of people (or animals) who could live in a given region on a sustainable basis. Unfortunately, a region's carrying capacity is a very dynamic concept so that it is highly complicated to determine. This is particularly true in the case of determining the carrying capacity for human population.

First, human beings can either expand or diminish the carrying capacity of a region with technology. The reduction of a region's carrying capacity is usually caused by environmental mismanagement, such as deforestation, that has resulted in shortages of water supply during dry seasons, as well as larger floods in many watersheds of tropical countries, and desertification that has brought about famine in the Sahelian region.

According to Ledec et al.,(1985), technology can improve the region's carrying capacity in two ways. It offers people a way of substituting, to some limited extent, a natural resource which is abundant for one that is scarce. Inorganic fertilizers, for instance, allow farmers to compensate for a shortage of arable land by applying chemicals that are not in short supply, at least until the petrochemical or coal feed-stock used to synthesize many of them become too expensive. Additionally, technology can increase the efficiency of the transformation of natural resources into more useful (economic) goods, and thereby allow people to harness more economic value from a given natural resource base.

The enhancement of the carrying capacity through technology, however, will eventually reach a stage of 'diminishing returns' and restrict the unlimited growth of population. For instance, at high application levels, fertilizers can produce sharply declining marginal returns. This occurs because, at some point, increased fertilizer application will cause 'nutrient poisoning' of crops or cultured fish and, in turn, actual decline in yields. The intensive use of fertilizers in agricultural development also has proven to cause a multitude of negative externalities, such as eutrophication of lakes and coastal waters, and health-endangering nitrate levels in drinking water.

Furthermore, technology can neither increase the total amount of natural resources available nor enhance the biosphere's assimilative capacity for wastes. It will not be able to create more raw materials out of nothing, nor can it step up the efficiency of transformation of these materials into economic goods beyond the constraints imposed by the physical laws of thermodynamics. As a corollary, technological advance can not eliminate natural constraints entirely.

The second way of expanding a region's carrying capacity is through trade, by exchanging resources which are locally abundant for those that are scarce. City states like Hongkong and Singapore, for example, support population densities approximately 100 times higher than the local carrying capacity by buying food with the value added to labour-intensive goods. Similarly, countries in the Persian Gulf region can support population far in excess of their local agricultural carrying capacity by trading oil with industrialized nations for food. That is to say, trade allows one region to make use of the excess carrying capacity of another.

Third, human carrying capacity is dependent on the standard of living expected (Munn, 1989). A region under the same technological inputs and trade patterns could support more people with subsistent lifestyle than those with a consumption-oriented one.

It is clear from the above discussion on the concept of carrying capacity, that it essentially reflects the ability of an ecosystem (a region) to supply ecological endowments for mankind. It covers the three other ecological dimensions of sustainable development (spatial suitability, sustainability, and assimilative capacity) as well as human responses to the dynamic of a region's carrying capacity through technology, trade, and changes in the standard of living.

Thus, if we are to achieve sustainable development in a given region (coastal zone, province, country or the globe), then the human demand on ecological endowments should not be more than the region's carrying capacity to supply them. This condition can only be acquired by an earnest effort to change human behaviour, which include socioeconomic, legal and political, institutional, and ethical aspects, to meet such an ecological balance.

2. Socioeconomic dimensions of sustainable development

From the preceding discussion, it can be inferred that the primary threats to the sustainable development path, such as over-exploitation of resources, pollution, soil erosion, and global warming, occur essentially because human demand on ecological endowments exceeds their supply provided by nature.

Human societies have three alternatives to bring the demand and supply on ecological endowments in balance. The first is by reducing the ecological demand to its supply capacity. The second is by expanding the carrying capacity of a region to supply ecological endowments. The third is to use the resource base beyond its carrying capacity, and thereby liquidating natural capital for one time use.

The first human response is the most sustainable one. The second, to some extent and with a great care, might be a sustainable approach, while the last will damage the long-term carrying capacity of the biosphere (Ledec et al., 1985). The difficulty for people in appreciating the danger of the last approach to sustainable development occurs because any associated ecological or economic loss is likely to be apparent after a substantial time lag and after it has become largely irreversible. The increased demand on ecological endowments has been occurring due to population growth and excessive consumption by some societies in the world. Since both factors have been proven to cause unsustainable development in many parts of the world, then any socioeconomic policy for addressing this issue should deal with these factors.

In dealing with population aspects as a cause of environmental degradation, it is not solely its quantity (numbers) that should be considered. More importantly, policy should ensure that people should have an equitable access to ecological endowments, education, health care, nutrition, and basic freedom both within and between countries. In addition, there should be assurance that the poor get a fair share of the use of ecological endowments to sustain economic development in any region. This is a crucial step towards sustainable development in several respects.

There has been strong evidence that environmental deterioration is caused not merely by the consumptive lifestyle of the affluent societies, but also by poverty. This is particularly true in developing countries like Indonesia, where much environmental damage, such as coral mining, indiscriminate mangrove cutting, fish blasting, and cultivation on steep marginal lands, have their root in conditions of poverty and ignorance. It has also been widely recognized that the tradition of having a large family in poor societies is usually intended as a social security for parents in their old age. Ameliorating poverty, therefore, will also help to limit population growth.

Expanding the carrying capacity of a region, through prudent applications of technology and fair trade systems, could foster sustainable development. Technology, which expands carrying capacity, can basically be classified in two broad categories. The first group is one that enhances the production of natural resources and increases the efficiency of the transformation of these resources into economic goods. Examples are agricultural technology (e.g. fertilizer, high-yielding seeds, irrigation techniques, and soil conservation), aquaculture, animal husbandry, biotechnology, genetic engineering, and food processing technology. The other group is one that reduces the volume of wastes, such as recycling, resource and energy efficient production technology, and waste treatment technology.

As far as socioeconomic dimensions are concerned, the achievement of sustainable development calls for various adjustments of economic development policies at both national and international levels. At both levels, instead of the sole pursuit of economic growth, the main goal of economic development should be focused on enhancing the quality of human life and the environment. In other words, economic and ecological considerations should be merged in development planning and decision-making processes at all government levels. Furthermore, economic growth priority should be given to developing nations, while industrialized countries should emphasize their growth in quality terms which can be achieved, for instance, through 'a steady-state economy' strategy (e.g. Daly, 1977; Colby, 1989; Daly and Cobb, 1989).

Some approaches for integrating environmental considerations into economic development are: complementing the conventional indicator of development achievements (i.e. Gross National Product = GNP) with national resource accounts, complementing the 'present value criteria' of development projects with sustainability criteria, internalizing environmental costs (negative externalities), and reforming tax systems.

At present, the calculation of GNP is concerned mainly with the flow of economic activities. Changes in stocks of ecological endowments, as a result of such economic activities, are generally neglected. Combining GNP and national resource accounts would present a better indicator of sustainable development, because the combination of these two accounting systems portrays not only the value of all final goods and services produced by a country within a certain period (economic growth), but also the depletion in the country's ecological endowments such as stocks of fisheries, forests, productive soils, and the quality land and water.

With such information, decision makers and development planners, particularly those who are in charge of more development-oriented agencies (e.g. finance, public works, industry, agriculture, and mining and energy) could get not just more accurate figures on a country's economic performance, but also some idea of the way economic development policies are influencing ecosystems and their embodied resources.

From the vantage point of sustainable development, such an integrated national accounting system is crucial, because the GNP system has frequently misled planners and decision makers about their country's development achievement. With conventional GNP calculations, a country could erode its cultivable soils, cut down its forests, overexploit its fisheries and wildlife, exhaust its minerals, and pollute its watersheds and atmosphere, yet the GNP value (national income) for that time period would not be discounted in any way to reflect the loss of these life-and-income supporting assets. The most telling illustration of this is a preliminary national accounting system prepared for Indonesia by the World Resources Institute (WRI), which concludes that when resource depletion is factored into calculations, the estimated rate of national income growth throughout the period 1975 - 1984 is significantly reduced (ADB, 1990).

To date, especially in developing countries, environmental services (e.g. clean rivers, lakes, and marine waters as well as the atmosphere) are regarded as 'free goods' with zero prices. As a result, pollutants disposed of into these ecosystems by some human activities have not yet been charged. Internalizing these negative externalities, for example, through a 'Polluter Pays Principle' should be a sound approach to representing the real costs of development in the economic decision-making process (McNeill, 1990).

One of the most popular approaches in assessing whether or not a development project or program will be beneficial from a societal point of views is benefit-cost analysis. It is a systematic method of identifying and measuring the economic benefits and costs of a project or program. The benefits of a project are the values of incremental outputs of goods and services generated by the project, and the costs are the values of incremental real resources used by the project. Both project costs and benefits are appropriately discounted over time to make them commensurate for a comparison (Anderson and Settle, 1977; Hufschmidt et al., 1983).

The common practice of discounting competing streams of future benefits in project analysis, however, will systematically undervalue the needs of future generations and undermine all attempts to define a truly sustainable path for economic development. Therefore, a more constructive method to investment criteria in project analysis is to complement 'present-value criteria' with sustainability criteria i.e. to maximize present value subject to constraints that future generations are not made worse off (ADB, 1990).

Tax and subsidy systems can also be used to incorporate environmental concerns into economic decision-making and planning processes. In practice, taxes could be levied on socioeconomic activities that deplete environmental quality and the resource base (a disincentive system). On the other hand, human activities which enhance environmental integrity, like recycling, waste treatment plants, and energy and resource efficient production systems, should be given a subsidy or be tax free when buying such equipments (an incentive system).

Although such a tax system may bring about an equivalent reduction in labour, corporate and value-added taxes, it could exert a significant effect on consumption patterns and on the cost structure of industry without adding to the overall tax burden on industry and society. This approach is essential to stimulate a transition to sustainable development (McNeill, 1990).

3. Legal and political dimensions of sustainable development

Law and regulations order a society's social relationships by employing a powerful array of statutes, courts, police, and devices such as permits, taxes, subsidies, insurance, and, ultimately criminal sanctions, to serve social policies (Robinson, 1989). Accordingly, relevant laws and regulations should be created and enacted to implement development policies based upon sustainable development principles.

It should be emphasized, however, that such laws and regulations should have 'legal teeth' in the sense that they are enforceable. Two key ingredients are needed to make a set of laws and regulations enforceable. They should be based upon objective conditions in the field. Many current environmental regulations are not implementable because they do not reflect aspirations of people who will be complying with them. Thus, lawyers who created environmental laws and regulations should observe the social behaviour as well as biophysical and technical aspects of the case under consideration. This could be done through various channels, such as public participation and consultation (hearings), consultations with experts, and field observations.

Another ingredient is the political will of the government. The top decision maker (e.g. President and Prime Minister), must support such laws and regulations. Without serious commitment from the government, the enforcement of environmental regulations will face tremendous impediments. This is particularly true in developing countries where many bureaucrats tend to play around with regulations in order to make work for themselves.

4. Institutional dimensions of sustainable development

Once all necessary socioeconomic policies and their associated law and regulations, based on sustainable development principles, are established, we then need institutions and agencies that have clear mandates and authority to implement them in practice. Depending on the political constellation and objective conditions of the country, institutions which take care of environmental concerns can be a separate (single) agency, a coordinated agency, or an environmental division within each department of government.

Three major prerequisites are needed to establish an institutional arrangement which is able to carry out the mandate of implementing sustainable development. First, the conceptualization and operationalization of economic development in all levels of organizations have to be reformed to take into account ecological considerations into their planning and decision-making processes of the whole cycle of development projects and programs. One of the stumbling blocks in implementing sustainable development into the current development pattern is the separation of environmental agencies (departments) from development-oriented agencies (WCED, 1987). Most nations still consider that the environmental management is the task of environmental agencies, such as EPA (Environmental Protection Agency) for the USA, the Department of Environment for Canada, and the State Ministry for Population and the Environment for Indonesia.

Second, there is a need to reform a more democratic political system within both national and international levels. Such a political system should guarantee active participation of all citizens in development planning and decision-making processes (Effendi, 1991). This is of highly important because most environmental deteriorations caused by development projects are treated as externalities, which do not directly affect the owner or executor of these project. Instead, such externalities become social costs that normally inflict on weaker or poorer groups within a society. Thus, social control mechanisms supported by the democratic political system would be the only way to bring out ecological considerations and the interest of the affected parties in development planning and decision-making process.

Third, institutional arrangements for sustainable development should be dynamic and flexible that have capability of making necessary adjustments to both social and ecological changes. This is essential due to the fact that the need and aspiration of people, individually or collectively, are changing over time. The same is true for the ecological conditions of our living environment both through human interference and natural processes.

5. Ethical and cultural aspects of sustainable development

Most policies, laws and regulations required for ensuring sustainable development are, in one way or another, concerned with values and ethical judgments. From previous discussion, it is obvious that the destiny of socioeconomic systems depends on ecological systems, and ultimately on the sustenance of the global life-support systems. Meanwhile, the long-run survival of human society is also dependent on certain functional requirements which are met by a set of social norms i.e. principles of behaviour that have to be complied with (Pearce and Turner, 1990). If sustainable development is the agreed global policy goal, then over time such norms should be in harmony with the natural laws governing the structure and functions of ecosystems.

In order to make such norms consistent with those natural laws, sustainable development principles should be inculcated into the value systems and ethic of the people. Because, after all, human beings are creatures with many dimensions. He or She is not solely *Homo sapiens* but also *Homo economicus and Homo religiosus*. Thus, people can be regulated by various combinations of economic incentives, law, and regulations. However, the decision to comply with these man-made regulations eventually rests on the people's choices and actions.

It is such individual rights, value systems, and ethics that, most likely, have been stumbling blocks for the implementation of sustainable development for national governments around the globe. Sustainable development requires ethics that appreciates long-term benefits (objectives) rather than short-term benefits at the expense of environmental degradation.

Sustainable development calls for a sense of sharing with their fellow brothers and sisters in poor countries on the part of affluent people in industrialized countries and in the upper class of developing nations. Those in developing countries often have no option but to degrade marginal ecosystems just for the sake of life subsistence, while the affluent consumed the world's resources and released wastes into the environment at a rate several times than their poor counterparts. The concept also demands project developers, industrialists and the like take environmental damages (negative externalities) into account.

More radically, some environmentalists also believe that the achievement of sustainable development requires ethics and value systems which appreciate the intrinsic or inherent values of nature that exist whether or not humans are around to sense and experience them (Hanson, 1990; Pearce and Turner, 1990).

The question is, then, how to inculcate an ethic of sustainable development into human society. Should we start by establishing laws and regulations first, to frame the society to be align with such an ethic, or should we start by educating people first ?. This is not egg and chicken-like debate. We should start simultaneously. It may be fruitful to consider Schumacher's (1973) suggestions that religious aspects can be used to make social engineering for sustainable development possible. Education will play a big role in building a constituency for sustainable use of resources and the environment.

2.3. THE RELEVANCE AND EVOLUTION OF SUSTAINABLE DEVELOPMENT CONCEPTS IN INDONESIA

Traditionally, Indonesian people have been living in harmony with nature for many centuries (Salim, 1986). The majority of the population lives in rural areas and derives a livelihood from agricultural activities such as cultivation of crops, fisheries, gathering of forest products, hunting and fishing, and aquaculture. These types of activity have shaped Indonesian society with strong social (family) ties as well as with a sense of closeness to the natural environment.

This closeness to nature is reflected, for example, in many traditional ceremonies such as ones that occur before the planting season begins and prior to the harvest of agricultural crops. The ceremony is an expression of farmers about their dependence on nature, particularly for the success of crop harvest. This benign attitude towards the environment can also be seen from a variety of customary laws ('hukum adat') existing in almost every province of the country (e.g. 'Marga Law' in South Sumatra and 'Sashi Law' in Moluccas) which obviously show a great respect for the integrity and well-being of the natural environment. These customary laws allocate natural resources (e.g. inland and marine fisheries, and forest) to appointed members of the society with an obligation for the members to manage them wisely. Sashi Law, for example, implements the conservation measures by imposing closed-season systems to the fisheries.

At the national level, the environmental awareness of the Indonesian nation is reflected in Article 33 paragraph 3 of the 1945 Constitution which states that "land and water and natural resources therein shall be controlled by the State and shall be utilized for the greatest welfare of the people". These constitutional provisions imply the scope of: (1) the authority of the State and the responsibility of the Government; and (2) public versus private rights and obligations, so as to permit the future development of 'environmental control' and the development of 'environmental policy and legislation' (Hardjasoemantri, 1989).

As population grows and the intensity of economic development increases, environmental damage has been ever increasing. At the same time, the positive attitude toward the environment is gradually weakening, especially in urban societies and among the younger generation of rural residents. Since the early 1970's, three systematic environmental problems, namely deforestation and its concomitant effects (e.g. soil erosion, flooding, and coastal sedimentation), overexploitation of natural resources (e.g. overfishing and overuse of agricultural land), and pollution (from industrial, agricultural and domestic sources) have threatened the sustainability of Indonesian economic development (e.g. Gauchon, 1977; Soemarwoto, 1980; Birowo and Hansen, 1981; Olf, 1981; Sujastani, 1981; Bee, 1982; Hainsworth, 1985; and Gillis, 1987).

Despite such pressing environmental degradation, environmental concerns in Indonesia did not gain public support until the 1970's. This was due probably to a mis-conception on the part of most decision makers and the Indonesian public with regard to environmental problems. They perceived that environmental problems had to do only with pollution. Therefore, they thought of environmental problems as belonging only to industrialized nations (Soemarwoto, 1980; Salim, 1981). For developing countries, like Indonesia, economic growth was perceived to be of foremost importance compared to environmental considerations. The notion of sustainable development was far from their way of thinking at that time.

Gradually, however, this incorrect perception became unpopular as environmental problems in the country began steadily to appear. The echo of the United Nations Conference on the Human Environment in 1972 also helped Indonesian people, particularly the government officials, to understand environmental problems properly and to view environmental concerns as an integral part of the development process. The 1972 U.N. Convention was also signed by the Government of Indonesia (Salim, 1986).

In June 1972 a National Committee for the Environment was established with a basic task of promulgating environmental legislation, procedures and guidelines (Salim, 1986; Soerjani, 1988). At the beginning of PELITA III (1978) the President of Indonesia appointed a Minister of State for Development Supervision and the Environment, which was responsible to incorporate environmental aspects into economic development. Since 1983 the designation of this Ministry has been changed to the Ministry of State for Population and the Environment. This change reflects a recognition that the country's environmental problems are highly related to its large and still growing population as well as to a lack of trained manpower (Soerjani, 1988).

Other institutions having environmental responsibilities or concerns include the National Planning Board (BAPPENAS) which is in charge of assessing development plans and programs proposed by national and provincial agencies, provincial Bureaus for Population and the Environment (BKLH), Environmental Study Centres in most universities throughout the country, and non-governmental organizations (NGOs).

The gradual commitment of the Government of Indonesia to sustainable development has actually been manifested in Guidelines for the State Policy (GBHN) decreed by the People's Consultative Assembly once every five years and the National Five Year Development Plan (PELITA), which now emphasizes that national development must be sustainable.

To translate and implement these general guidelines into practice, several laws and regulations with respect to the management of the environment have been promulgated. These include, as already mentioned in Chapter I, the Government Act No.4/1982 concerning Basic Provisions for the Management of the Living Environment, Government Act No.5/1983 concerning the Indonesian Exclusive Economic Zone, the Government

Regulations No.29/1986 concerning Environmental Impact Analysis, Presidential Decree No.59/1989 concerning Spatial Planning Law, and the Government Act No.5/1990 concerning the Conservation of Living Natural Resources and their Ecosystems.

Most of these environmental regulations have not yet been implemented effectively. EIA requirements for development projects which are considered to have significant impacts on the environment, for example, are sometimes conducted in a 'pro forma' fashion (Dahuri, 1990). In other words, most project proponents do not use the results of EIA studies as a basis for planning and design of the project's development, let alone as a guide for environmental monitoring.

Reforestation and 'selective cutting' regulations in the forestry sector, which are intended to ensure the sustainability and integrity of forest resources, have not been seriously applied by most forest concessionaires. According to Wijaya and Wijaya (1990), only 4 % of the total forest concessionaires did implement such regulations. Not surprisingly, therefore, the total loss in Indonesian forest cover from 1950 to 1985 amounted to about 39 million hectares, an average annual loss of 1.1 million hectares (Gillis, 1988).

In coastal and marine related sectors, ecosystem stress and resource degradation also have been increasing. The Canada/Indonesia Medium Term Planning Support Project (1988) has identified eleven types of environmental degradation in Indonesia, particularly in populated coastal areas, ranging from water pollution to a massive conversion of mangroves to other uses such as tambak (brackishwater fish/shrimp pond) development.

Another indicator which shows that the sustainable development concept has not been taken seriously is the persistent single-sectoral approach in conveying development programs and projects. A lack of an integrated and interdisciplinary approach in resource development has led to economic inefficiencies as well as conflicts among resource users.

As public awareness and understanding of the close relationship between economy and the environment increases, the prospect of sustainable development in Indonesia will be more promising. The fact that Indonesia's economic development relies heavily on the productivity of ecosystems and their natural resources should be a key incentive for the widespread application of sustainable development principles in development planning and management.

2.4. THE APPLICATION OF SUSTAINABLE DEVELOPMENT PRINCIPLES IN INDONESIAN COASTAL RESOURCE MANAGEMENT

Coastal zones are commonly characterized by a richness of both renewable and non-renewable resources. This fact combined with an easy access to transportation, waste discharges, and water have made the coastal zones the hub of human activities for centuries. Within the Indonesian context, coastal zones provide more potential than other land and water resources for increasing and diversifying the country's economic development, and therefore coastal ecosystems will play major a role in supporting such development in the years to come.

Although current practices of coastal resource development have indicated unsustainable patterns (e.g. overfishing and clear cutting of mangroves on the North Coast of Java, coral mining in Bali and Jakarta Bay, and pollution in several coastal cities), substantial opportunities, particularly in the eastern parts of the country, still exist to develop the coastal zone and its embodied resources on a sustainable basis.

2.4.1. Characteristics of Coastal Zone

The delineation of coastal space over which development and management policies are applied is in practice quite a challenging task. In fact the term coastal zone itself has been used with considerable variation. Almost every nation, or even states (provinces) within countries, have their own definition with regard to coastal zones.

There is a common agreement, however, that the term coastal zone conveys the notion of a land and sea interface. The land-sea interface has two principal axes: parallel to the shoreline (longshore), and the other is perpendicular to the shore (cross shore). For the longshore axis, relatively little controversy arises as to the definition. On the other hand, there is considerable debate concerning the cross-shore axis (Sorensen et al., 1984).

A proposed working definition of the coastal zone formulated by the Indonesian Government is the area where the land meets the sea; landward it is defined by both inundated and un-inundated areas influenced by marine processes like tides, sea winds and salt intrusion; seaward it is defined as areas influenced by land-based natural processes like sedimentation and influx of freshwater, and human activities like deforestation and pollution (Panitia Perumus dan Rencana Bagi Pemerintah di bidang Pengembangan Lingkungan Hidup, 1976 in Koesoebiono et al., 1982).

Despite a wide variety of definitions, coastal zones all over the world have, at least, three common characteristics: a unique set of interconnected ecosystems, dynamic ecosystems, and productive and vulnerable ecosystem.

1. A Unique Set of Interconnected Ecosystems

Typically, a coastal zone is a place of several ecosystems. They do not exist in isolation from one another. On the contrary, many of them are closely interlinked because of the flow of energy and nutrients among ecosystems, their physical interdependence, similarities in physical tolerances between one system and another,. and the presence of many organisms that are residents of one ecosystem but spend part of their life cycle in another ecosystem (Burbridge and Maragos, 1985).

The inextricable linkage between mangrove, seagrass meadow, and coral reef is a common example of a set of interconnected ecosystems in the tropical coastal zones. There are five major types of interactions usually taking place within this complex of ecosystems: physical, flows of nutrients and dissolved organic matter, flows of particulate organic matter, animal migrations, and human impacts (Ogden and Gladfelter, 1983).

Besides internal interactions among ecosystems, the coastal zone also has interrelationships with both upland and offshore marine systems. Burbridge and Maragos (1985) have identified ten ecosystems occurring in Indonesia's coastal zone, two of which are man-made (i.e. agroecosystems and tambak = brackishwater fish/shrimp ponds). Ecological interactions among these ecosystems as well as influences from upland and offshore marine systems were also described.

The movement of materials and energy among ecosystems within the coastal zone as well as between the coastal zone and the adjacent upland and offshore systems mostly takes place through water. In addition, water is used in every economic activity: agriculture, aquaculture, transportation, recreation and tourism, and waste disposal. So, water can be considered as the major integrating force for the coastal zone system (Clark, 1985).

2. A Dynamic Ecosystem

The influences of freshwater (e.g. river inflow and run off) and seawater (e.g. salinity, tides, and waves) on the coastal system have made it a dynamic and complex system. The coastal zone is undergoing continuous changes often very rapidly. The coastline changes, not only over centuries or decades, but in a matter of hours or minutes. This rapid change occurs both in the form of the coastline (the beach profile may change quite significantly during a single day) and in the coastal processes, tidal variations being most obvious illustration (Pethic, 1984).

The dynamic nature of the coastal zone is one of many factors that has caused the delineation of its boundaries to be a complicated task. Yet it is crucial to regard the coastal zone as a system consisting of various interdependent ecosystems, so that the boundary of a coastal management unit has to take into account ecological functional relationships and dynamics rather than be based merely on administrative concerns. The boundaries should include the areas where impacts on coastal ecosystems may be felt as well as sources of these impacts (Clark, 1985).

3. A Productive and Vulnerable Ecosystem

A coastal zone is frequently characterized by abundance of natural resources. The historical economic significance of the coastal zone is probably best exemplified with regard to fisheries. According to Levy (1976) in Berwick (1983), 90 % of global marine fish production originates from the continental shelf. These fishing grounds are frequently associated with shallow waters where highly productive coastal ecosystems such as mangroves, coral reefs, estuaries, coastal lagoons, and seagrass meadows play a key role in providing fisheries with support systems like breeding, nursery, and feeding grounds .

In Indonesia, as elsewhere, coastal resources have gained additional significance with the onset of more recent development opportunities, such as petroleum and mining industries, marine-based tourism, the siting of ports and energy facilities, the extraction of forest products as well as agricultural and/or aquacultural development.

It is not a coincidence, therefore, that the majority of the world's population lives along the coastline and along the banks of rivers that drain into the coastal waters. This makes the coastal zone both highly productive and vulnerable (Mann, 1982). The effects of pollution are most significant in nearshore waters. At the same time, the extraction of natural resources and landscape alterations have been increasing. The double impacts of harvesting natural resources while discharging wastes have exerted a great strain on coastal ecosystems. Indonesia's situation is closely parallel to this general condition of the coastal zone, almost all major cities are located near the sea, and the coastal zone is an area of concentrated rural settlements as well.

2.4.2. INTEGRATED COASTAL RESOURCE MANAGEMENT

Until very recently, the management of the coastal zone and its embodied resources was based upon sectoral development policy. This management approach, however, had led to economic inefficiencies, depletion of coastal resources, pollution of coastal waters, and conflicts among different coastal resource users (United Nations, 1982; Snedaker and Getter, 1985).

Since the early 1970s, development planners and scientists have recognized the unique nature of coastal zones, as a spatial units which require special analysis and management approaches in their use (Camhis and Coccossis, 1982; United Nations, 1982). This new management approach for coastal resource utilization is commonly termed integrated coastal resource management (ICRM) (Sorensen et al., 1984).

The primary goal of ICRM is to use the coastal zone and its resources on a sustainable basis. The ICRM, in this case, refers to an integrated approach operating through a multiple-use strategy in order to obtain social benefits from the utilization of coastal resources on a sustainable basis. It is chiefly concerned with resolving of conflicts among various users, and with determining the most appropriate and optimal use of coastal resources. Furthermore, Sorensen et al (1984) suggest that integrated planning, in the context of coastal zone management, usually implies the programmatic goals that balance and optimize environmental protection, public use, and economic development. Frequently, integration also means coordination between data gathering and analysis, planning, implementation, and construction.

In a broader context, Hanson (1988) defines integrated resource planning and management as a step-wise progression in considering cross-sectoral impacts of resource uses to arrive at optimal use of resource systems. Optimal use, in this context, refers not only to socioeconomic gains but also to environmental integrity and, ultimately, should be related to sustainable development. Meanwhile, Lang (1986) suggests that the integration in resource planning and management should take place at three levels:

(1) Technical - to ensure that technical, economic, social, and environmental considerations are incorporated and appropriately balanced within resource development plans.

(2) Consultative - to provide, in preparation and review of these plans, for the views of affected parties to be expressed and taken into account before the implementation of plans (in the form of programs and projects).

(3) Coordinative - to achieve necessary cooperation among the executing parties, i.e. public (government) and private agencies responsible for planning, implementing, regulating, and managing resource development projects.

It should be obvious that integrated resource planning and management is the most appropriate means for managing the utilization of coastal resources on a sustainable basis. Unfortunately, such an approach is easy to describe but difficult to implement in real development practices. This is especially true in developing nations where the necessary conditions (e.g. sufficient information base, capable manpower and skill, and an orientation toward long-term objective) for implementing such an approach are weak or not existent.

Most literature on integrated coastal resource management (e.g. Odum, 1976; Hanson and Koesoebiono, 1979; United Nations, 1982; Maragos et al., 1983; Sorenson et al., 1984; Clark, 1985; Snedaker and Getter, 1985; Burbridge et al.,1988; and ASEAN/US CRM Project, 1990) has so far only dealt with the conceptual, and qualitative aspects of this potentially powerful resource management approach. They lack quantitative and systematic insights with regard to interrelationships between economic and ecological systems within the coastal zone, which are basically the foundation for designing sustainable development scheme. Since most planners and decision makers, especially in Indonesia, are economists with limited background in ecology, they are usually reluctant to use such qualitative (descriptive) information as a basis for the planning and decision-making process.

On the contrary, the more systematic and quantitative approaches, using various quantitative methods ranging from linear programming to simulation modelling, (e.g. Hopkins and Day, 1977; Kelly and Spofford, 1977; Kremer and Nixon, 1978) mostly touch only on either a specific sector or the impacts of human activities in the form of wastes on ecological systems. Moreover, most of these quantitative approaches had, in a way, not incorporated the five dimensions of sustainable development into their analysis. Most of them are only concerned with the ecological dimension of the concept. In particular, the spatial dimension of sustainable development has yet to be included in these studies.

However, there have been scattered attempts which employed systematic and quantitative approaches (e.g. Meta System, 1975; Boynton et al., 1977; and Zucchetto and Jansson, 1985) as a means for managing the utilization of coastal resources on a sustainable basis. A systems ecology study of the Island of Gotland, Sweden (Zucchetto and Jansson, 1985) has so far been one of the best examples with regard to the application of sustainable development principles in coastal resource management. Gotland is an island of some 3100 km^2 in area located in the Baltic Sea about 200 km southeast of Stockholm.

The study used systems ecology methods which treat ecological and energy principles as unifying factors between ecological and human (economic) systems. Such an integrated approach was used as an input for regional development planning of the island, which is entirely a coastal land mass. Figure 2.2. is a modified diagrammatic framework of the Gotland study that can be adopted in other cases for applying sustainable development principles in resource management and planning.

The diagrammatic model essentially consists of three main sub-systems: economic, environmental, and the coupling of ecologic-environmental (optimization and spatial) models. The economic model is used to assess the needs of human systems determined by the population number and living standard in

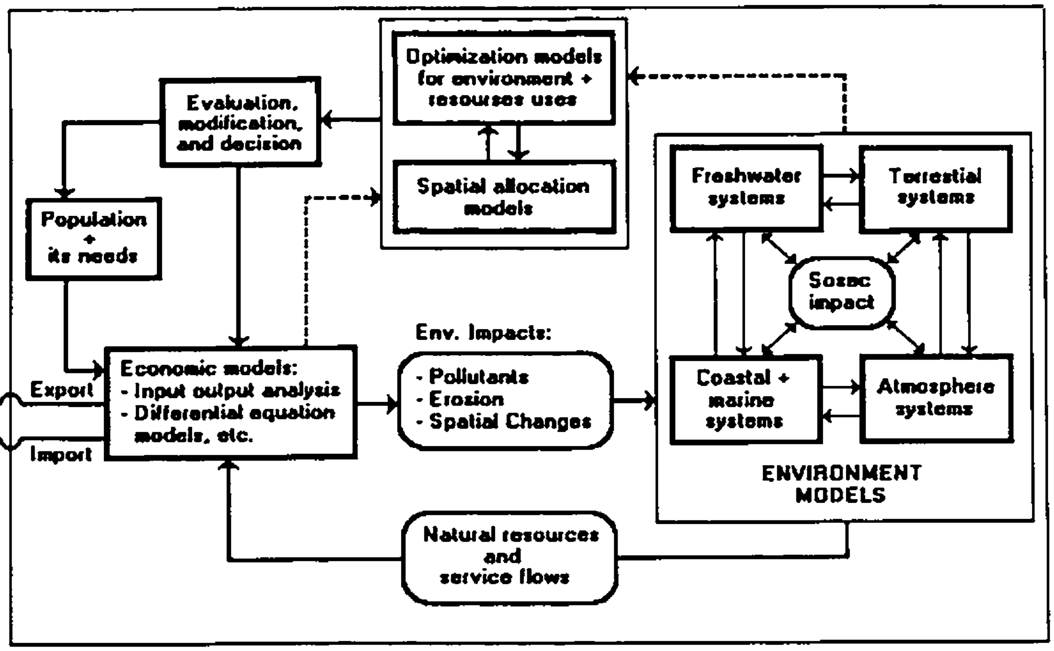


Figure 2.2 An Holistic Framework for designing the Management of Sustainable Coastal Resource Utilization (Modified From Zucchetto and Jansson, 1965)

relation to natural resources and environmental services. The economic model can be constructed by using differential equations or input-output models. In the Gotland study, the input-output model was employed.

Input-output models provide a useful accounting scheme for the systematic analysis of interactive effects among a group of sectors in an economy. They also have served as a meaningful calculation scheme in determining the total embodied energy cost of various goods, for predicting the indirect impacts on industry (sector) activity due to future demand in a given economy, and for estimating wastes generated by various sectors in the economy (Leontieff, 1966; Isard, 1972; and Richardson, 1972).

Wastes and other ecological impacts produced by each sector in the economy are then used as inputs for environmental (ecological) models to assess their effects on the performance and responses of environmental systems (ecosystems) within the region under study. The outputs from economic and ecological models can be used as inputs for the coupling of ecologic-economic models that consist of spatial allocation models (e.g. spatial suitability analysis) and optimization models (e.g. linear or dynamic programming, and simulation modelling).

Once the information generated by these models has been evaluated, planning and management decisions can be made for both social (population) and economic systems regarding the optimal rate of each sector (economic activity) and its spatial distribution, in order to define sustainable economic development. In other words, the rate of the sum total of development activities is determined by the estimated carrying capacity of the region.

Yet, there are several constraints in applying the above integrated and holistic approach to coastal resource planning and management. To comprehend the characteristics and works of ecosystems within a coastal zone under consideration takes a considerable amount of time. A study like the Gotland example, which was carried out by a strong expert team, required about 6 years.

Understanding of the behaviour of ecosystems and their interrelationships in a coastal zone is generally insufficient for an integrated management approach to be fully applied in the early years of a development process. Indeed, the performance of ecosystems is less predictable and sometimes even 'chaotic' (Gleick, 1987). Therefore, in order to apply integrated resource management in real world problems, an 'adaptive planning' approach should be adopted. In such an approach, each development activity is treated as an experiment. There is willingness, on the part of development implementer, to realize that deviations have taken place and that a fundamental interest in examining interactions between various types of resources and resource users is necessary (Hanson, 1988).

2.5. CONCLUSION

This Chapter has identified key elements (principles) of sustainable development for coastal resource management (CRM) and presents a means of incorporating such principles into the management of coastal resource utilization.

At the core of sustainable development is the balance between human demand on ecological endowments and the capacity of the natural environment to supply them. Therefore, any CRM endeavour should strive to maintain such a balanced condition. This may be achieved by aligning development activities both within the coastal zone and adjacent areas to four basic ecological principles, namely: (1) spatial suitability, (2) sustainability, (3) assimilative capacity, and (4) carrying capacity. In practice, this requires that the economic system, the legal system, institutional arrangements, and sociocultural aspects of society should be designed in such a way as to support such an alignment.

Since the nature of both coastal ecosystems and social systems is complex as well as dynamic, an integrated (systems) approach is needed to manage the utilization of coastal resources on a sustainable basis. Systems approaches tackle resource management problems holistically, in the sense that they focus the effort to comprehend present and potential organized complexity, the effects of human activities and interactions of components within the whole of the coastal zone system under investigation, and the impacts of other activities lying outside the systems that has been defined.

III. METHODOLOGY

3.1. PROBLEM DEFINITION

As mentioned above, this dissertation is essentially an attempt to apply sustainable development principles in the development and management of coastal resources. Therefore, its existence should not be merely as an academic document, which may enrich the discipline of coastal resource management, but also has to be practical, in the sense that it can be used to aid planning and decision making processes in the area of coastal resource management.

To achieve this mission efficiently, the dissertation has been based upon a problem-oriented approach. It is believed that the most critical stage in the cycle of resource development policy and planning is problem definition. Without a clear definition of the problem, any associated policy and decision on coastal resource management will most likely end in failure. Indeed defining the problem of a resource management scheme precisely is not a straightforward task.

In the case of coastal resource development in the study area, there are at least four different viewpoints about the problems conceivably faced by CRM. First, the government official (technocrat) group perceives the basic problem of coastal resource development as a lack of investment and infrastructure. Second, the coastal communities (e.g. farmers, fishermen, and low-wage labor) feel that the real problem is the difficulty of getting basic needs (such as clean and potable water for their domestic use), good incomes (due to low prices for their production outputs), and health services. Third, the industrial groups (e.g. oil and gas companies) consider the problem of coastal resource development as a lack of skilled manpower and the insecurity of the facilities from theft. Fourth, academics and non-governmental organizations see the problem of CRM as one of the degradation of environmental qualities like water pollution, coral reef destruction and mangrove conversion.

Resource management problems basically arise from the discrepancy between the existing conditions of environmental and social systems and the expectations (objectives) of the society regarding the use of the environment and its embodied resources. Inconsistencies in the above problem definition are mainly due to each group using different criteria in analyzing problems and issues. Since the key goal of the dissertation is to design a model for the sustainable use of coastal resources, the yardstick used to analyze the problem of CRM in the study area is based on sustainable development principles.

Based upon the discussion in Chapter II, there are basically five fundamental principles embodied in the sustainable development concept: intergenerational trade-offs, intersectoral/interregional trade-offs, multiple-use principles, risks and uncertainties, and social justice.

Intergenerational trade-offs are certainly the crux of sustainability, because the use of the environment and its resources may affect or even foreclose their use for future generations. The fact that a development activity which takes place in one area usually influences other areas and/or other development sectors makes interregional/intersectoral trade-offs a mandatory consideration in planning and developing coastal resources. The reason for observing multiple-use principles with regard to sustainability is to identify feasible and optimal combinations of resource uses, particularly the boundary conditions of each of these uses. Uncertainty is an inherent property of any real-world system, be it environmental, economic, or social. Thus, risks and uncertainties should be seriously examined in every development plan in order to establish anticipatory or adaptive measures, rather than reactive ones. The principle of social justice requires assurance that any development endeavour should be first directed towards the fulfillment of basic needs for the poor, as well as the maintenance of the sustainable livelihood of the population as a whole.

Currently, the East Kalimantan coastal zone is at a cross-roads for sustainable development. On the one hand there are some areas of the coastal zone (e.g. Balikpapan, Muara Badak and Bontang) suffering from the pressures of intensive development such as oil and gas production, industries and domestic sewage. On the other hand, substantial opportunities do still exist to increase production of the resources of underutilized coastal areas.

Although, from the RGDP (Regional Gross Domestic Product) per capita figure, East Kalimantan is one of the three richest provinces in the country [1], the majority of the population is still in poverty. This is because the RGDP of the province is mainly generated by oil and gas production activities (60 %), which only provide limited employment opportunities, particularly for the local people who are for the most part less educated and less skilled than migrants from Java and elsewhere. In the meantime, the development of other economic bases such as agriculture, aquaculture, fisheries and manufacturing is still lagging behind.

Both regionally and nationally this socioeconomic situation is neither beneficial nor sustainable. It is apparent that the oil and gas sector has created various multiplier effects for the economy of the Province. Part of the oil and gas revenue circulates in the provincial economy and thereby creates additional demand for local goods and services. Furthermore, the 1975-80 "oil bonanza" was believed to have resulted in confidence among the provincial business community that would have led to additional investments in non-oil related production and service activities (LRDC/Bina Program, 1987). However, this sort of multiplier effect has only slightly "trickled down" to the poor people who are actually the most needy ones.

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[1] Based upon the 1983 prices, the RGDP per capita of East Kalimantan Province amounted to Rp 3.2 million in 1987, while the average Indonesian RGDP per capita in the same year was Rp 475,000 (LRDC/Bina Program, 1987).

There has been strong evidence that poor coastal people, who have had part of their livelihood displaced by the presence of industrialization in the coastal area, have engaged in livelihood activities which threaten the sustainability of coastal ecosystems. Examples of this are coral mining in the Bontang area and the conversion of mangrove forests within Kutai National Park into brackishwater fish/shrimp ponds.

If the exhaustion of oil and gas resources of the Province should occur in 2020 (Lemhanas, 1989), before the full diversification of economic bases has been achieved, it would be a gloomy situation for both the Province and the country at large. This is because most employees of oil-related production activities are migrants, especially from Java and South Sulawesi. Based on intensive interviews, the majority of Java-migrant respondents will go back to Java when the oil-related production activities are gone.

For East Kalimantan, this means that the bounty of oil and gas would leave only "dead areas" such as Sanga-sanga in the Samarinda District, Samboja in the Kutai District, and Tarakan, all of which used to be prosperous oil cities in the province. Meanwhile, for the nation at large this would mean increasing the ecological, economic, and demographic burdens of the Island of Java, which is already overpopulated with more than 120 million people.

Thus, what is needed for the management of the East Kalimantan coastal zone are coastal development planning and policies which could provide a means for utilizing optimally the coastal zone and its resources. In this context, an optimal condition means the multiple use of resources that should be beneficial to all people without compromising the sustainable capacity of the coastal ecosystem. In other words, the overall coastal development in the region should be socioeconomically viable and environmentally safe so that the sustainable utilization of these resources can be realized. This is actually in accordance with the objectives of the regional development of the province namely, increasing the population's standard of living, ensuring an equitable distribution of welfare, establishing a firm base for future economic development, and conserving the environment and natural resources (LRDC/Bina Program, 1987).

3.2. STUDY APPROACH

In order to arrive at the sustainable utilization of coastal resources, a model (framework) of planning and decision making processes should be created, accommodating overall development objectives. The model should facilitate an appropriate means for planners and decision makers to design development policies and programs which ensure that the sum total of all development activities within and related to the coastal zone will be socioeconomically sound and lie within its functional capacity. As reviewed in Chapter II, the sustainable development concept encompasses both biophysical and socioeconomic dimensions. The biophysical dimension requires the application of four criteria: spatial suitability, sustainability (e.g. MSY = Maximum Sustainable Yield and MEY = Maximum Economic Yield), assimilative capacity, and carrying capacity. Meanwhile, the socioeconomic dimension demands an assurance that the use of coastal resources should be for the benefit of all communities, particularly the poor. Such an egalitarian criterion should be backed up by public policy and institutional arrangements which secure effective public participation.

To translate all these dimensions into coastal resource management, a planning framework for the CRM is proposed in this dissertation (Figure 3.1). Since planning is in essence a systematic and intelligent scenario to attain certain objectives, it is logical that goals and objectives of the CRM should be clearly defined at the outset of the planning process. To define the goals and objectives properly, they must be derived from the actual problems and issues facing the CRM. The analysis of existing problems and issues as well as the goals and objectives of CRM should be used as a stepping stone for the subsequent stages of this planning framework.

To locate development activities in suitable sites of the coastal zone (the spatial suitability criterion), their biophysical suitability should be first identified. The assessment of biophysical suitability of the coastal zone is made by defining the biophysical requirements of each development activity that will be undertaken, then comparing

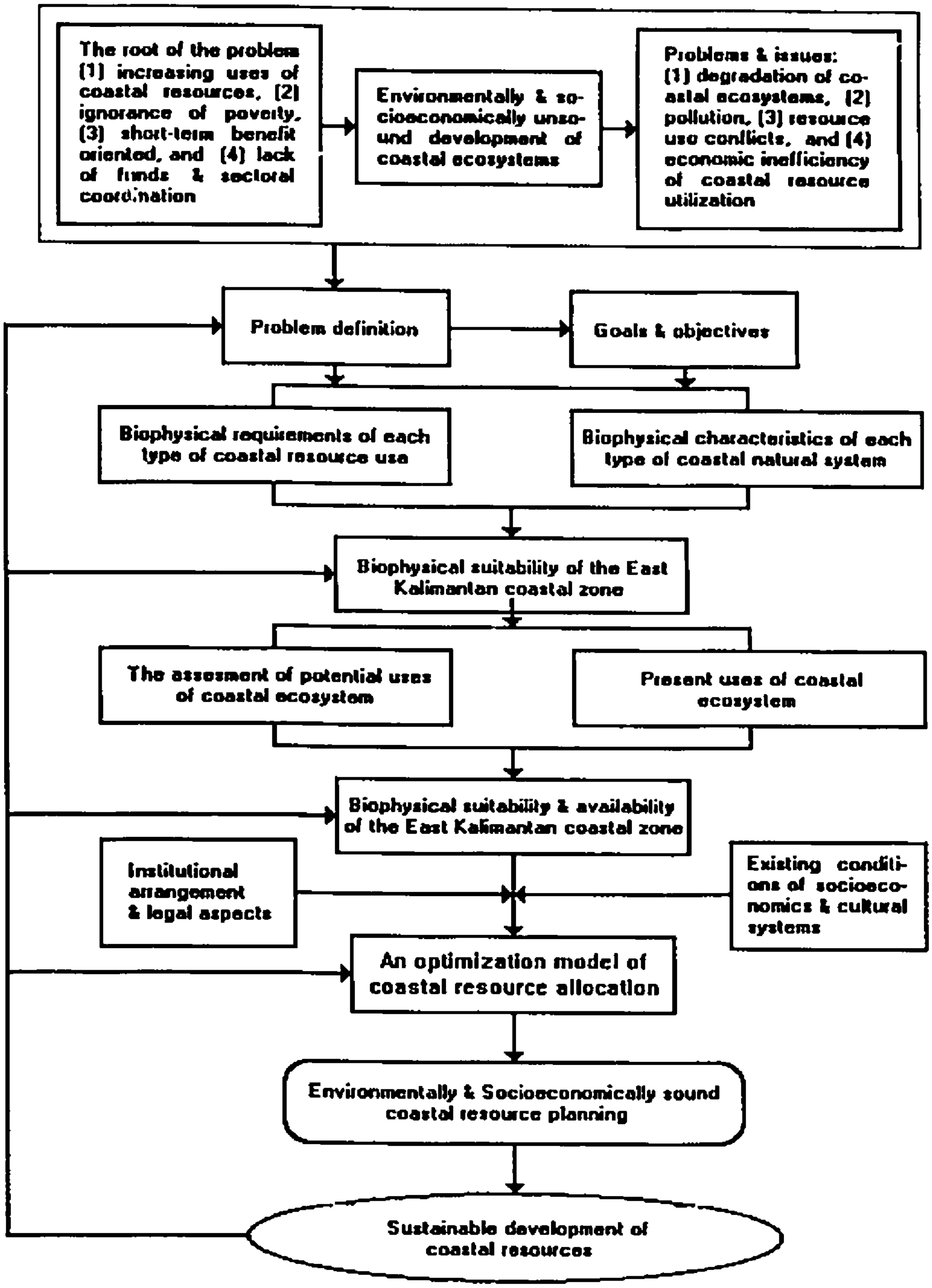

Figure 3.1. An Analytical Framework for Sustainable Development Planning of Coastal Resources.

these requirements against the biophysical characteristics (conditions) of each spatial unit of the coastal zone, and finally deciding whether a certain coastal spatial unit is suitable for a particular type of development activities. Placing development activities within their suitable locations means not only preventing the excessive deterioration of the coastal environment but also helping to ensure the economic viability of these development activities. For instance, one of the major factors causing the failure of some coastal transmigration projects in the country was that soil conditions in the transmigration areas were unsuitable for rice cultivation (Knox and Miyabara, 1984).

When the biophysical suitability map of the coastal zone is matched against the present land (spatial) use map, then the spatial availability of the coastal zone for various development activities can be determined. Moreover, if the future demand on spatial use of the coastal zone can be assessed, an anticipatory and alternative development scenario could also be generated.

Once the location of various development activities has been decided, the next logical step is to determine an optimal level (rate) of each associated development activity. This step is essentially the application of the aforementioned sustainability, assimilative capacity, and carrying capacity criteria. For the CRM this is possibly the most challenging task because: (1) it involves a multiobjective decision-making process, (2) it calls for the consideration of interregional/intersectoral trade offs, and (3) it involves temporal aspects or intergenerational trade-offs.

On the basis of the preceding steps, planners and decision makers will then inquire about when and how these development activities should be carried out, and who will be in charge for looking after implementation, monitoring, and evaluation. These inquiries call for a series of analyses including, among others, infrastructural capability, resource investment potential, socioeconomic conditions, and institutional arrangements of the coastal zone of East Kalimantan Province. This step is basically an effort to ensure the correct implementation of planned activities, events, and managerial resources set out in the preceding stages.

After all, planning is a dynamic as well as an adaptive process. Therefore, it should have enough flexibility to be able to cope with uncertainties occurring either externally or internally in the system under study. In this respect, a proper monitoring and evaluation process could help enhance the flexibility of the planning framework through feedback mechanisms.

3.3. SPATIAL PLANNING ANALYSIS OF THE COASTAL ZONE

This section deals with spatial planning for the coastal zone. In this context, spatial planning is interpreted as a means of spatially allocating the coastal zone for various development activities according to their biophysical suitability. Given the complex and dynamic nature of coastal ecosystems and their management requirements, a Geographic Information System (GIS) namely ARC/INFO, is used to help generate this spatial planning analysis. A brief description of the ARC/INFO GIS is presented in Appendix 3.1.

To accomplish this spatial planning analysis, five major steps were undertaken: (1) defining the objectives and criteria, (2) developing a procedure for the suitability classification and the generation of proposed development areas, (3) creating the database, (4) performing the spatial analysis, and (5) presenting the results.

3.3.1. Defining objectives and criteria.

The overall goal of spatial planning analysis is essentially to provide a relevant information base for planners and decision makers to help in locating development activities in coastal areas based upon their biophysical suitability as well as the spatial availability of the coastal zone. This goal is then broken down into three objectives: (1) the generation of the biophysical suitability classification for various development activities, (2) the establishment of mangrove green belts, and (3) the delineation of use-conflict areas.

The biophysical suitability classification of the coastal zone encompasses three main sequential steps: (i) the definition of biophysical requirements of development activities, (ii) selection of suitability rating criteria, and (iii) the delineation and appointment of spatial units (coastal lands or waters) that meet these requirements or criteria (LRDC/Bina Program, 1987 and McRae and Burnham, 1981).

Based upon both existing and potential uses of the study area (LRDC/Bina Program, 1987, GTZ/TAD-PPSb, 1990 and Personal Observation in the field, November 1989 - May 1990), there are 15 development activities which need to be considered in the spatial planning analysis: wetland rice, dryland rice, maize, soybean, cocoa, rubber, oil palm, banana, coconut, sugarcane, pasture/livestock, and agroforestry (agriculture), tambak (brackishwater shrimp/fish ponds), oil and gas, and quarrying.

The biophysical requirements and suitability rating criteria for agricultural development activities were adapted from the CSR/FAO (1983) study (Appendix 3.2.), while those for tambak and quarrying were derived from the LRDC/Bina Program (1987) (Appendix 3.3.). The CSR/FAO (1983) report sets out 15 land characteristics, which are grouped into 7 land qualities, as a basis to classify a particular land unit for agricultural activities into 4 suitability ratings namely: S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), and N (not suitable). Meanwhile, the LRDC/Bina Program (1987) categorizes the suitability of a spatial unit of the coastal zone for tambak or quarrying into only 2 suitability ratings which are either suitable (S) or not suitable (N).

To come up with proposed development areas, the spatial unit of the study area identified as biophysically suitable for development should also be available. Areas regarded as unavailable for proposed development activities are protected

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that will be affected by a certain development project and to apply mitigation measures before such impacts taking place (Beanlands and Duinker, 1983).

3.3.2. Procedures for creating suitability classification and proposed development areas

The second step in generating the suitability classification basically involves comparing the biophysical requirements and environmental impacts of each development activity with the biophysical characteristics (conditions) and sensitivity of spatial units within the study area. The spatial unit is, in this case, referred to as a land system which is based upon ecological principles and presumes inherent interdependence between rock types, hydroclimatology, landform, soils and organisms (Christian ard Stewart, 1968). The land system data for the coastal zone under study are in the form of spatial features (polygons = area features) at a map scale of 1:250,000 and their associated non-spatial attributes presented in tables (LRDC/Bina Program, 1987).

In essence, the non-spatial attributes of land systems are made up of their biophysical characteristics, which include more than 40 parameters, ranging from climatic conditions to soil characteristics (Appendix 3.4). For the purpose of this study, however, only 13 biophysical characteristics (Appendix 3.5) are used in defining the suitability classification of land systems for various agricultural activities. The selection of these 13 biophysical characteristics was based on the biophysical requirements for agricultural development listed in Appendix 3.2. The total N (nitrogen) and surface stoniness parameters were not included simply due to the lack of data.

To arrive at the suitability classification of land systems for various agricultural developments, the biophysical conditions of each land system (Appendix 3.5) were contrasted against the biophysical requirements of each agricultural development (Appendix 3.2). This classification procedure follows the worst case scenario (the law of the minimum) principle (CSR/FAO, 1983). That is to say that the lowest rating of land (biophysical) characteristics is considered as the final suitability class of a land system under evaluation for a particular agricultural activity.

To illustrate this procedure, suppose the result of comparing land (biophysical) characteristics of a land system against the biophysical requirements for cocoa is as follows:

- Annual mean temperature	= S2
- Dry month	= S2
- Average annual rainfall	= S1
- Soil drainage class	= S1
- Soil texture	= S2
- Rooting depth	= S1
- Cation exchange capacity (CEC)	= S2
- Ph (top soil)	= S3
- Available P2O5	= S3
- Available K2O	= S1
- Salinity	= S2
- Slope	= S2
- Rock outcrop	= S1

Then the suitability class of such a land system for cocoa cultivation will be S3 (marginally suitable), with soil pH and available phosphate as limiting factors. Information concerning these limiting factors is therefore valuable for planning and management purposes. For example, if the limiting factors are those which can be improved by human efforts, such as raising low soil pH values through liming, then one will still be interested in planting cocoa in that land system. On the other hand, if the limiting factor (e.g. the climatic one) can not anthropogenically be improved then the decision might be made not to grow cocoa on such a land system.

It is important to note that the suitability classification generated in this study refers to the current suitability, in the sense that such a suitability represents the value of the land system in its naturally existing conditions without any human intervention. The classification of potential suitability for agricultural activities, which refers to the value of the land system in the future through human improvements, could also be assessed (Subaryono, 1990).

The final product of this suitability classification contains not only information regarding the suitability classes of all land systems in the study area for each individual development activity, but also the suitability map depicting areas (land systems) that are suitable for more than one type of development activities. This sort of information is crucial for determining alternative development scenarios, such as a rotation planting scheme of crops in the coastal zone under study.

3.3.3. Creating the database

The establishment of a database for this study in the ARC/INFO GIS involved four major steps: (1) preparing and designing the database, (2) digitizing and editing spatial features, (3) entering attribute data and relating the attribute with the spatial features, and (4) managing the database (ESRI, 1990).

3.3.3.1. Preparing and designing the database

To perform the analysis required in this study, eight types of coverage were captured. A coverage is the unit of information in the ARC/INFO GIS. These seven coverages are land system (LSYS), land use (LUSE), forest status (FSTA), polygon-base coverage(POLB), line-base coverage (LINB), point-base coverage (PNTB), and regional boundaries (REGB). Then, a data dictionary, which is a list of the names of the attributes and a description of the attribute values including a description of each code for each coverage in the project database, was developed.

All coverage, except the SEAB coverage, were derived from two map series of "Land System" and "Present Land Use/Forest Status" with a scale of 1:250,000 (LRDC/Bina Program, 1987). The land system, land use, and forest status are essentially polygon (area) based feature data. Within the study area, there are 19 types of land systems (Appendix 3.5), 3 types of forest status (Table 7.2), and 12 land uses (Table 7.3).

The polygon-based coverage consists of coastline, double-line rivers, lakes, and urban areas. The point-base coverage includes settlements, airports, harbours, and regency capitals. The line-base coverage consists of surfaced and unsurfaced roads, and single-line rivers (streams). The regency boundary coverage comprises the polygon regency boundaries.

3.3.3.2. Capturing and editing the data

The data capture was done by the author with the assistance of 28 students in the GIS/RS class of 1990/91 at the College of Geographic Sciences, Lawrencetown, Nova Scotia. Accordingly, each data coverage was split into 8 panels and a group consisting of 4 people was responsible for the data capture of each panel.

All data coverage were digitized using a digitizing table. This device is equipped with a moveable cursor to convert the geographic feature location into X,Y Cartesian coordinates set to inches in digital forms. The digitized records of the mapped information were based upon Tic registration coordinates. An Arc Macro Language (AML) program was written to carry out this data capture by way of ARCEDIT digitizing sessions.

Once the data capture was completed, all digital map coverage were topologically built and were scrutinized for possible errors during the digitizing process. Each identified error including dangling arcs and nodes, open polygons, missing or redundant labels in polygons, and missing arcs were edited by invoking appropriate ARCEDIT commands. Finally, the topology (spatial relationships) for each coverage was reconstructed.

3.3.3.3. <u>Entering attribute data into the database</u>

Through the creation of topology, each coverage has a feature attribute table which is a tabular data file storing standard attributes about the features (ESRI, 1990). There are currently three types of feature attribute tables: the polygon attribute table (PAT), the arc attribute table (AAT), and the point attribute table (PAT) that are associated with area, line, and point features, respectively.

The associated attribute (non spatial) data of land system areas including their biophysical characteristics, their suitability class for each development activity, their suitability class for all fourteen development activities, the total length of roads, double-line rivers, streams, and the total number of settlements within each land system area were stored in an INFO data file. To link these attribute data with their associated geographic features on the digital map of the coverage, a common identifier called 'LSCODE' was added within both PAT (polygon attribute table) and the INFO data file. It is in this context that the power of a relational database as provided by the ARC/INFO system plays a crucial role. To calculate the total length of roads, double-line rivers and streams, and the total number of settlements as well as to load this information up into the INFO data file, several INFO programs were developed and applied.

3.3.3.4. Managing database

At this stage, all coverage were projected from a latitude-longitude registration into a UTM (Universal Transverse Mercator) coordinate system. Furthermore, the digitizer coordinates (in inches) of all coverage were also transformed into the real-world coordinate, UTM. These operations were carried out by using PROJECT and TRANSFORM commands in ARC sessions.

Each coverage of the eight panel areas (as derived in the previous stage) were then merged to become a single coverage which represent the entire study area. This was done for each of the aforementioned seven thematic layers. These operations were conducted by using the appropriate edge matching commands under ARCEDIT sessions and relevant join commands in ARC sessions.

3.3.4. Performing the analysis

Three groups of analyses were carried out:(1) the generation of suitability maps, (2) the delineation of use-conflict areas, and (3) the construction of proposed development areas.

The biophysical characteristics of each land system in the study area (Appendix 3.5) were contrasted sequentially against the criteria for each agricultural development activity (Appendix 3.2) to determine ratings of land qualities. These ratings were then compared and selected to define the final suitability classification of each land system for a given agricultural development activity. Meanwhile, the suitability classification of land systems for tambak and quarrying activities were adapted from LRDC/Bina Program (1987). Because the biophysical data are in a different format from the criteria set out by CSR/FAO(1983), this matching operation was done manually instead of using an INFO programming.

Once the process of suitability classification of all land systems for each of the aforementioned fourteen development activities was completed, the suitability classification of each land system for the fourteen development activities were then created (Appendix 7.12). The diagrammatic view of generating suitability maps and their associated tabular data is presented in Figure 3.2.

As mentioned above, proposed development areas should be those which are not only suitable for one or more development activities, but also available in the sense that they are not currently used for the aforementioned development activities. Accordingly, the generation of maps of proposed development areas and their associated tabular information was undertaken by making polygon overlays of Land System, Present Land Use, and Forest Status coverage.

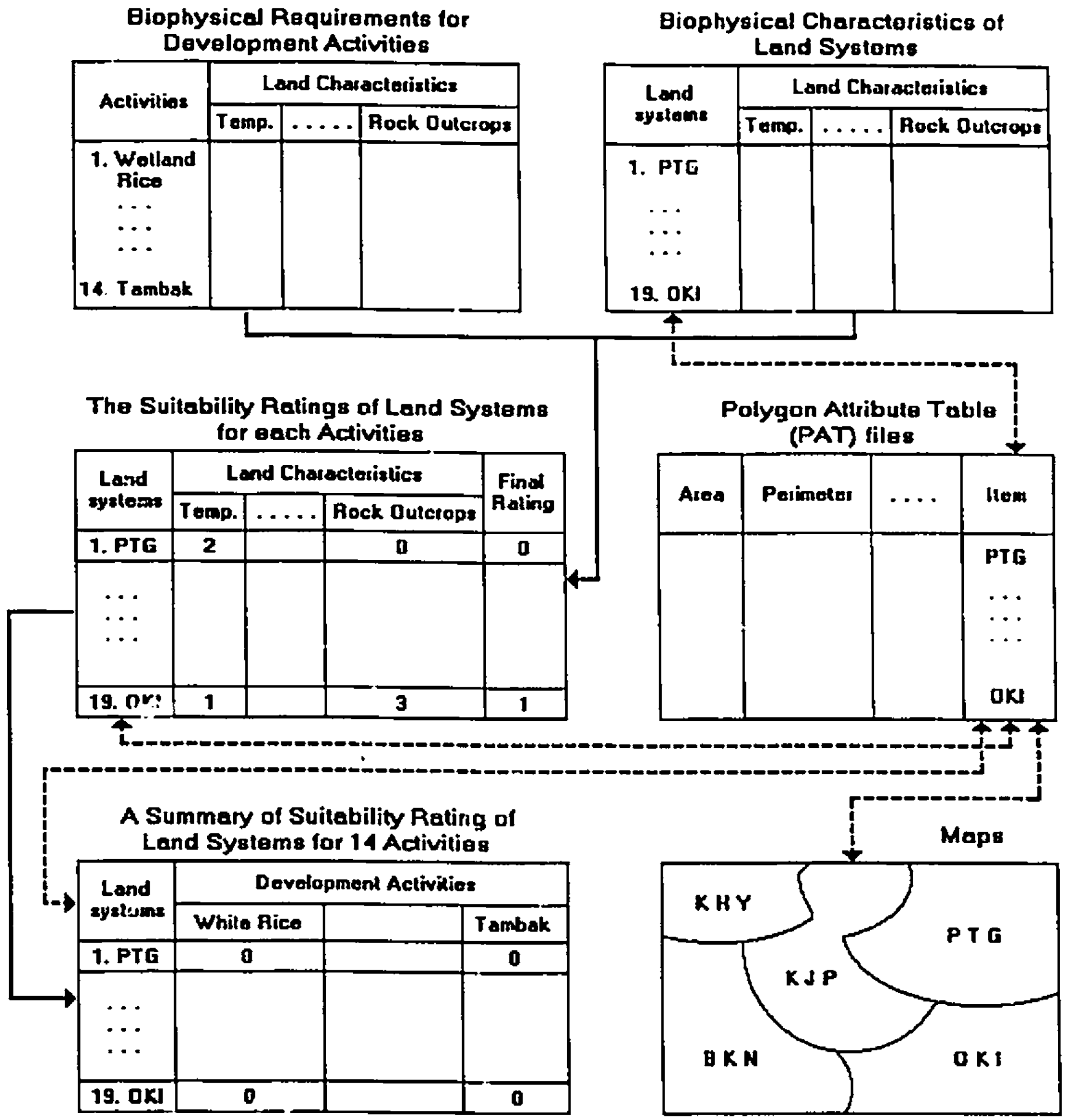


Figure 3.2. A Process in Generating Suitability Maps

To determine the priority scale for proposed development areas, in terms of an implementation phase, proximity to existing transportation networks and marketing centers were used as criteria. Accordingly, the length of roads and rivers as well as the number of settlements (as a proxy of the marketing center) are provided on the associated tabular information of each suitability map (see Figure 7.2 to 7.6).

3.3.5. Presenting the results

The product of the spatial planning analysis is a series of maps and descriptive analyses which depict the suitability classification, proposed development areas, and use-conflict areas along the coastal waters, as well as their corresponding tabular forms. For the sake of manageability in the dissertation, the study area was partitioned into five map compartments for the above analyses.

The process of generating these maps was interactively carried out using appropriate MAP COMPOSITION commands during ARCPLOT sessions. To produce more informative and appealing maps, they were composed with polygon texts, annotations, color shadings, symbols, legend, scale bar, and north arrow, as normally appear on a conventional map. Polygon color shading symbols assigned for suitability classes were stored in a look-up table within INFO sub-system.

In the meantime, the associated tabular forms were generated by using appropriate REPORT commands under INFO sessions. These digital tabular data can be examined and retrieved within INFO sessions. The maps produced under ARCPLOT sessions can also be retrieved at any time on the terminal screen or output to a plotter.

3.4. A SIMULATION MODEL FOR THE UTILIZATION OF COASTAL RESOURCES

The complexity and uncertainty inherent in both natural and human systems have led to the use of models in carrying out planning and decision-making processes of environmental and natural resource management (Gordon, 1985). The main reason underlying all simulation and certain other modelling works is to analyze the operation of a system in order to evaluate its performance, particularly with respect to human interferences.

The question of how to determine an optimal and sustainable rate of each development activity within the coastal zone is the one that involves complex and dynamic interactions between human society (economy) and coastal ecosystems. Hence, a simulation modelling technique is used in this dissertation to help answer such a question. In this modelling effort, the determination of an optimal rate of each development activity within the coastal zone under study will be estimated by simulating and analyzing the trade-off between economic benefits gained and environmental quality lost as a result of the implementation of these development projects. The model consists of three main sub-models: economic, ecological, and resource-damage assessment submodels (Figure 8.1 of Chapter VIII).

The economic submodel is used to simulate the economic benefits (total profit) and environmental degradation (i.e. the discharge of waste and the degradation of mangroves) generated by development activities. The ecological submodel will be used to assess the likely impacts of development activities on the performance of coastal environmental quality which, in this case, is reflected in the form of the level of organic wastes (BOD = Biological Oxygen Demand), oil wastes, and thermal wastes in the coastal water. The resource-damage assessment submodel is used to assess the economic value of environmental degradation as a result of development activities. This economic value is a feedback from ecological submodel to economic submodel, which decreases social benefits of development activities.

The primary objective of the modelling work is to provide decision makers and planners with a framework for determining the profitable level of development activities which, in this context, include oil, LNG, fertilizer, and brackishwater fish/shrimp pond (tambak) in such a way that their impacts on the coastal environment are within acceptable limits set by environmental standard guidelines. The model will concentrate on, and is defined by, the critical management problems encountered. In this case, it is how to carry out the above development activities profitably without endangering the sustainable capacity of the coastal environment.

The threats of development activities upon the coastal environment are wastes that they produce, the decrease in the supply of detritus (organic matter) to coastal waters due to mangrove cutting, the loss of mangrove biomass as a habitat for coastal organisms as well as its physically protective role for the stabilization of the coastal zone from storm and wave actions, and general physical disturbance.

The model is built and run by using the STELLA dynamic simulation modeling software (Appendix 3.6). Inputs to the model consist of the level of the above development activities:

- Oil production : how many barrels produced each year;
- LNG production : how many tonnes produced each year;
- fertilizer factory: how many tonnes are produced each year; and
- tambak production: how many hectares are in operation each year

Outputs of the model consist of the following items:

- the total profit, total economic losses due to ecological damage, and social benefits generated by these development activities;
- the level (concentration) of each type of wastes in coastal water generated by development activities; and
- the affected area (see its definition in Chapter VIII) of coastal waters by waste discharge.

3.5. DATA AND INFORMATION COLLECTION

Both primary and secondary data, as a basis for the development of this dissertation, were collected starting from the beginning of October 1989 to the early June 1990. Primary data were collected through field observations and measurements along the coastal zone under study, and through interviews. These interviews were conducted with local residents (e.g. farmers, fishermen, factory workers, and traders), government officials (e.g. Deputy Minister of State Ministry for Population and the Environment, and provincial government officials), researchers and scientists in various universities and research institutes, informal leaders (religious leaders), and local non-governmental organizations (NGOs). Informal leaders were chosen based upon the information given by the majority of people in a certain society. Representative from government officials and NGOs were selected purposedly.

Interviews were carried out randomly with local residents in six villages of four sub-districts by using questionnaires as a guide. However, sometimes questionnaires were not used because the respondent was not willing or was suspicious of such a questionnaire. Secondary data were collected from a variety of relevant agencies in Jakarta, Bogor, Bandung (all these three cities are in Java), Balikpapan, Samarinda, and several sub-districts of the Kutai District. The secondary data were also obtained from literature studies.

Data for supporting spatial planning analysis (including biophysical characteristics of coastal land systems) were mainly derived from the LRDC/Bina Program (1987). The information regarding biophysical criteria for development activities, presently or potentially, occurring within the coastal zone were obtained from CSR/FAO (1983) as well as LRDC/Bina Program (1987).

Data and information for developing an optimization model consisting of oceanographic data (current, bathymetry, salinity, and water temperature); the fate of oil, thermal, and organic matters in the coastal water; the production and waste generation rate of each development activity being optimized; and socioeconomic data of development activity (profit and employment) obtained from companies and governmental agencies as well as published and unpublished literature sources.

Meanwhile, data and information on: the regional setting of the coastal zone; the types, extent and nature of uses of coastal resources; the economic value of coastal resources; impacts of development activities on the coastal resource base and human communities; institutional aspects; socioeconomic and cultural aspects (for making up Chapters IV, V, VI, and IX) were gathered from various agencies, interviews and the literature.

On the basis of the regional setting, and the potential as well as use of coastal resource bases (Chapter IV and V); problems and issues facing the CRM (Chapter III and VI); the output of spatial planning and simulation modeling analyses (Chapter VII and VIII); and the conceptual framework of sustainable development with respect to the CRM (Chapter II), an integrated management framework for sustainable development of coastal resources is offered in Chapter IX.

IV. REGIONAL SETTING OF COASTAL KUTAI AND SAMARINDA

4.1. INTRODUCTION

Borneo, which has been known to the western world for centuries, is the third largest island in the world after Greenland and New Guinea. Kalimantan, as the Indonesian part of Borneo, occupies the southern three quarters of the island. The remaining part of the island belongs to the Malaysian states of Sabah and Sarawak, and the independent Sultanate of Brunei Darussalam. Kalimantan itself makes up about 28% of the total land area of Indonesia and is divided into four provinces: West, Central, South and East Kalimantan.

East Kalimantan, the second largest province of Indonesia after Irian Jaya, covers a land area of 211,440 km^2 and is geographically located between 4°25′ N and 2°25′ S, and between 113°44′ and 119° E (Figure 4.1). In addition, this province with approximately 850 km coastline is also blessed with a marine territory of 120,000 km^2 (Dinas Perikanan Dati I Kaltim, 1987). Administratively, the Province of East Kalimantan is comprised of 7 districts (Pasir, Balikpapan, Samarinda, Kutai, Berau, Bulungan and the Administrative city of Tarakan), 71 sub-districts, and 1,088 villages (Kantor Statistik Propinsi Kaltim., 1989).

The coastal area of Kutai and Samarinda encompasses an area of about 36,022 km^2 which is roughly 17 % of East Kalimantan's total area. According to the Provincial

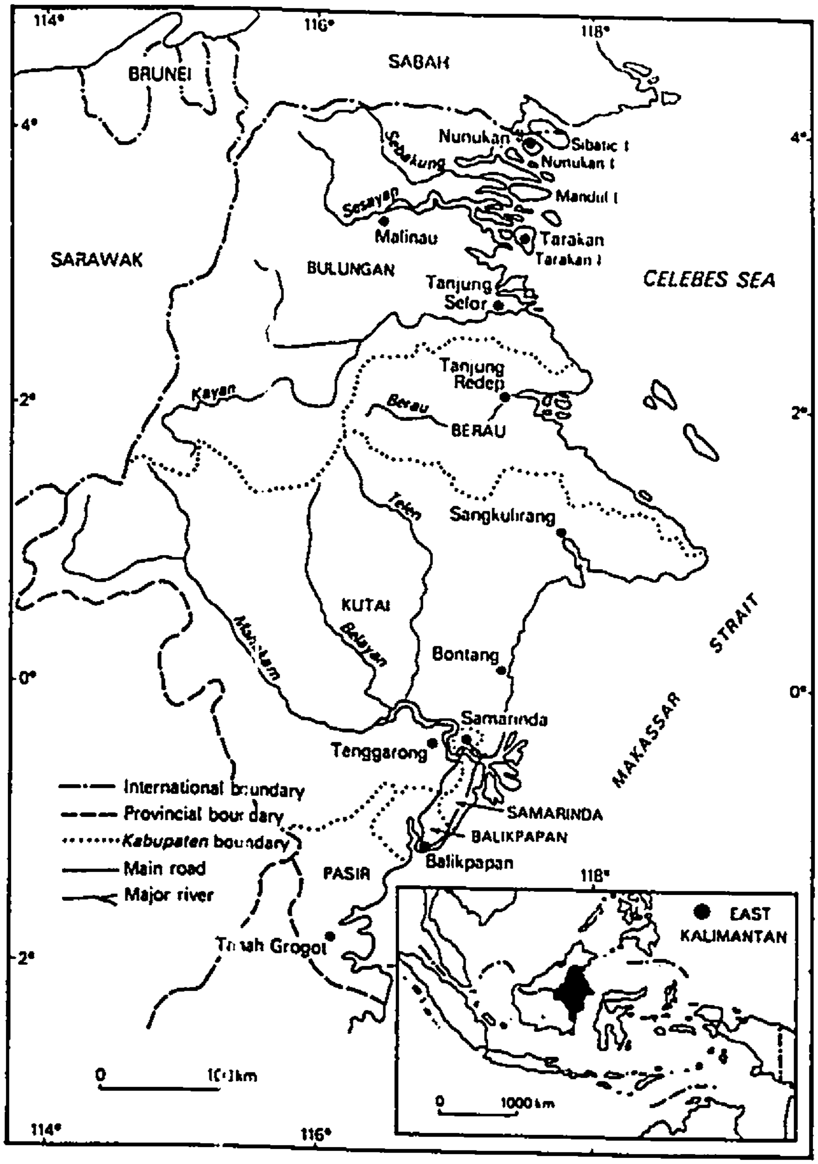
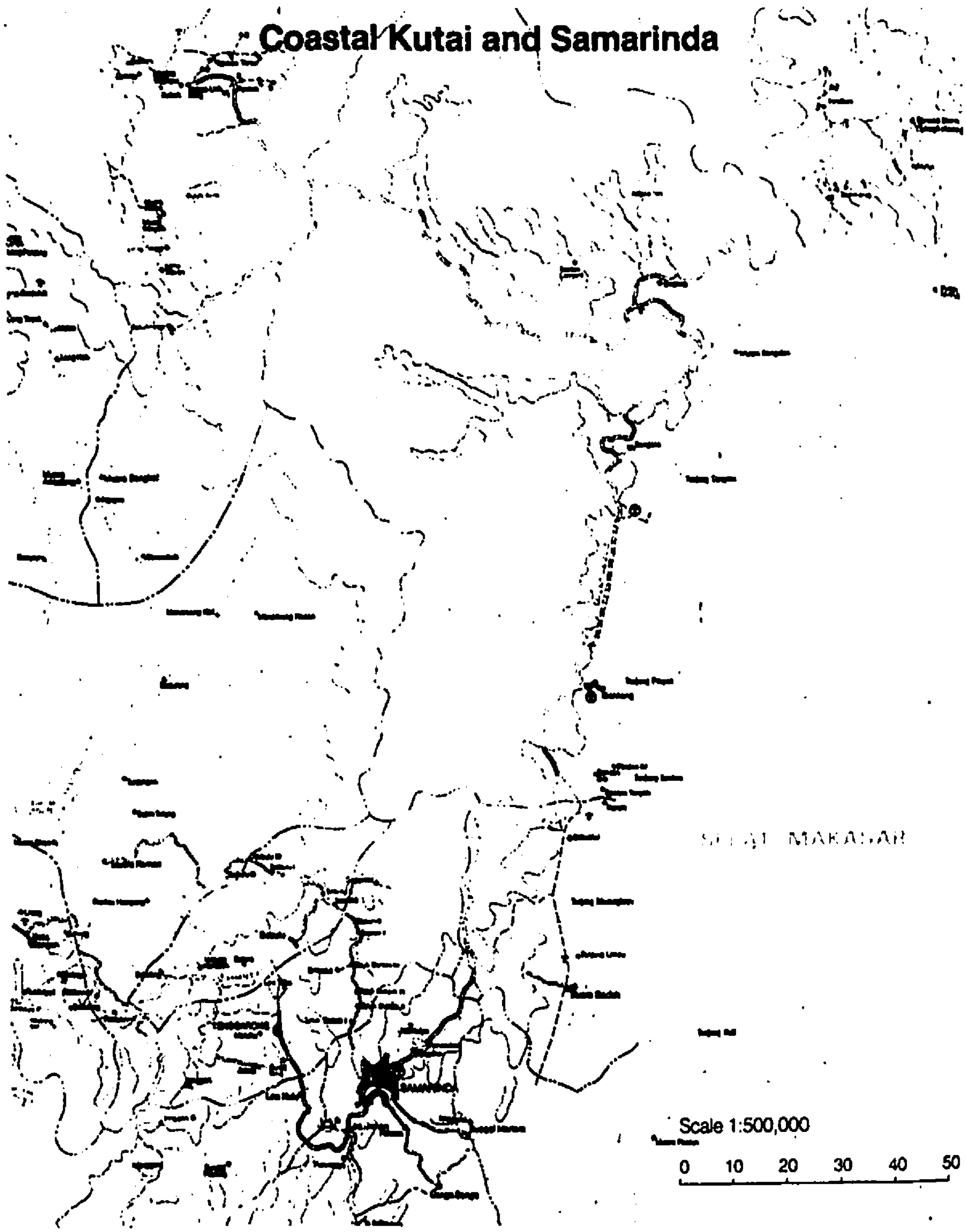


Figure 4.1. Map of East Kalimantan (Pangestu, 1989)

Government of East Kalimantan, this coastal area consists of 17 sub-districts and is geographically situated between 1° Nand 0° 45′ S, and between 116°45′ and 118° E (Figure 4.2). The area is delineated in the east by the coast facing the Makasar Strait. The northern border is marked by the Sangkulirang - Muara Wahau Road, the western border by the Kedang Rantau and Wahau Rivers, and the southern border stretches from Samarinda westward along the Mahakam River to Tenggarong (Capital city of Kutai District) and further west along the road to Kota Bangun (GTZ/TAD-PPS, 1990a). This definition of the area is primarily based on the network of economic (development) activities and their potential effects on the coastal ecosystems (personal communications with Mr. Syaiful Teteng and Dr. J.F. Von Franz,1990).

However, if it is viewed from ecological perspectives (in terms of elevation, geomorphology, and the extent of both marine and inland influences on the coastal zone under consideration), then the landward boundary of coastal Kutai and Samarinda will include only the land area of 10 sub-districts. These are Sangkulirang, Bontang, Muara Badak, Anggana, Sanga Sanga, Muara Jawa, Palaran, Samarinda Seberang, Samarinda Ulu, and Samarinda Ilir. The seaward boundary of this coastal area, in this case, is the edge of the continental shelf, where the gradually sloping ocean floor begins to drop off markedly, the water's properties change, and open ocean begins. According to international agreements, the water depth of 200 m is defined as the mark for the

Figure 4.2. The Coastal Kutai and Samarinda defined by the Provincial Government of East Kalimantan



Source: GTZ/TAD-PPS (1990a)

continental shelf's edge (Gillman, 1977). The coastal Kutai and Samarinda shelf varies in width. It drops off close tothe shore just in front of Sangkulirang River mouth and close to the Mangkalihat Peninsula. The subsequent description and analysis of the setting of this coastal zone covers both areal boundary definitions.

4.2. PHYSIOGRAPHY AND GEOLOGY

So far there have been a lack of research and publications on the physiography, including geology and geomorphology, of East Kalimantan region. Besides recent geological maps of 1 : 2,000,000 (1965) and 1 : 500,000 (1970), the most prominent source of East Kalimantan geology is the remarkable book by R.W. van Bemmelen, "The Geology of Indonesia" (1949). Although the coastal zone of this province has been extensively investigated for oil and gas exploitation, the only published maps accessible to the public are about the sedimentology of the Mahakam Delta (LRDC/Bina Program, 1987). Yet, with a few additional surveys, Voss (1983) and LRDC/Bina Program (1987) have been successful in providing a more comprehensive picture of the physiography of East Kalimantan.

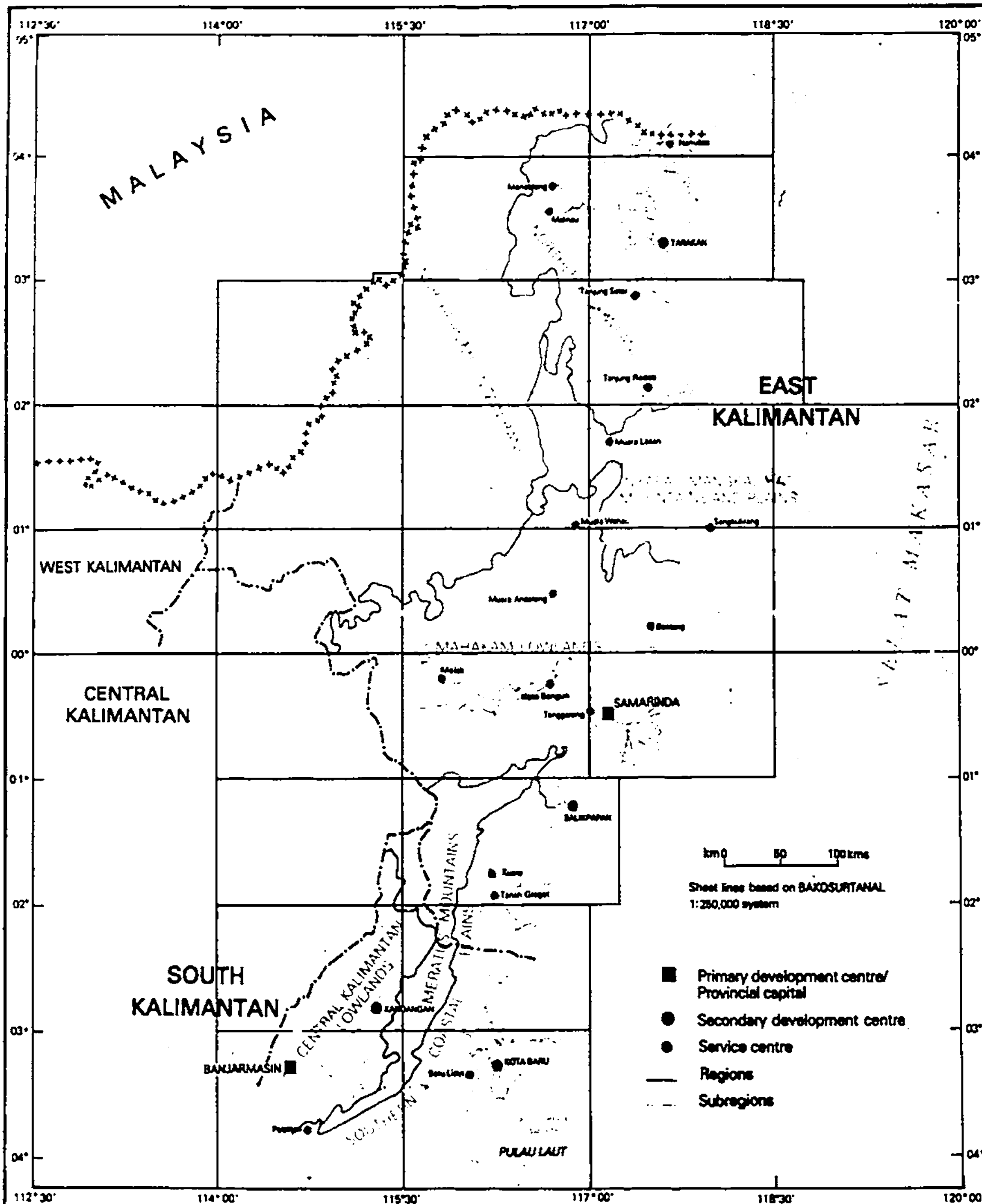
During the last glacial low-sea level phase, Sumatra, Java and Kalimantan were joined to the mainland of Southeast Asia, forming an enlarged Malaysian Peninsula separated by deep straits, one of which is the Makasar Strait, from Sulawesi and eastern islands (Bird and Schwartz, 1985 and Morgan and Fryer, 1985).

East Kalimantan along with South Kalimantan province forms a large southern salient of the earth's crustal plate named the Sunda Shelf. To the immediate east lies the narrow (200 km) but deep (1,500 m) Makasar Strait and the Island of Sulawesi which was separated from Borneo in fairly recent geological history, first in the middle and then in the late Tertiary by rifting of the crustal plate (Hamilton, 1979). The whole region has been, and still is, a zone of tectonic instability, in which sometimes diverging, sometimes converging plates created broad sedimentary basins or subduction zones of intensively mixed and fractured strata.

Under a physiographical classification established by LRDC/Bina Program (1987), most of the Coastal Kutai and Samarinda area belongs to the Mahakam Lowlands. Only the small northern part of the area (Sangkulirang and Muara Wahau) is classified as the Nyapa Mangkalihat Mountains and Plains, particularly the sub-region of the Mangkalihat Karstic Plains and Ranges (Figure 4.3). Furthermore, the Mahakam Lowlands is divided into three major and two minor sub-regions. The Raha-Wahau Hills and Lawa-Sangatta Ridge Systems consist of series of high ridges separating the Interior Lakes Basin, a major swampy depression in the middle Mahakam, from the coastal area. The two minor sub-regions are the West Kutai Volcanic Plateau in the west and the Delta Swamp in the east.

The Mangkalihat and Sangkulirang region is underlain by limestones and calcareous mudstone with occasional tufaceous

Figure 4.3. Physiographic Regions and Sub-regions of East Kalimantan



Source: LRDC/Bina Program (1987)

sediments derived from more or less simultaneous volcanism. Tuff and tufaceous sediments are widespread in the marine mud of the western Mangkalihat Peninsula (Voss, 1983).

The geological stratigraphy of East Kalimantan ranges in age from the Pretertiary and the Quaternary (GTZ/TAD-PPS, 1990a). The oldest rocks belong to the Palaeogene. They are weakly metamorphosed and contain igneous material. They occur towards the edge of the Mahakam Lowlands region and have resulted from tectonic upwarding of the surrounding mountains. However, the landscape is predominantly covered by younger Neogene or Miocene-age rocks up to early Quaternary sedimentary rocks. Meanwhile, younger alluvial can be found in the Interior Lake Basins and the Delta Swamp, and sub-recent volcanic form the West Kutai Volcanic Plateau. In the early Tertiary, tectonic activity caused the formation of geosynclines in the central Mahakam and offshore beyond the Mahakam Delta (Kutai Basin), in which the thickness of sediments surpasses 8,000 m in a depositional environment ranging from deltaic and reef to deep marine ecosystems. Bordering and separating the basins are strongly-folded zones trending southwest-northeast (LRDC/Bina Program, 1987).

Geomorphologically, most of the area is a series of strongly rolling parallel ridge systems, joined by less linear blocks. These ridge systems consist of partly very steep-sided, long, narrow-crested ridges in a weakly parallel or often non-ordered pattern, reaching altitudes of less than 250 m. The associated drainage pattern is dendritic offering little valley floor suitable for development (GTZ/TAD-PPS, 1990a).

The coastal fringe is irregular and formed by alternating estuaries, tidal mudflats, mangroves, coral reefs, hilly headlands and beaches. It has many inlets and swamp-fringed embayment. The larger rivers reach the coast in small alluvial plains, trapped behind mangrove swamps. The velocity of river flows to coastal waters, usually with high sediment loads, are reduced upon reaching a body of still water. Coarse particles are deposited first, and finer clays may be deposited offshore. Changing river flows and sediment rates affected by coastal current has resulted in the development of deltaic environments within major rivers in the area (Voss, 1983).

The largest deltaic system, Mahakam, has the classic form of a bird's foot delta. It extends 40 km seawards and is nearly 100 km broad at base. Coarse sandy sediments derived primarily from ridges and valleys in the Samarinda area are prominent in the delta, which has numerous distributaries branching among the swampy islands (Magnier et al., 1975 and Allen et al., 1976).

The delta is typically flat and covered with mangrove and nipah swamps. Three major distributaries branch out from the delta head at Sanga-sanga sub-district, dividing and subdividing into 15 fluvial channels entering the sea. Between these distributaries are tidal inlets and sinuous creeks practically unconnected to the more rectilinear fluvial system (LRDC/Bina Program, 1987).

The Mahakam Delta covers an area of about 5,200 km2 which consists of 1,500 km2 of deltaic plain with topographically flat and 0.1 % in slope, 1,000 km^2 of deltaic front as a part of the deltaic system that is inundated when spring tide and partly emerged during the ebb tide, and 2,700 km^2 of prodelta as the outer part of the system with slope ranging from 0.5 to 10 % seawards. The Sangatta and Sangkulirang are other rivers in the area which drain into the coastal water in funnel-shaped tidal estuaries. They are located in the northern part of the coastal Kutai.

Based upon a tracing on marine sediment 1.5 m below the sea floor within 340 m water depth, the marine sediment of East Kalimantan is predicted to have an age of about 30,000 years. This implies an average rate of marine sedimentation of 0.05 mm per year. All sediment materials come from the Kalimantan land mass which originate in both new sediments and the decomposition of old rocks (Faugeres et al., 1989 and Gayet et al., 1990 in UNOCAL, 1990).

The sea floor condition of the coastal water in the study area is not homogeneous. In areas where major rivers flow, such as between the Mahakam Delta and Tanjung Santan, the mouth of the Sangatta, Bengalon and Sangkulirang rivers, the bottom sediments mostly consist of muddy sand, sand and mud, reflecting the submerged coastal plains. By contrast, coastal areas far from river flow influences, such as between Bontang and Sangatta, and between Sangatta and Bengalon, coral reefs form the dominant feature (Voss, 1983 and UNOCAL, 1990).

4.3. CLIMATE

Being located in the equatorial belt, the Samarinda and Coastal Kutai Area have an equatorial climate characterized by uniformly high temperature and wet conditions throughout the year. Accordingly, the main determinants of climate in the area are its equatorial location, and the seasonal wind and precipitation patterns associated with monsoonal circulation.

There are no seasons similar to those of the temperate zones. Instead, seasonal weather changes are governed by the two great opposing monsoons that converge along the ITCZ (Intertropical Convergence Zone). The ITCZ moves north and south with the sun heralding the change from one monsoon to another (Anonymous, 1987). During April through September as the sun migrates from the south to the north, the southerly wind blows. The northerly-wind season start in October and ends in March, while March to April and September to October are usually identified as being transition periods (Dinas Perikanan Dati I Propinsi Kaltim., 1987).

Based upon the Koppen climatic classification system, the region has climate type of Aafw which is a tropical rainy isothermal climate with no dry season (wettest month more than 60 mm mean rainfall). It has two rainfall maxima: April - May and December - January. The mean annual rainfall in the region is 2,000 to 3,500 mm/year. It then decreases to less than 2,000 mm/year over a large coastal and inland area, covering the Sangatta and Bengalon catchment areas as well as the Lower Mahakam area.

The air temperature is almost uniform throughout the year, with small seasonal variations in different parts of the Samarinda and Coastal Kutai area. Mean monthly maximum temperature ranges from 30 to 32° C, and mean monthly minimum temperature is 22 - 26° C. Relative humidity varies from 68 to 87 %, being drier inland and more humid on the immediate coastal area. Sunshine averages around 2,000 hours/year and the actual evapotranspiration is estimated at 1,500 to 1,600 mm/year (GTZ/TAD-PPS, 1990b).

4.4. HYDROLOGY AND DRAINAGE

More than 20 rivers flow to the coastal water of the study area. The biggest river is the Mahakam with a total length of about 920 km, of which about 700 km is navigable (Kantor Statistik Propinsi Kalimantan Timur, 1989). The drainage pattern of the area is essentially dominated by the Mahakam river. The catchment area of this river, covering an area of 77,400 km^2, is the third largest in the country (UNOCAL, 1990). In addition, there are five smaller coastal catchment to the north, namely the Santan, Sangatta, Manubar, Bengalon and Kerangan rivers.

At the mouth of the Mahakam, Sangatta and Bengalon rivers, the mean monthly flow is approximately 4,150, 50 and 40 m^3 per second respectively. The river regime of the Mahakam has a minimum flow from June to September, and two runoff peaks in December - January and April - May. In terms of water availability, allowing a demand of 2.5 litres/ha of rice field, the irrigation potential is huge for the Mahakam (1,700,000 ha) and smaller but still significant for the Sangatta (20,000 ha) and the Bengalon (16,000 ha) (LRDC/Bina Program, 1987).

4.5. BIOPHYSICAL CONDITIONS OF THE COASTAL WATER

Unlike the land area, the natural conditions of the wet side (coastal water) of East Kalimantan coastal zone are not well documented. All oceanographic observations (e.g. UNOCAL, 1990; Anonymous, 1987; Birowo and Arief, 1986; Universitas Mulawarman, 1983; and Wyrtki, 1961) in the study area are very general in nature and mostly are over a short period of time.

This section describes bathymetry, tides, current, waves, water properties, and biological conditions of the coastal water under study. Such a description may provide information regarding both the productivity of the coastal water and its ability to assimilate wastes.

4.5.1. Bathymetry

In general, the seafloor of East Kalimantan coastal water is characterized by a relatively flat continental shelf extending from the coast to about 200 m depth seaward. On areas in front of river mouths such as the Mahakam and the Sangatta, the shelf is wider than those where no river flows. Offshore of the coastal water lies the Makassar Strait with depth ranging from hundreds of metres to 2,000 m.

4.5.2. Tides

The tidal patterns in the study area are mixed tides with diurnal dominance (Wyrtki, 1961; UNOCAL, 1990). Based upon one year predicted tidal records (Janhidros, 1990), the annual tidal ranges in Samarinda, Bontang, and Sangkulirang coastal waters are 1.40, 1.75, and 1.55 meters respectively. This quite agrees with the field observation data in Bontang area that reveal the sea levels at 0.73 m and 2.51 m for the neap tide and the spring tide respectively (UNOCAL, 1990; personal observation, 1990).

4.5.3. Current

Analysis of current data in the study area identifies three major constituents:(1) tidal current, (2) offshore current, and (3) longshore current.

In the coastal areas of Makassar Strait tidal current are usually predominant, but offshore tidal current are weak (Anonymous, 1987). In certain coastal areas and times, coastal tidal current can be weak. For instance, the field observations in Tanjung Santan coastal water in November 1989 and in Bontang coastal water in 1983 recorded the average and maximum speeds of tidal current at 0.3 and 0.4 knots, and 0.13 m/second and 0.46 m/second respectively (UNOCAL, 1990; Universitas Mulawarman, 1983). Although the dominant direction of tidal current in coastal areas is southward, more offshore current tend to flow northward.

The speed and duration of both flood and ebb rise when setting in the same direction as the non-tidal current. In estuaries, such as the deltaic systems of Mahakam, Sangatta and Bengalon, the flood current occasionally are masked by high river discharge from heavy rains. Among the reefs, the current are strong and variable. Rips caused by opposing current or by the wind moving against the current are most pronounced during the west monsoon (Anonymous, 1987).

The offshore current, which flow through the Makassar Strait, are very slightly affected by the monsoon winds except in the southern entrance. The general surface current (circulation) flows southward all year around, with little variations toward southeast and southwest directions. The range of mean current speed is 0.4 to 0.6 knots. However, most surface current flow at speed lower than 0.48 knots, except in August they can reach at speed of 0.73 knots (Wyrtki, 1961; Anonymous, 1987).

The non tidal current flow into the Strait from the Celebes (Sulawesi) Sea and set south and southwest with large clockwise gyres in the western (Kalimantan) part during May through September. Along the Sulawesi coast, a northward flow occurs in December and January. In the southern entrance to the Strait, the current set southwest during April through October and southeast during November through March. The mean speeds vary from 0.4 to 2.2 knots with the highest speed in the narrow part of the Strait in April (Anonymous, 1987).

The longshore current generally flow southward with speeds of less than 1.0 knot. This flow pattern of longshore current is also reflected in several recurved sand spits in the study area, such as the Marang Kayu, the Santan canal of UNOCAL, and the Sangatta, which bend southward (personal observation, 1990; UNOCAL, 1990).

4.5.4. Waves and sea levels

In the offshore areas, the waves can be as high as 1.5 m during strong winds. However, in the nearshore areas, the surface water is usually calm due to protection from coral reefs and other emergent land features (islands). In the Bontang Bay, for example, the maximum wave height is only 0.5 m (Universitas Mulawarman, 1983).

By the turn of this century, the global warming due to an increasing greenhouse effect could bring about climate changes and accelerate sea level rise. Although the warming effect caused by the increase in the atmospheric concentration of greenhouse gases has some inherent uncertainties as reflected in all climate models, several empirical observations indicate that the earth is warmer now than in the last century (Hansen et al., 1983; Kerr, 1988).

According to Titus (1985) and Jaeger (1987), the projected sea level rise on the global level by the year 2050 could range from 23 to 30 cm (low scenario) to 116.7 to 150 cm (high scenario). This was based upon the projected temperature rise of 0.3° C (low scenario) and 5° C (high scenario) for the same year (Jaeger, 1987). Meanwhile, Paw and Chua (1991) predict that the likely mean value of temperature rise for the humid tropical region (latitudes 0° - 30°) by the year 2050 is in the range of 1 - 2° C. This means that the potential sea level rise for East Kalimantan coastal zone in the middle of next century would be in the range of 41 - 67 cm. Because most areas of the coastal zone under study are flat with slopes of no greater than 3% (LRDC/Bina Program, 1987), the possible impacts of such a sea level rise on the physical environment and socio-economy of the region could be very significant. A detailed discussion of these impacts will be described in Chapter VI.

4.5.5. Water Properties

Properties of the coastal water, in this case, include both its physical (temperature, salinity and density) and chemical (nitrogen and phosphorous concentrations) characteristics.

4.5.5.1. Temperature

Sea surface temperatures in the study area are consistently high throughout the year, ranging from 28.4 to 30.6 ° C. Vertically, a temperature gradient is clearly present. At 50 m depth, water temperature declines to a range of 25.2 to 29.4 ° C. At 100 m depth, it becomes 21.5 to 26.2° C, and at 900 m depth the temperature ranges from 4.5 to 4.9° C (Birowo and Arief, 1986).

4.5.5.2. Salinity

On the water surface, the salinity ranges from 33.5 to 34.0 ppt (part per thousand). At 50 m depth, it ranges from 33.0 to 34.4 ppt. From water depths of 100 m to 1,400 m, the salinity difference only ranges from 34.2 to 34.8 ppt (Birowo and Arief, 1986). The salinity tends to increase northward, probably due to the influence of water mass from the Pacific Ocean that has a relatively homogeneous salinity of greater than 34 promil (Wyrtki, 1961).

The salinity in the study area is also affected by freshwater influx from both rainfall and river discharges. During the wet season (December to April), the salinity ranges from 30 to 32 promil, and during the dry season (June to October) it ranges from 32 to 34 promil (Anonymous, 1987). In the vicinity of rivers like the Mahakam and Sangatta, the surface salinity ranges from 14 to 21 promil (personal observation, 1989).

4.5.5.3. Nutrients

Data on nitrogen compounds in the forms of N $-NH_3$ (N - ammonia), N $-NO_2$ (N -nitrite), and N $-NO_3$ (N -nitrate) as well as phosphorus in the form of ortho phosphate (P $-PO_4$) in the study area are available based upon snapshot sampling. Values of these nutrients along with other chemical characteristics in Tanjung Santan and Bontang coastal waters are presented in Table 4.1.

Table 4.1 clearly shows that some portions of the coastal water in the study area have been polluted by oil wastes and nitrogen compounds. The oil concentration in Tanjung Santan coastal water has already exceeded the environmental standard as much as two to five times. Meanwhile, nitrate and ammonia far exceed the existing ambient standard.

Table 4.1. Some Chemical Characteristics of Tanjung Santan and Bontang Coastal Waters

No.	Parameter	Units	Bontang Min.*)	Bontang Max.*)	Bontang Mean*)	Tanjung Santan Min.**)	Tanjung Santan Max.**)	Tanjung Santan Mean**)	Ambient Standard
1.	pH	-	7.0	7.0	7.0	7.8	8.1	8.0	6-90
2.	DO	mg/l	6.7	8.0	7.2	5.2	6.5	5.8	>4
3.	BOD	mg/l	0.6	2.4	1.4	1.5	5.0	3.7	<45
4.	COD	mg/l	3.2	7.9	4.6	60.4	82.3	65.8	<80
5.	$N\text{-}NH_3$	µg/l	200	600	400	0.1	0.3	0.7	<1,000
6.	$N\text{-}NH_4$	µg/l	300	600	400	n.a.	n.a.	n.a.	0.0
7.	$N\text{-}NO_3$	µg/l	2,200	6,800	4,800	1.2	1.8	2.9	0.0
8.	$N\text{-}NO_2$	µg/l	30	30	30	0.2	0.4	0.6	0.0
9.	$P\text{-}PO_4$	µg/l	n.a.	n.a.	n.a.	0.1	0.2	0.3	0.0
10.	SiO_2	µg/l	720	873	1,200	n.a.	n.a.	n.a.	0.0
11.	Hg	µg/l	0.0	0.0	0.0	0.7	1.0	1.2	<3
12.	Cd	µg/l	0.4	0.7	0.8	u.d.	5.0	9.0	<10
13.	Ni	µg/l	0.5	0.5	0.5	u.d.	u.d.	u.d.	<2
14.	Pb	µg/l	8.6	9.1	9.8	u.d.	6.0	8.0	<10
15.	Cr	µg/l	7.9	9.0	9.6	u.d.	7.0	8.0	<10
16.	Oil	mg/l	n.a.	n.a.	n.a.	u.d.	9.9	0.7	<5
17.	Grease	mg/l	n.a.	n.a.	n.a.	u.d.	0.2	0.4	0.0

Sources: *) = Universitas Mulawarman (1983)
**) = UNOCAL (1990).
Notes: n.a.= data are not available
u.d.= undetectable.

4.6. The Socioeconomic and Cultural Conditions

Socioeconomic and cultural information is essential to designing an appropriate planning and management of coastal resource development which could meet the needs and aspirations of human communities. When specific data for the study area are unavailable, the information is derived from either Kutai and Samarinda Districts or the Kalimantan data.

The history of East Kalimantan and even Kalimantan as a whole actually originated along the coast of East Kalimantan. The oldest historical record yet found in Indonesia revealed that in 400 AD there was an Indianized (Hindu) kingdom called "Kutai" which was ruled by Mulawarman (Kodhyat, 1988). Located on the coastal area around the Mahakam river, this kingdom was likely developed as a sea port and became a trade center on the much travelled trade route between China, the Philippines and Java.

4.6.1. Demographic Characteristics

As shown in Table 4.2, the study area encompasses all area of the Samarinda District consisting of 4 sub-districts with 52 village and a part of the Kutai District which consists of 13 sub-districts with 109 villages. Demographic characteristics of the study area include population distribution and density, its structure, its growth, education pattern, and migration pattern.

The coastal Kutai and Samarinda with the total area of 36,022 km^2 is inhabited by 679,611 people in 1989 which is 40.5 % of the total population of East Kalimantan Province (Table 4.2). This means that the average population density of the area is 19 people per square km. During the period of 1971 - 1980 and 1980 - 1989, the average population growth in

Table 4.2. The Population and Area of Coastal Kutai and Samarinda by Sub-districts.

Sub-district	Area (sq.km)	Population 1971	1980	1989	Growth per annum 1971-80 (%)	1980-89 (%)	Pop. density
A Samarinda	293	110,553	219,332	325,441	8.69	4.48	1,111
Palaran	126	5,263	11,695	22,528	9.28	7.56	179
Samarinda Sbrg.	33	9,547	21,120	44,472	9.22	8.62	1,348
Samarinda Ulu	65	31,713	72,936	114,366	9.70	5.12	1,760
Samarinda Ilir	69	64,030	113,581	144,075	6.58	2.68	2,088
B Kutai	35,729	123,358	231,250	354,170	6.65	4.85	10
Muara Kaman	2,679	10,564	11,379	17,681	0.93	5.02	7
Muara Bengkal	2,925	7,592	9,016	10,748	1.93	1.97	4
Sebulu	1,044	6,084	10,959	17,951	6.76	5.64	17
Tenggarong	926	17,090	37,862	69,245	9.24	6.94	75
Loa Kulu	1,310	10,331	15,242	23,783	4.42	5.07	18
Loa Janan	952	14,137	23,954	20,471	6.03	-1.73	22
Sanga Sanga	406	9,182	10,957	11,904	1.98	0.92	29
Muara Jawa	646	6,784	11,429	14,850	5.97	2.95	23
Anggana	505	11,603	19,702	17,768	6.06	-1.14	35
Muara Badak	1,252	6,102	18,521	30,805	13.13	5.81	25
Bontang	7,855	10,290	34,491	73,201	14.38	8.72	9
Muara Wahau	7,720	4,830	8,558	21,371	6.56	10.70	3
Sangkulirang	7,509	8,769	19,180	24,392	9.09	2.71	3
Total	36,022	233,911	450,582	679,611	7.56	4.67	19
E. Kalimantan	211,422	725,015	1,216,781	1,678,537	5.90	3.64	8

Source: TAD-PPS/GTZ(1990a)

the area was 7.56 and 4.67 % per annum respectively. The decrease in population growth is believed to be a result of the success of the fashionable national family planning program that has consistently been supported by the Government of Indonesia since the beginning of REPELITA I (1969/1970).

From Table 4.2, it is clear that most people reside in sub-districts that are just adjacent to either the Mahakam River (all sub-districts of the Samarinda District) and Tenggarong, Sanga Sanga and Anggana in Kutai District or the sea including Muara Badak, Muara Jawa, a part of Bontang, and

Table 4.3 Population of Coastal Kutai and Samarinda by Sub-distict, Age group and Sex, 1986

District and Sub-district	Children	Adult			Total	% Children	Ratio M/F
		Male	Female	Sub-total			
A. Samarinda	107,370	91,709	82,032	173,741	281,111	38	1.1
1 Palaran	8,621	5,829	4,264	10,093	18,714	46	1.4
2 Samarinda Seberang	9,486	9,323	8,362	17,685	27,171	35	1.1
3 Samarinda Ulu	37,025	34,216	31,542	65,758	102,783	56	1.1
4 Samarinda Ilir	52,238	42,341	37,864	80,205	132,443	65	1.1
B. Kutai	142,599	103,662	85,826	189,488	332,087	43	1.2
1 Muara Kaman	7,469	5,110	4,484	9,594	17,063	44	1.1
2 Muara Bengkal	6,138	2,318	2,153	4,471	10,609	58	1.1
3 Sebulu	8,115	4,839	4,313	9,152	17,267	47	1.1
4 Tenggarong	28,066	17,225	15,131	32,356	60,422	46	1.1
5 Loa Kulu	10,251	6,050	5,407	11,457	21,708	47	1.1
6 Loa Janan	13,567	12,290	10,877	23,167	36,734	37	1.1
7 Sanga Sanga	5,460	3,372	2,960	6,332	11,792	46	1.1
8 Muara Jawa	6,912	4,241	3,574	7,815	14,727	47	1.2
9 Anggana	8,628	7,145	6,834	13,979	22,607	38	1.1
10 Muara Badak	9,908	10,644	7,452	18,096	28,004	35	1.4
11 Bontang	23,986	21,638	15,243	36,881	60,867	39	1.4
12 Muara Wahau	5,899	2,967	2,944	5,911	11,810	50	1.0
13 Sangkulirang	8,200	5,823	4,454	10,277	18,477	44	1.3
Study Area	249,969	195,371	167,858	363,229	613,198	41	1.2

Source: Kantor Statistik Propinsi kalimantan Timur (1987)

Sangkulirang sub-districts. The attachment of people to rivers and the sea is because most transportation is by water. The proximity to transportation networks and accessibility to water supply for various human needs ranging from domestic to industrial activities have made river bank and coastal fringe areas an attractive space for both development activities and living.

The population of the area is relatively young. In 1986, the under 15 group comprised 41 % of the total population (Table 4.3). This figure remained stable until 1988 (Kantor Statistik Kabupaten Kutai, 1989). In Indonesia, the population group between 15 to 54 years is usually considered productive. If this is the case, then the study area has a productive work force of almost 50 % of the total population, which is about 363,229 people, consisting of 195,371 males and 167,858 females.

In areas close to development projects such as oil and gas production activities in Muara Jawa (Total Indonesie), Muara Badak (Huffco which has been changed to Vico since 1990), Tanjung Santan (UNOCAL), and Bontang (PT. Badak NGL Co.), the higher proportion of male population is mainly due to males who are working with these companies. They come and stay temporarily in the area without their families. They leave their families in their permanent residences, such as in Samarinda, Balikpapan, South Sulawesi and even Java (personal communications with The Head of Bontang and Muara Badak Sub-districts, 1989).

Depending on skill and education level, this vast labour force can be either a positive or negative factor for sustainable economic development in the area. Most of those who are seeking work (47 %) have only primary school background. Those seeking work who have educational backgrounds of junior high school, senior high school, and university are 11 %, 40 %, and 2 % respectively (Kantor

Statistik Kabupaten Kutai, 1988). Thus, the types of jobs that should be created for the majority of the population must have the ability to absorb this relatively uneducated labour force.

It is commonly acknowledged that education is a key ingredient in the process of sustainable development. The education level in both the study area and East Kalimantan that may be reflected in terms of the number of schools, teachers and students is presented in Table 4.4. The education level in the study area is obviously much better than in other areas of the province. More than 90 % of university resources (school buildings, teachers and students) exist in the study area (Samarinda city and Tenggarong, the capital city of Kutai District) which is only 17 % of the total area of East Kalimantan Province. In addition, the percentage of senior high schools to kindergartens, which is on average about 40 %, indicates that the study area is indeed more developed than the rest of the province. However, because universities are only available in the above provincial and district capital cities and the transportation networks are still relatively poor, they can only be accessed by a small fraction of the young people in areas far from these two cities.

The religious mix consists of Moslem (86 %), Protestant (9.0 %), Catholic (4.0 %), Buddhist (0.9 %), and Hindu (0.1 %) (Kantor Statistik Propinsi Dati I Kaltim., 1989). The Islamic pioneers were "the Sultans" (the Kings of Islamic

Table 4.4 Number of School, Teacher and Pupils by Type of School in the Study Area and East Kalimantan, 1986.

Type of School	Total for Study Area			Total for East Kalimantan			Percentage of Study Area from East Kalimantan.		
Type of School	Sch-ool	Tea-cher	Pup-pil	Sch-ool	Teach er	Puppil	Sch-ool	Tea-cher	Pup-pil
1 Kinder-garden	104	360	6671	248	794	16167	42	45	41
2 Primary	523	4784	109712	1759	12459	294066	30	38	37
3 Yunior High	105	1944	27040	289	4650	66781	37	42	40
4 Senior High	59	1238	16494	133	2683	36499	44	46	45
5 Univer-sities				13	1250	9849			

Source: Kantor Statistik Propinsi Kalimantan Timur (1987).

Kingdoms in the region). An historical document relates that in 1600 an Arab trader married a Princess Petong of the Pasir Kingdom, which is currently one of seven districts of East Kalimantan Province. In 1900 the people of Kutai mostly converted to Islam through Prince Adipati. Since then, the majority of the people in East Kalimantan region have been devoted followers of Islam (Syahrir, 1978).

Christians, both Protestant and Catholic, are mostly Toraja and Menado people who come from South and North Sulawesi. They came to East Kalimantan for economic reasons, as they perceive that employment opportunities in various development projects, especially the oil and gas sector, would make them better off.

Besides the above official religions, there is a local belief (religion) namely "Kaharingan". The followers of this religion almost entirely are indigenous people called Dayaks. According to this religion, the spirits of the ancestors and others inhabit the environment where we live (Koentjaraningrat, 1975). The Kaharingan religion thus has some similarities to animism that performs rituals in order to penetrate and communicate with these spirits.

Almost all communities in the coastal Kutai and Samarinda are a mixture of migrants and local people. The economic boom in the province, particularly in forestry as well as oil and gas sectors, has attracted people to East Kalimantan from other provinces and islands. Sixty two percent of the population increase in the province, from 725,000 in 1971 to 960,000 in 1976, was reported as a result of immigration from other provinces (Fischer and Rasyid, 1977). Since the new road between two largest cities of the province, Balikpapan and Samarinda, was opened for the public in 1976, many more migrants mainly farmers from South Sulawesi have arrived in East Kalimantan. Most South Sulawesi people (Buginese) who live along that road make their living from pepper cultivation (Vayda et al., 1985).

The other way for people to come to East Kalimantan is through a government-sponsored transmigration program. There have been 134,206 people (32,958 families) from Java, Bali, Lombok, and other islands moved to the province via this kind of program from 1954 to 1986/1987 (Kantor Statistik Propinsi Dati I Kaltim., 1987). As most development activities take place in the coastal areas, the majority of these newcomers also tend to swarm within these areas.

According to Bappeda Kabupaten Kutai (1989), local people are formed by various ethnic groups which can be broadly classified into two major ethnic groups: 'Suku Haloq' (Haloq ethnic group) and 'Suku Dayak' (Dayak ethnic group). The latter, commonly called indigenous people, mostly live in remote upland areas, isolated from other communities and a more modern way of life. The Department of Social Affairs (1976) defines indigenous people as those groups of people, who because of their isolated locations, have a limited form of communication with other communities and public services, causing them to be more 'backward' in lifestyle, religion, ideology, politics, economy, and culture. At the present time, there are eight Dayak ethnic groups existing in East Kalimantan: Tunjung, Benuaq, Bahau, Modang, Kenyah, Penihin, Kayan, and Punan.

The former consisting of Kutai, Banjar (from South Kalimantan) and Bugis (from South Sulawesi) mostly reside along the Mahakam river and its lowland tributaries as well as along the coastal fringes. It should be noted that for Banjar and Kutai to be considered as local people, they have to stay quite a long time and/or be born in the region.

4.6.2. Regional Economy

4.6.2.1. Development Trends

The existing size, composition, and occupational characteristics of East Kalimantan's labour force are a result of economic, social and political forces which, over the years, have shaped the structure of the provincial economy. Since Indonesian independence in 1945, the economic foundation of East Kalimantan Province has been heavily dependent on the resource base: forest, agriculture, fisheries, and oil and gas. Prior to the 1970's East Kalimantan was usually called "A Sleeping Kalimantan", a province that was left far behind the other provinces of the country. The primary livelihoods were subsistence agriculture, gathering, fishing and hunting.

In agriculture, they use shifting-cultivation techniques that to some extent are still practised by rural communities. Such a system utilizes dry lands through a rotational mechanism. In principle, the main components of the system are: (1) rotating the use of the land with a short planting season and a long fallow period; (2) opening the land by burning part of the forests; (3) using human power as the major production input with very little use of animal and machinery power, fertilizers and pesticides; and (4) using quite simple tools such as planting sticks and hoes (Birowo, 1974).

In a situation where the land was abundant and the population was sparse, this sort of agricultural practices used to be sustainable. This was simply because shifting cultivators provided enough fallow periods to the land so that it had opportunity to renew itself for the next planting seasons. As in other provinces of the country, since PELITA I the province has embarked on systematic economic development mainly through oil and gas, and forestry industries. Initiated by the 'log boom', East Kalimantan with 17.929 million ha. of tropical rain forest (85 % of its total area) generated foreign earnings as much as US $ 510,912.91 by the end of PELITA I (Hamid et al., 1989).

By the end of PELITA II (1974/75 - 1978/79), the foreign earning from forestry increased by 110 % with a production volume of about 43 million m^3. Most of the products are exported to Japan and most recently to South Korea. By the end of 1986, the export wood products of this province was more than 100 million m^3 (about 783,538,774 tonnes) with the cutting area approximately 1.2 million ha. The value of this export was US $ 226,011,264,000 (Kantor Statistik Dati I Propinsi Kaltim., 1987; Hamid et al., 1989). According to Kodhyat (1988), 70 % of the country's timber export originates from this province.

In the meantime, East Kalimantan Province has also been blessed by an oil and gas boom. By the end of PELITA I, 46.8 million barrels of oil were produced. The oil production rate in the province has increased steadily and reached its peak in 1978 with a total production of 225 million barrels. Furthermore, through a joint effort between Pertamina (State Oil Company) and its Production Sharing Contractors involving Huffco, Unocal and Total Indonesie companies, the LNG Plant of

Bontang delivered the first Indonesian LNG to Japan in August 1977 (PT. Badak NGL Co. and Pertamina, 1989).

The domestic needs in Japan for clean burning LNG resulted in a doubling of Plant capacity from 4 to 8 million tons in 1983. In 1985 the Master Plan was revised to increase the Plant layout to eight LNG trains and to add LPG (Liquified Petroleum Gas) extraction facilities to the production scheme. Two years later, Taiwan joined the growing number of LNG users, and expansion was underway once again. Since the completion of the fifth LNG train in December 1989, the Plant has become capable of producing over 11 million tons of LNG annually (Kartasasmita, 1989).

The development of these industries has also stimulated development in other sectors such as coal and gold mining, agriculture, transportation and communication, trade and services. As a result of these increasing development activities since the end of the 1970's East Kalimantan has become one of the three richest provinces in the country.

The progress of economic development of a region under the current economic system is usually measured by its Regional Gross Domestic Product (RGDP). Since there is, so far, no data on RGDP at the sub-district level, the RGDP picture of the study area will be approximated by using the picture for Kutai District. Based upon constant 1983 market prices, the 1987 RGDP of Kutai District, including the oil and gas sector, was Rp 1,815,838,200,000. This constituted about 38 % of the overall East Kalimantan's RGDP which was Rp

Table 4.5 The 1987 RGDP at 1983 Constant Market Prices for Kutai Distric and East Kalimantan Province, with and without the oil and gas sector (in million rupiahs)

Economic Sectors	Kutai Distric		East Kalimantan	
	With oil and gas	Without oil and gas	With oil and gas	Without oil and gas
1 Agriculture	202,086.70	202,086.70	448,864.61	448,864.61
2 Mining and Quarrying	1,471,700.13	25,835.11	3,141,851.32	38,130.63
3 Manufacturing industries	7,138.84	7,138.84	373,107.67	291,210.61
4 Electricity, gas and water supply	676.94	676.94	12,823.79	12,823.79
5 Constructions	3,540.11	3,540.11	42,774.50	42,774.50
6 Trade, restaurant and hotel	71,285.20	71,285.20	448,800.71	267,398.38
7 Transportation and communication	28,659.94	28,659.94	122,335.63	122,335.54
8 Banking, other financial institutions, ownership dwelling	19,791.21	19,791.21	112,173.01	112,173.01
9 Public services social and public administration	10,959.12	10,959.12	98,177.61	98,177.61
RGDP	1,815,838.20	369,973.17	4,800,908.85	1,433,88.68

Source: Kantor Statistik Kabupaten Kutai (1989) and Kantor Statistik Propinsi Kalimantan Timur.

4,800,908,850,000,-. When the oil and gas sector is not included, the RGDP of both Kutai District and East Kalimantan Province declines sharply to Rp 369,973,170,000,- and Rp 1,433,888,680,000,- in the same year (Table 4.5).

Table 4.5 also clearly shows that the sectoral contribution of the RGDP for both Kutai District and East Kalimantan is considerably different with and without the oil and gas sector. For instance, the contribution of agriculture is 54.6 % when oil and gas sector is excluded from the RGDP calculation, and only 11.1 % when it is included. This picture obviously indicates that the region's economy has been and will be relying heavily on the oil and gas sector at least until the year 2020. In conjunction with the Provincial Government effort to diversify its economic bases, however, the contribution of non-oil and gas sectors to the regional economy is increasing (Kantor Statistik Kabupaten Kutai, 1989; Kantor Statistik Propinsi Kaltim, 1987).

In a five year period (1983 - 1987), the average annual growth of the RGDP of Kutai District based on constant 1983 market prices is 23.8 % with the oil and gas sector included, and 12.5 % without it. At the same time, its annual population growth averages 3.6 %. As such, the real growth rate of Kutai's RGDP is 20.2 % and 8.9 % with and without oil and gas sector respectively (Kantor Statistik Kabupaten Kutai, 1989). In other words, the rate of economic growth of this district (as a representative of the study area) was 8.9 % annually.

4.6.2.2. Facilities and Infrastructures for Economic Development

To support economic development in the region, various facilities and infrastructures have been established. These include production infrastructures (e.g. reservoirs and irrigation systems, and electricity and potable water); distribution infrastructures (e.g. transportation networks, communication systems, and trade facilities); and supporting facilities (e.g. capital towns, training and education facilities, and research and development facilities).

The construction of reservoirs and irrigation systems is intended to support the growing agricultural development as a means of diversifying economic bases in the region. Eight rivers in the Kutai District have been dammed for reservoirs, five of which are located within the upper portion of the study area (BKPMD Propinsi Kalimantan Timur, 1989). The existence of such reservoirs also has other functions such as generation of electrical hydropower, provision of clean water for domestic use, and regulation of water flows in respective rivers so that floods and droughts can be more manageable.

Electricity and potable water are still scarce resources for the majority of people in the study area. Only in Samarinda and Tenggarong cities and adjacent sub-districts do people have access to continuous electrical power and potable water supplies. Even in these two cities, only the middle and upper classes of the society can afford to get clean water for their daily life. The majority of population is still using rivers and rain water for bathing, washing and defecating, and even for drinking for some people.

In rural areas, particularly near the coastal fringe, conditions are even worse, as the quality of river water becomes poorer as one moves downstream. It is this sort of sanitary problem that has caused waterborne and skin diseases to be the two largest diseases commonly found in the study area (Kantor Statistik Kotamadya Samarinda, 1987; Kantor Statistik Kabupaten Kutai, 1989; and personal observations, 1989).

Coastal communities which are located next to base camps for development projects, such as Total Indonesie Oil Company in Muara Jawa, Vico in Muara Badak, Unocal in Tanjung Santan, and PT. Badak LNG and PT. Pupuk (fertilizer) Kaltim, usually have some electrical supply. However, the ability of these companies to provide electrical power is very limited. Thus, most coastal communities obtain light from oil lamps or from cooperatively using electrical generators.

Transportation networks in the study area are relatively more developed than in the other areas of the Province, except in Balikpapan city. Three types of transportation systems are available: land, water and air transportation.

The land and water transportation network of East Kalimantan is essentially linear. The major rivers, such as the Mahakam and Sangatta, provide the means for transporting bulky and heavy goods into and out of the interior areas. Roads offer the connecting links between rivers in the coastal zone, and there are normally markets as well as trading centres with jetties where roads meet rivers. The Trans Kalimantan Highway runs roughly north-south and at present connects the three main river ports of Samarinda, Balikpapan, and Banjarmasin in South Kalimantan Province. A portion of this highway, connecting Samarinda and Bontang, was officially opened only last year for public use. Thus, the only part of this highway which has not been completed yet is the one that connects Bontang and Sangkulirang through Kutai National Park.

Besides budgetary constraints, the delay in the construction of that road portion is also due to careful consideration of the conservational integrity of the Park once the road is constructed and open to the public. Consideration of how to mitigate negative impacts from the construction of this road on the Park environment is still underway. Presumably, some suggestions made by Wirawan (1985) should be taken into account in the development of the road crossing the Kutai National Park.

Samarinda, the provincial capital of East Kalimantan, is located about 60 km upriver from the mouth of the Mahakam. It is also well known as a logging city. Its harbour is the hub of commercial activities, especially the timber trade, both within the province and the inter-islands as well as international trade mainly with Japan and South Korea. Meanwhile, there are several special harbours for transporting oil and gas products (Handil II, Muara Jawa of Total Indonesie; Muara Badak of Vico; Tanjung Santan of Unocal; Bontang of PT. Badak LNG; and Teluk Lombok, Bontang of Pertamina), fertilizer (Lhok Tuan, Bontang of PT. Pupuk Kaltim), and coal (Muara Bengalon of PT. Kaltim Prima Coal) that exist along the coastline of the study area.

Transportation from the Kutai District's capital city, Tenggarong, to sub-districts that are located more downstream on the coastal fringe, such as Anggana, Muara Badak, Bontang, and Sangkulirang is still carried out by water. The route from Tenggarong to Samarinda can be achieved by smaller water taxi. Then, to continue from Samarinda to those coastal sub-districts, one has to go by sea using larger motor boats. Since the opening of the all-weather road between Samarinda and Bontang, however, transportation from Samarinda to Muara Badak and Bontang is easier overland than by sea.

There is one airport (Temindung of Samarinda) and eleven airstrips, with the length of landing strips ranging from 450 m to 600 m (BKPMD Propinsi Kalimantan Timur, 1989). Only four out of eleven airstrips have pavement. These airstrips are for commercial activities, such as logging, oil and gas, fertilizer, and coal as well as providing access for Christian Missionaries. The Province of East Kalimantan is also equipped with an International Airport, Sepinggan, in Balikpapan which is about 120 km south of Samarinda. The Sepinggan airport is believed to be the second busiest airport in the country after that of Jakarta's Soekarno-Hatta airport.

Communications are served through postal and giro services as well as telecommunications. The automatic long-distance phone services from the province to other areas of the country and to other countries are available in Samarinda, Balikpapan, and PT. Pupuk Kaltim and PT. Badak LNG in Bontang. Telex, telegraph and fax services are also available in

Samarinda and Balikpapan. In the capital of Kutai District itself, only non-automatic telephone is available.

To run economic activities in the region, each sub-district has one or more marketing centres. However, the flow of trade goods in and out of the study area and between the province and other areas of the country is mostly conducted through Samarinda harbour. Bank and finance services are also provided to support the expansion of economic activities in the region. So far there are only 17 banks existing in the study area, 11 in Samarinda, 3 in Tenggarong, and 3 in Bontang (GTZ/TAD-PPS, 1990a). In addition, cooperative systems are also established in almost every village of the study area. The cooperative system is meant to help small farmers, fishermen, and other business activities.

4.6.3. Sociocultural Characteristics

In essence, the sociocultural characteristics of coastal communities within the study area are directly related to their ethnic background. Accordingly, three major socio-cultural patterns can be recognized: (1) indigenous people, (2) local people, and (3) newcomers.

The customs and traditions for the Dayaks (indigenous people) encompass all the rites and cults regulating relations with the cosmos (Abdurrachman, 1975). As in most traditional-agrarian communities, Dayak marriages take place at an early age about 13 years old for girls and 17 for boys. The selection of a spouse is either arranged or by choice of the individuals involved (Syahrir, 1978).

According to Dananjaya (1975), the Dayaks adhere to the ambilineal system, i.e. some of them follow the descent along the male line (matrilineal), while others along the female line (patrilineal). The family structure is closely linked to the structure of their 200 m-long houses called 'lamin'. They are commonly constructed along the river with wood materials. As a protective measure, the lamin is usually surrounded by a bamboo fence. Each village may have one to eight houses.

The long house for the Dayaks serves as a social centre. It is a place for ceremonies, a refuge during tribal wars, and the residence of several families who, although not blood relationships, are considered as if they were (Mazetina, 1974). Even though the lamin is occupied by several families, each person lives with his or her own nuclear family. The number of families living in a long house can be identified by the number of kitchens. With socioeconomic changes in the province, the Dayak's longhouses are now disappearing. However, the extended utrolocal family and kindred still exist, together with the nuclear family as the centre of family life (Syahrir, 1978)

As previously mentioned, the indigenous people live in small isolated communities. Their lives are heavily dependent upon resources that nature provides by a way of shifting cultivation, hunting, fishing and gathering of forest products. Fishing and hunting as well as the yield from shifting cultivation are mainly for their own subsistent life. However, forest products are usually sold either directly or through simple processing as handicrafts.

The attitudes of newcomers and local people towards the utilization and management of the environment are basically rooted in ethnical background. For instance, the Buginese, who have strong attachments to the sea for their life, are mostly seeking their livelihood from marine resources, either directly as fishermen and fish farmers or indirectly as traders. The Sundanese from West Java, who are skilful wetland rice farmers, still maintain such practices in the study area. Moreover, the practice of homegarden (pekarangan) systems as a way of utilizing the land around the house on an optimal and yet sustainable basis is a common scene in every Sundanese settlement found in the study area, such as Sindang Jaya of Muara Jawa.

The extended family forms a dominant structure unit within the coastal community. The extended family usually consists of three or more generations living together. Each family is a member of a clan or kinship group. The social structure encourages social stability and strong kinship ties which eventually constitute the social structure of a clan or kinship group.

The coexistence of various ethnic groups in the coastal areas has gradually brought about cultural exchanges (e.g. assimilation and acculturation) among them. As a corollary, some commonalities in sociocultural conduct can be observed in the coastal zone. For example, the rice cultivation system brought by the Javanese people is now also practised by the Kutai people. The conservation ethics which used to be applied in the daily life by both indigenous and local people through 'taboo' systems are now loosening. Even worse, the symptoms of consumerism brought by newcomers, especially within oil and gas, timber, fertilizer and coal companies, has influenced the local people, particularly the younger generation.

V. AN ANALYSIS OF COASTAL RESOURCE BASES

Information on the resource base of the coastal zone under study is one of the building blocks in designing the plan and management strategies for its allocation and use on a sustainable basis. Three major elements should be included in such an analysis: (1) the condition of the resource base in terms of types, extent, and levels of its utilization; (2) the economic and ecological significance of the resource base; and (3) interrelationships among components of the resource base within the coastal zone system, as well as with those outside the system.

Nine major resource systems form the coastal resource base of the study area, namely: (1) Kutai National Park, (2) agroecosystems, (3) estuaries, (4) beaches and islands, (5) mangroves, (6) seagrass, (7) coral reefs, (8) pelagic and demersal ecosystems; and (9) oil and gas industry. In this case, a resource system is defined as a combination of human, biotic, and abiotic elements that provides for human needs (Ruddle and Rondinelli, 1986). It is, therefore, a whole cycle of events through which a component of the general environment is considered as a resource and passes from its source through processing (or technological transformation) to the creation and delivery of an end product that satisfies a perceived human need. So, a resource system in essence contains three main sub-systems: procurement, processing, and delivery.

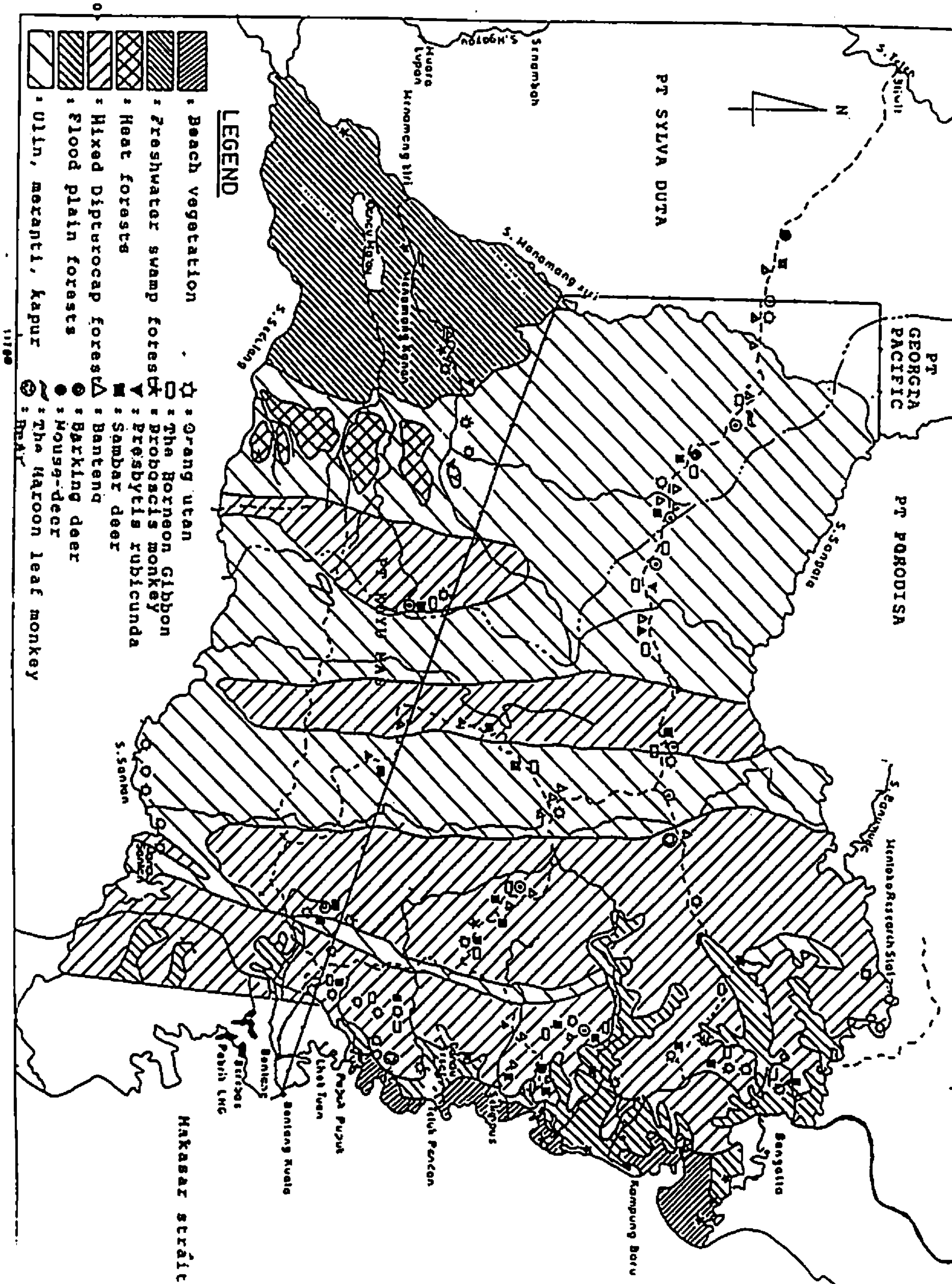
5.1. KUTAI NATIONAL PARK

Kutai National Park, which originated from a 306,000 hectares of 'wildreservaat' by the Decree of a Sultanate of Kutai in 1936, was established at the Third World Congress on National Parks in Bali in 1982 through the Decree of the Minister of Agriculture No.736/Mentan/X/1983. The areal coverage of the park is 200,000 hectares. Geographically, it is located between 0° - 0° 35' N and 117° 0' - 117° 30' E. The land area of the park stretches 65 km inland from the coastline. It is bordered to the south by the city of Bontang subdistrict, a Protected Forest of Bontang, and the Kayu Mas concessionaire; to the west by Sylva Duta and Georgia Pacific Indonesia concessionaires; to the north by the Sangatta river; and to the east by the Makasar Strait (Figure 5.1).

In order to maintain the integrity of the Protected Forest of Bontang, the Directorate General of Forest Protection and Nature Conservancy enacted three consecutive decrees (No.46/Kpts/VIsek/1984, No.32A/Kpts/VIsek/Tlk/1985, and No.67/Kpts/DJ-VI/1987). These stipulate that the authoritative working area of the Kutai National Park also includes the area of the Protected Forest of Bontang, which is 20,580 hectares, providing a total protected area of 220,580 ha (Taman National Kutai, 1988).

A more detailed account of Kutai National Park is given in Wirawan (1985), Taman Nasional Kutai (1986), Taman Nasional Kutai (1988), and Bachruddin (1989). The following description and analysis are based on these sources of information.

Figure 5.1 Boundaries of Kutai National Park and the Distribution of its Habitat Types and Fauna (Bachruddin, 1989)



The elevation of the park ranges from 0 to 400 m above sea level. Eleven rivers flow through the park, but only three (Sangatta, Sangkimah, and Teluk Pandan rivers) flow directly to the coastal water. In addition, a dense network of drainage channels and streams exist within the Park. In general, however, the drainage pattern of the Park can be divided into four main catchment areas: Menamang, Santan, Sangatta, and Coastal catchments.

The integrity of the Park and its conservational value have been severely damaged by the 1983 forest fire that occurred after the long dry period in 1982 and as a result of human activities. In 1969, approximately 100,000 ha of the Park's area (at that time still under the name of the Reserve) was cut out for logging and oil exploitation. In addition to these two activities, the hand logging on river sides undertaken by common people (popularly called the 'banjir', or flooding cut) that spread throughout the island of Borneo contributed to such damage. The term 'banjir cut' means that the logs were cut during various times of the year and then floated downstream only during the flooding period, mainly during the rainy season. Although the 'banjir cut' was prohibited in 1970, sporadic activities along the Sangatta, Banumuda, Palakan, and Santan rivers are continuing.

Fortunately, some 100,000 ha of forest ecosystems within the Park, including a 7,000 ha mangrove forest, were not affected by the forest fire and are relatively intact. This area meets the minimal limit, set by the IUCN Congress in New

Delhi in 1969, for a National Park in the larger islands outside of Java.

The vegetation growing within the Park can be classified into six major types as follows (see Figure 5.1):

(1) The beach vegetation

This vegetation, which is mangrove forest with dominant species *Rhizophora sp.* and *Bruguiera sp.*, exists along the coastline of the park. On sandy areas, however, the more typical strand flora that include *Casuarina equisetifolia*, *Hibiscus tiliaceus*, and *Scaevola sp.* are more dominant.

(2) The freshwater swamp forests

They grow in depressions or low grounds which are often or continuously inundated by freshwater. They are found to be scattered as small pockets along rivers but extensive stands occur in the Menamang area. The dominant species found here are *Alstonia sp.*, *Ficus sp.*, *Eugenia sp.*, *Dillenia sp.*, and *Lophopetalum sp.*

(3) The heat forests ('kerangas')

This type of vegetation exists at the foot-hills west of Teluk Kaba and in the Menamang area. Species which are found in this vegetation area include *Shorea sp.*, *Eusideroxylon zwageri*, *Artocarpus sp.*, *Mangifera sp.*,and *Eugenia spp.*.

(4) The 'ulin' - 'merantai' - 'kapur' forests

This vegetation occurs on poorly to moderately drained soils in the western half (50 %) of the Park's area. Its structure is characterized by an open canopy layer which is up to 30 - 40 m high, and a closed sub-canopy that has rather thick biomass from near the ground up to 20 - 25 m high. Dominant species found here are *Eusideroxylon zwageri* ('ulin'), *Dryobalanops spp.* ('kapur'), *Shorea spp.* ('meranti'), *Instia palembanica*, *Palquium sp.*, and *Eugenia spp.*.

(5) The floodplain forests

By and large, the characteristics of this type of vegetation are almost identical to the fourth type of vegetation mentioned previously. Dominant species occurring within this vegetation class are *Octomeles sumatrana*, *Pterospermum javanicum*, and *Baringtonia sp.*.

(6) The mixed dipterocarp forests

This type of vegetation mostly grows on well-drained soils in the eastern part of the Park. The structure of these forests is essentially similar to the forest on the poorly to moderately drained soils, except they have higher diversity in plant species. Dominant species are *Shorea spp.*, *Dryobalanops beccari*, *Dipterocarpus cornutus*, *Koompasia excelsa*, *Koordersiodendron pinnatus*, *Schima walichii*, *Alstonia sp.*, *Dillenia sp.*, and *Diospyros sp.*.

Economic and Ecological Significance of the Park

Viewing the Kutai National Park from local to global perspectives, one would recognize that the Park has a great value to the sustenance of human life. This can be best understood by looking at some of its major economic and ecological significance.

According to Ashton (1984), the vast lowland forests of Kalimantan and Sumatra, dominated by trees of the family Dipterocarpaceae, are frequently regarded as the most precious remaining tropical forest estate in the world. It is strongly believed that Kutai National Park contains one of the last intact Dipterocarpaceae forests in the country (Wirawan, 1985).

Recent data reveal that the floristic potential of the Park, which spreads over the six vegetation types mentioned above, consists of 12 protected species and 88 non-protected species. Meanwhile, its faunal potential contains 171 protected animal species and 92 non-protected animal species, which belong to primate, ungulate, carnivorous, and reptile groups.

Although the Sumatran rhinoceros (*Dicerorhinus sumatrensis*), one of the most endangered species on earth, has been reported as extinct in the Park, some of the large protected mammals including Malayan Sun Bear, Sambar Deer, Barking Deer, Mouse Deer, 'Banteng', 'Orang Utan', the Bornean Gibbon, the Maroon Leaf Monkey, and the Proboscis Monkey can still be observed. The last three species occur only on Borneo island.

On top of this faunal assemblage, about 300 bird species belonging to 47 families and sub-families are present, representing approximately 83 % of the total Bornean birds. This combined floristic and faunal potential makes the Park one of the most important single conservation areas on the island.

With such a highly diverse and rich floristic and faunal assemblage, the Park provides exceptional abundance and variety of genetic resources that are essential for the sustainability of modern agriculture, industry, medicine, and energy. Furthermore, the Park has been supplying a variety of environmental services to mankind, including the protection of soils from erosion, safeguards for watershed systems, maintenance of groundwater reserves, and a part of the 'lung system' of the Globe that can absorb CO_2.

In the case of hydrological functions, the Park has been providing direct benefits to the two giant industries in the area (the LNG and Fertilizer Plants) and local communities by maintaining the ground water aquifers. The aquifers are the most important source of freshwater supply for both industrial and domestic purposes. In 1983, these two companies drew as much as 40,000 m^3 of freshwater from these aquifers, which are located beneath the Bontang Protected Forest. With some additional processing units in these two plants, their daily requirement of freshwater will be doubled by the year 2000 (Sir William Halcrow and Partners, 1983 a, b).

Kutai National Park is one of the best natural laboratories for studying biological and ecological aspects of dipterocarpaceae forests, endangered animal and plant species, and genetic resources. The Park can also function as a control (as being natural) ecosystem in the study of human impacts on tropical forest ecosystems so that their management strategies and programs can be properly designed. The research and educational functions of the Park have been utilized by academic communities of both domestic (high schools and universities) and international origins.

The beauty of the scenery, the observation of wild animals and plants, hiking and camping, and canoeing along the rivers have been attractions on their own for tourists. Many employees of oil and gas industries and other modern sectors in the area have been using this potential for quite some time.

Intersectoral and Interregional Linkages

As a conservation site, Kutai National Park is essentially an impact taker from other activities. It receives both direct and indirect negative impacts from various human activities around the Park, which will be described in further detail in Chapter VI. On the other hand, as described above, the Park has been, and will be, supplying a variety of economic and environmental goods and services to human beings, particularly the ones who live in the vicinity of the Park. Unfortunately, under the current setting of economic development, most of those benefits have not been appreciated by most government officials and the public in the region. They usually perceive the Park as being a constraint to economic development, at least in terms of spatial needs.

5.2. NATURAL COASTAL ECOSYSTEMS

Coastal ecosystems that are naturally found in the study area include mangroves, seagrasses, coral reefs, estuaries, beaches, and islands. None of these ecosystems have been studied thoroughly. Only very recently, mangroves and coral reefs have gained some attention through several EIA (Environmental Impact Assessment) studies in the area, whereas other coastal ecosystems have not yet been examined.

Mangroves grow on the coastal areas that receive suspended sediments from river flows or offshore current. They also occur extensively on deltas and river banks extending for tens of kilometers inland. Such mangrove coverage can be found on the Mahakam Delta, the Sangatta and the Bengalon rivers. Prominent species commonly occurring in mangrove forests of the study area are *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorrhiza*, *B. parviflora*, *Sonneratia alba*, *S. caseolaris*, *Avicennia alba*, *A. officinalis*, and *Nypa fruticans* (Kartawinata, 1988; Total, 1989).

There has been no consensus on the total areal coverage of mangroves in the province. However, recent estimates indicate that the province has mangrove coverage as large as 280,615 ha (Dinas Perikanan Propinsi Kaltim, 1987), which is the third largest in the country after Irian Jaya and South Sumatra provinces (Koesoebiono et al, 1982). The study area (Samarinda and Kutai coastal areas) contains about 69,450 ha (24.75 % of the total mangrove area in the province). Unfortunately, there has been no detailed information with regard to the areal distribution of mangroves either in the study area or in the province as a whole.

Yet, based upon the author's field observations (1989 - 1990), mangroves in the study area can qualitatively be grouped into four areal groupings: (1) the Mahakam Delta, (2) the area between Muara Badak and Bontang, (3) the Kutai National Park, and (4) the area between Sangatta river and Teluk (Gulf) Sangkulirang. Except on sandy coastal areas, such as Teluk Lombok within Kutai National park, and Sambera in Muara Badak sub-district, mangroves can be found along the coastline of the study area. Among these four mangrove areas, only those that grow on the Mahakam and in Kutai National Park have a record of their areal coverage. It is estimated that the areal coverage of mangroves occurring in these two areas is 25,305 ha and 7,000 ha respectively. They constitute about 47 % of the total mangrove coverage in the study area(Dinas Perikanan Propinsi Kaltim, 1987; Wirawan, 1985).

The utilization rate of mangroves in the study area has two meanings: the conversion of mangrove area into other uses (oil and gas, aquaculture, settlements, etc.), and the harvesting of mangrove trees. The conversion of mangroves to other uses claims an area as large as 5,150.1 ha, which is about 7.5 % of the total mangrove area within the coastal zone under study (Table 5.1). It is apparent, however, that this figure is much lower than the actual percentage because the conversion into other uses, such as settlements and agriculture, is not recorded yet.

The harvesting of mangrove trees is entirely conducted by local communities for their domestic (household) needs, such as firewood, construction materials, tanin and poles. These traditional uses of mangroves have not so far been documented.

Table 5.1. The Area of Mangrove Conversion to Other Uses (ha)

Area	Oil & gas related activities	Tambak	Total
1. Mahakam delta	1,446.0	342.0	1,788.0
2. Muara Badak - Bontang	1,030.0	1,366.0	2,396.0
3. Kutai National Park	623.0	200.0	823.0
4. Sangatta - Sangkulirang	NA	143.1	143.1
The study area	3,099.0	2,051.1	5,150.1

Source: Taman Nasional Kutai (1988), Total Indonesie (1989), Dinas Perikanan Kabupaten Kutai (1990), and field observations (1989 -1990).

Coral reefs are well developed in areas where there is little or no influence from river flows and other freshwater runoffs. In the study area, coralline fringing reefs occur along the shore between South Bontang Bay and Teluk Lombok, and between the north side of the Sangatta river (about 6 km) and Teluk Sangkulirang. But, wherever there are streams (small rivers) flowing into the coastal water (including the Sanganakan river of Teluk Pandan, the Sangkimah river, the Bengalon river of Muara Bengalon, and Kaliorang river), the development of coral reefs is poor.

Coral reef ecosystems in the study area posses high biological diversity. An observation from 7 sampling sites in the coral reef of South Bontang Bay, for instance, found 128 coral species, 30 macrobenthic species (consisting of

Echinoderm, Crustacea, and Mollusc classes), 6 microbenthic species (consisting of Polychaetae, Amphipoda, Tanaidaceae, and Ophiurideae), 3 algal species (*Coralopsis salicornia, Padina australis,* and *Euchema edulis*), and 2 seagrass species (*Thalassia hemprichii* and *Enhalus acoroides*). In addition, more than 30 fish species that feed on a variety of phytoplankton, zooplankton, and algae within the coral reef are observed (P.T. Widya Pertiwi Engineering and Nedeco, 1986).

In general the reef flat of the study area is shallow and is exposed during the low tide. The outer edge of the reefs are commonly steeply sloped, while natural channels and gullies with a depth of about 14 m can be found within these coral reef ecosystems. As noted in Chapter II, seagrass beds frequently exist seaward of mangroves and landward of coral reefs, where they are sheltered from heavy wave action.

Except for the coral reefs of South Bontang Bay and Lhok Tuan coastal water, they are generally in a healthy condition. However, the coral reefs of Teluk Lombok and those about 10 km north from the Sangatta river are smothered by sediments, which seems to be a result of an increase in sediment loads of rivers flowing into these coastal waters i.e. the Sangkimah, Sangatta, Glam, and Bengalon rivers.

Economic and Ecological Significance

Tropical mangroves, coral reefs, and seagrass beds have been reported to be among the most productive ecosystems on earth. When one or more of these ecosystems occur in proximity to one another, overall organic productivity and biological diversity are synergistically enhanced (Burbridge and Maragos, 1985). Furthermore, the coexistence of these three ecosystems will also increase their protective function to the coastline and land mass behind it from wave action and storm surges.

Organic matter and nutrients available within a mangrove ecosystem, originating from freshwater influx, upwelled sea water, and abundant leaf production, let this ecosystem achieve a high level of productivity. Leaves falling on the mangrove sediment are the primary source of natural food for a large proportion of organisms in tropical coastal waters both within the mangrove forest and in adjacent coastal waters. Detrivores (detritus-feeding organisms) as well as bacteria consume a part of the leaves and decompose the rest. The total material and energy contained in detrivores and bacteria will, in turn, be used by other organisms within the rest of the food chain. In the meantime, the unused nutrients and organic matter are usually exported through water flows to adjacent marine ecosystems such as seagrass beds, coral reefs, and demersal and pelagic ecosystems.

Such a rich environment combined with its diverse and complex structure makes the mangrove ecosystem an important feeding, nursery, or spawning grounds for a variety of organisms. According to Snedaker (1978), as many as 90 % of tropical marine fish (and crustacean) species spend at least one stage of their life cycle in mangrove ecosystems.

A variety of finfish, crustaceans, mollusks, reptiles, mammals, and birds occurs within mangrove ecosystems in the study area. Penaeid shrimps and crabs are dominant types of crustaceans found in the area. Finfish, which are commonly found in the area, includes milkfish, mullet, barramundi bream (*Lates calcalifer*), catfish (Plotosidae), 'sidat' (Ophichythydae), 'samadar' (Siganid), 'kerapu' (Serranid), 'pari' (Dasyatids), and Eugralids. Clams and gastropods are dominant molluscs in the area (Total, 1989; and Field Observation, 1990). Besides using mangroves as fishing grounds for decades, local communities of the study area have been using them as a source of many other goods such as firewood; tannins for the preservation of fishing nets; construction materials for boats, buildings, and roads; and fodder as well as green manure (Field Observations, 1989 - 1990). Moreover, mangrove forests have other functions in reducing coastal erosion and in maintaining water quality of the coastal waters through sediment entrapment from surface water runoff, and nutrient release in a steady-state equilibrium (Darovec, 1975).

Unfortunately, almost all economic valuation methods of natural ecosystems (including mangroves, seagrass beds, and coral reefs) have not taken into account the entire stream of benefits provided by these ecosystems. Instead, they only include the directly marketed goods and/or services, which are just a small fraction of the total array of goods and services that are beneficial to human beings. In the case of mangroves, the directly marketed goods may include such things as charcoal, poles, woodchips, and fish and other organisms caught within the mangrove. In many economic analyses, subsistence uses of these directly marketed goods by local communities are still frequently ignored.

As a corollary, most planners, decision makers, and the public, particularly in the region, still perceive mangrove forests as wasted lands or low-value ecosystems. They are, therefore, prime candidates for conversion to other uses like shrimp/fish ponds, tidal agriculture, industrial complexes, ports and marinas, and settlements. Since mangrove ecosystems have been proven to be a natural asset that can be used for human benefit on a sustainable basis (Dixon, 1989), any decision on their conversion to other uses should take into account all of the benefits provided by the mangrove, forgone as a result of such conversion. This is indeed not an easy task for any economic analyst.

Hamilton and Snedaker (1984) proposed an ingenious framework for a more comprehensive economic analysis of mangrove ecosystems. The framework basically classifies the whole array of goods and services offered by mangrove into four quadrants of a simple 2 x 2 matrix (Table 5.2). In most economic analyses, the value of a given mangrove forest is traditionally assessed only based upon those goods and services found in the first quadrant. Unfortunately, the value of a mangrove forest in the first quadrant is often much smaller than the expected benefits derived from such a conversion. Consequently, extensive mangrove conversion to

Table 5.2 Relation between Location and Type of Mangrove Goods and Services and Traditional Economic Analysis.

	Location of goods and services	
	On-site	Off-site
Marketed	1 Usually included in an economic analysis (eg., poles, charcoal, wood-chips, mangrove crabs)	2 May be included (eg. fish or shell-fish caught in adjacent waters)
Nonmarketed	3 Seldom included (eg. medical uses of mangrove, domestic fuelwood, food in times of famine, nursery area for juvenile fish, feeding ground for estuarine fish and shrimp, viewing and studying wildlife)	4 Usually ignored (eg. nutrient flows to estuaries, buffer to storm damage)

Source: Hamilton and Snedaker (1984) after Dixon (1989).

other uses, especially for shrimp ponds in the last ten years, have been undertaken in the name of economic efficiency.

The exclusion of the value of mangrove forest in quadrants 2,3, and 4 in most current economic analyses is presumably because of difficulties in placing monetary value on such benefits. So, economists and ecologists need to work more cooperatively in order to be able to address such a challenge. Yet several attempts at assessing the value of the entire goods and services (in quadrants 1 to 4) provided by mangrove ecosystems have been carried out in Trinidad, Fiji, and Puerto Rico, which arrived at an assessment of this value at US $ 500; 950 - 1,250; and 1,550 per ha per year respectively (Hamilton and Snedaker, 1984).

If such a range of value is taken to assess the economic value of mangrove forests within the study area, then the economic contribution of mangroves to the region would be US $ 34,725,000 to US $ 107,647,500 per year. This value is certainly much smaller than that generated by oil and gas industries, which will be discussed in Section 5.4. The real difference is that the value yielded by mangroves can be on a sustainable basis, while oil and gas industries will only last until the year 2020 (Lemhanas, 1988).

In the setting of the coastal zone under study, the challenge is then how to determine a combination of resource uses on an optimal and sustainable basis within the coastal zone over time. Such a challenge will be addressed in Chapter VII, VIII, and IX.

Intersectoral and Interregional Linkages

It is obvious from the above discussion that mangroves, seagrass beds, coral reefs, pelagic and demersal ecosystems of the coastal zone are highly intertwined. So, changes (human influences) in one ecosystem will, in one way or another, affect the other. In the real world, the complexity of CRM is even more complicated due to negative externalities exerted by natural processes or human activities further away from the coastal zone, such as upland areas and the high seas. Hodgson and Dixon (1988), for example, observed the interaction between logging activities in the upland area of Palawan island, the Philippines and the integrity of coastal ecosystems (i.e. mangroves and coral reefs) through the increase in sediment loads of rivers. The environmental impact of logging, in turn, affects the coastal tourism in the island.

5.3. AGROECOSYSTEMS

Agroecosystems, in this case, include spatial units of the coastal zone that are intensively managed or developed for the purpose of growing crops (agriculture), forestry products (silviculture), fishery products (aquaculture), and livestock and poultry (animal husbandry).

The agricultural crops cultivated in the study area (of broader boundaries) are presented in Table 5.3. Vegetables consist of thirteen types: mungbean, other beans, red onion, green onion, chinese cabbage, chilli, tomato, eggplant, cabbage, cucumber, pumpkin, water spinach, and spinach. Fruit crops include twenty two types ranging from banana to avocado. Most vegetables and fruits are planted as a 'home garden' system and are not sold commercially. However, in some areas close to urban (settlement) centers, such as Samarinda and Bontang, the commercial planting of vegetables and fruits has been a quite lucrative livelihood for the local communities.

Within the food crop category, rice along with cassava are the dominant crop found in the study area. In the cash crop category, coconut and pepper are the main crops planted by farmers. Except for coffee in 1984, all crops, in terms of both harvested area and production, have increased in the last eight years.

Table 5.3 Agricultural Crops Cultivated in the Study Area (of Broader Boundary)

Category	Types
1. Food crops	Rice, maize, cassava, sweet potatoes, peanuts, soyabeans, mungbeans
2. Vegetables	Onion, garlic, green onion, potatoes, cabbage, ccarrots, radish, chille, tomatoes, cucumbers, pumpkins, spinach, swamp cabage
3. Fruits	Advocate, mango, rambutans, lanzons, grape fruits, durians, guava, watery rose aplles, malay rose aplle, sapodillas, papaya, banana, pineaplle, salacia
4. Estate crops	Rubber, coconut, coffee, pepper, cloves, cocoa, candle nuts

Source: Kantor Statistik Propinsi Kalimantan Timur (1989)
Balai Penyuluhan Pertanian Muara Badak (1989)

Coconut trees can generally be found within the coastal fringe and are operated by small holders who are mostly local people. Only two coconut estates, in the Mahakam Delta and Tanjung Santan close to the Unocal basecamp, are owned by private companies. At the same time, all rubber estates in the area belong to 'nucleus estate companies' (PIR = Perkebunan Inti Rakyat) that are essentially a government-sponsored project.

In silviculture, the main activities involved are harvesting and processing the timber into half-finished and finished products such as plywood, chipmill, particle board, and pulpwood. Prior to the banning of log exports (1980), most tropical timber from the country was exported in the form of logs. Forest concessionaires are also required to help the government with replanting the trees (reforestation) once an area has been logged. Unfortunately, only a small fraction of forest concessionaires have complied with such requirements. It is estimated that only 4 % of the total forest concessionaires are categorized as healthy companies, in the sense that they undertake reforestation programs (Wijaya and Wijaya, 1990).

While most agricultural crops are owned by small holders, in forestry almost all harvesting and production processes have been undertaken by forest concessionaires. Only subsistence or illegal utilization of forest products is practised by common people. The total forest area of the study area is estimated at 4,584,000 ha, 24.3 per cent of which is already cut over (Table 5.4). This figure seems to suggest that a good proportion of the area exists under forest cover. However, even within areas categorized as forested, the quality of forest stand has been degraded (interviews with Staffs of Faculty of Forestry, University of Mulawarman, 1989; Bappeda Propinsi Kaltim, 1990).

Furthermore, in Bontang - Sangkulirang and the Middle Mahakam forest districts, about 74 and 41 per cent of the forest area, respectively, has been excised for logging concessionaires since the early 1970's (Kantor Statistik Propinsi Kaltim, 1987). Logging activities combined with shifting cultivation, which increasingly uses the primary forested area, are indeed the major threat to the sustainability of forest resources in the region.

Table 5.4 Forest Area and Its Conversion (Non-forested Area) in the Study Area

Forest districts and sub-districts	Forest area ('000 ha)			Concessionaires		
	Fores -ted	Non-fores-ted	Total	Area	No.	%
A Middle Mahakam	2,173	411	21,584	1,054	12	41
1 Tenggarong	NA	NA	127	NA	NA	NA
2 Muara Kaman	NA	NA	246	NA	NA	NA
3 Muara Wahau - Muara Bengkal	NA	NA	2,211	NA	NA	NA
B Lowland Mahakan	253	191	444	143	3	32
5 Samarinda	NA	NA	271	NA	NA	NA
6 Loa Jana	NA	NA	173	NA	NA	NA
C Bontang-Sangkulirang	1,043	512	1,555	1,149	13	74
7 Marubar	NA	NA	224	NA	NA	NA
8 Sangkulirang	NA	NA	321	NA	NA	NA
9 Karangan	NA	NA	319	NA	NA	NA
10 Bengalon	NA	NA	250	NA	NA	NA
11 Bontang	NA	NA	441	NA	NA	NA
Total	3,469	1,114	4,583	2,346	28	
Percentage	75.7	24.3		51.2		

Source: Kantor Statistik Propinsi Kalimantan Timur (1987).

Aquaculture activities within the coastal zone under study are mostly in the form of tambak (brackishwater fish and/or shrimp ponds). The principal species being cultured are milkfish (*Chanos chanos*) and tiger prawn (*Penaeus monodon*). These two main species are cultured either separately (monoculture) or in a combination (polyculture), but the latter is still a dominant practice in traditional operation systems. In contrast, the monoculture technique for the principal species has been mostly practised in semi-intensive and intensive operation systems. [1]

Meanwhile other species such as mullet (*Mugil sp.*), *Tilapia Mozambica*, groupers, other shrimp species, and crabs are normally considered as secondary species which are not deliberately stocked by farmers. Instead, they enter the ponds naturally through tidal movements. These secondary species are usually harvested daily for both the cost of daily pond operation and consumption by pond's operators and the owner.

To date most tambak operations in the study area use either traditional or semi-intensive technologies. During the field observations, the author only encountered one tambak owner in Handil II, Muara Jawa sub-district (on one island of the Mahakam Delta) who has applied an intensive technology. This fact was also confirmed by information from both

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[1] Intensive technology is when fry (post larvae) of the cultured species were derived from hatchery, their food is entirely from supplemental food (pellet), and the stocking density is above 80,000 post larvae/ha/harvest season.

Semi-intensive technology is when during the first two month the food for cultured species relies on natural food (algae and plankton), then after that supplemental food is the main energy source for the cultured species, and the stocking density is between 20,000 - 80,000 fry/ha/season.

Traditional technology usually relies heavily on natural food that enter the ponds through tidal movement, the stoking density is not more than 20,000 fry/ha/season, and in some cases the fry also come from the adjacent coastal water, which enter to the pond via tidal movement (for more detailed description on this classification see Cholik, 1989).

Provincial and District Fisheries Departments (Personal Communications with the head of Fisheries at the Provincial and District levels, 1990).

The lack of intensive technology applications in tambak production within East Kalimantan province, especially in the study area, could be the result of several factors: (1) the high cost of the technology itself makes its application unaffordable for most fish farmers in the area, (2) uncertainties in production and in the price of shrimps, (3) and uncertainties in land ownership. The last one is believed to be the major impediment for tambak development in the area because most coastal lands perceived to be suitable for tambak have already been allocated for either oil and gas-related activities or conservation areas.

Nonetheless, tambak developments along the coastal zone of the study area have been growing since the early 1980s. According to Dinas Perikanan Propinsi Kalimantan Timur (1987, 1988) and Dinas Perikanan Kabupaten Kutai (1990), the total area of tambak in coastal Kutai and Samarinda in 1984, 1985, 1986, 1987, and 1990 was 612 ha, 638 ha, 1257.1 ha, 1472 ha, and 1858.9 ha respectively. The total number of fish farmers who have tambak operations in 1990 was 738. Average ownership was as large as 2.5 ha, and the range of areal ownership runs from 0.5 to 30 ha (Table 5.5).

The types of livestock being reared in the study area include cattle, buffalos, goats, sheep, pigs, and poultry (chickens and ducks). In general, the number of cattle,

Table 5.5 The Number of Fish Farmer and Area of Tambak, 1990.

District/village	Number of fish farmer	Area (ha)		
		Total	Average owner-ship	Range
A. Sangkulirang	60	143.1	3.1	
1. Marukangan	2	4	2	2 - 2
2. Susuk Luar	13	22.6	1.7	0.6 - 3
3. Benua Besar	4	20.5	5.1	2 - 10.5
4. Sakka	1	3	3	3
5. Tanjung Manis	1	5	5	5
6. Kerayan	1	3	3	3
7. Kaliorang	38	85	2.2	2 - 10
B. Bontang	299	635.8	2.4	
1. Sangatta	131	273.5	2.1	0.5 - 10
2. Teluk Lombok	21	42	2	2 - 2
3. Sangkimah	40	92	2.3	1 - 8
4. Lhok Tuan	6	24.5	4.1	2 - 8
5. Bontang Kuala	17	57.8	3.4	0.5 - 30
6. Tanjung Laut	55	78	1.4	0.5 - 5
7. Sekambing	3	4	1.3	0.5 - 2
8. Santan Ilir	26	64	2.5	1 - 8
C. Muara Badak	187	730.2	3.3	
1. Kersik	4	13	3.3	2.5 - 4
2. Sebuntal	22	77	3.5	1 - 12
3. Tanjung Liman	107	472.5	4.4	1 - 22

Table 5.5 (Continued)

District/village	Number of fish farmer	Area (ha)		
		Total	Average owner-ship	Range
4. Salo Pelai	11	27	2.5	1 - 6
5. Muara Badak Ilir	35	114.9	3.3	1 - 15
6. Muara Badak Ulu	6	21.3	3.6	1 - 10
7. Seliki	2	4.5	2.3	2 - 2.5
D. Anggana	103	267.8	2.7	
1. Muara Pantuan	44	93.3	2.1	0.8 - 7
2. Tani Baru	42	114	2.7	1 - 7
3. Sepatin	17	57.5	3.4	1.5 - 7
E. Muara Jawa	89	85	0.8	NA
1. Muara Jawa Ilir	41	33	0.8	NA
2. Muara Jawa Tengah	40	47	1.2	NA
3. Muara Jawa Ulu	4	3	0.8	NA
4. Teluk Dalam	4	2	0.5	NA
Total	738	1,858.9	2.5	0.5 - 30

Source: Dinas Perikanan Kabupaten Kutai (1990)
Note: NA = Not available

buffalo and poultry has been increasing since the early 1980s. On the other hand, the number of goats, sheep, and pigs decreased (Table 5.6). There is no clear explanation for such a trend. However, information from some local farmers indicates that the decline in the number of goats and sheep is due to lack of good pastures in the area, particularly within the proximity of coastal fringes, while the decrease in the number of pigs has been reported as a result of a low demand in the area.

Economic and Ecological Significance

Although the contribution of the agroecosystem's activities (grouped under the agricultural sector in the calculation of RGDP) to the RGDP (Regional Gross Domestic Product) is much lower than that of the mining and quarrying sector (see Table 4.6), the capacity of the agricultural sector to provide employment opportunities in the region is enormous. More than 80 per cent of the total labour force in the region is engaged in a variety of activities related to agroecosystems. Unless the diversification of other economic bases (e.g. manufacturing, tourism, and service sector) are successful, this figure will be even more prominent when the oil and gas production is over.

Yet ecological degradation as a result of agroecosystem development has emerged in the area. Apart from displacing the habitat of natural ecosystems (e.g. mangroves, lowland forests, and freshwater swamps), agroecosystem activities that have been and will be affecting coastal ecosystems include: (1) short cycle shifting cultivation; (2) deforestation; (3) poor land management practices which increase the erodibility of soils and alter the pattern of water runoff; (4) diversion of water for irrigation; and (5) wastes from timber industries particularly along the Mahakam river. These ecological effects may be apparent within the coastal zone in the form of water pollution and sedimentation.

Table 5.6 The Number and Types of Livestock in the Study Area and East Kalimantan By Sub-district, 1986.

District/ sub-district	Cattle	Buf-falo	Goat and sheep	Pig	Poultry
A Samarinda	2,302	555	7,576	0	1,435,787
1 Palaran	1,250	110	1,275	0	130,375
2 Samarinda Seberang	92	365	1,275	0	144,887
3 Samarinda Ulu	310	0	61	0	276,950
4 Samarinda Ilir	650	80	2,770	0	883,575
B Kutai	5,839	1,116	13,075	13,741	573,337
1 Muara Bengkal	47	35	475	275	13,600
2 Muara Kaman	40	385	400	0	15,300
3 Sebulu	48	33	465	0	33,250
4 Tenggarong	3,300	174	2,720	125	71,400
5 Loa Kulu	1,185	95	3,185	900	38,950
6 Loa Janan	90	85	2,250	850	181,350
7 Sanga-sanga	226	30	420	0	27,545
9 Muara Jawa	52	55	670	0	29,543
10 Muara Badak	165	45	450	0	26,000
11 Bontang	135	65	510	0	54,500
12 Sangkulirang	240	45	825	0	30,300
13 Muara Wahau	31	30	300	2,600	22,800
Study Area	8,141	1,671	20,651	13,741	2,009, 125
East Kalimantan	23,838	15,85 0	46,401	58,684	3,993,212
Percentage (%)	34	11	45	23	50

Source; Kantor Statistik Propinsi Kalimantan Timur (1987)

<u>Intersectoral and Interregional Linkages</u>

As indicated in Chapter II, most coastal ecosystems are closely linked through the flow of energy and nutrients, the physical interdependencies among them, and the migratory movement of organisms between ecosystems at different stages in their life cycle. In addition, coastal ecosystems are also influenced by activities taking place outside of what planners usually considered as the coastal zone boundaries, such as high seas and upland areas. Therefore, for the management of sustainable coastal development, the coastal zone should not be considered as an independent unit.

5.4. DEMERSAL AND PELAGIC ECOSYSTEMS

Marine fisheries in the region are essentially dependent on the productivity of demersal and pelagic ecosystems. The terms pelagic and demersal are commonly used in fisheries literature, even though they are loosely defined. The demersal component includes species that live on or close to the bottom of the marine environment during most of their lives, while the pelagic component consists of those living near the upper water surface or at mid-depth in the water column and are not directly associated with the bottom of the ocean.

Those two ecosystems can be found seaward of nearshore coastal waters (e.g. beyond the seaward limits of coral reefs and estuaries), where circulation and high sea conditions have a predominant influence on the characteristics and composition of the water, substrate, and resident organisms. A significant proportion of pelagic and demersal stocks in the western half of the archipelago, including East Kalimantan marine water, are distributed in shallower seas (Burbridge and Maragos, 1985).

The fishing gear which is commonly used to catch demersal stocks in the region includes beach seines, trawls, bottom gill nets, hand lines, bottom longlines, and a variety of traps. For the pelagic stocks the fishermen use gill nets, hand lines, longlines, and various kinds of traps that are specially designed to capture pelagic species.

There are no data on the potential of pelagic and demersal stocks specifically for the marine ecosystem of the study area. However, the MSY (Maximum Sustainable Yield) figure for the overall marine waters of the province is presented in Table 5.7.

Table 5.7 The Potential of Marine Fisheries Resources in the Province of East kalimantan.

Types of stocks	MSY (ton/year)
1. Demersal	39,960.00
2. Pelagic	30,450.00
3. Shrimps and prawns	1,463.00 *)
4. Coral reef species	513.78
Total	72,386.78

Source: Dinas Perikanan Propinsi Kaltim (1988).
*) Naamin and Uktolseya (1976), using time series data of catch per unit of effort, estimated that the MSY for shrimps in East Kalimantan marine waters was 3,400 tonnes per year.

In 1987 the harvest of marine fisheries resources in the province was 50,527.4 tonnes (Table 5.8). This was about 70 % of the MSY potential. Except for shrimps and prawns, therefore, the utilization rate of fisheries stocks in the region may still be on a sustainable basis. The overfishing of shrimp stocks, especially those species belonging to the family of Penaeideae, has actually been occurring since 1974 (Naamin and Uktolseya, 1976). The desire of fishermen to intensively capture Penaeid shrimps is undoubtedly due to the high demand and price for this commodity in the international market.

It has been argued that the overfishing of shrimp stocks in the country, including the province of East Kalimantan, was primarily due to the operation of trawlers. Trawlers were introduced for the first time in 1970 by P.T. Misaya Mitra, the fishing company formerly based in South Sumatra, which moved its nine trawlers to the South and East Kalimantan coastal areas (Unar, 1972). By 1979, 80 trawlers of 20 - 30 GT were operating in this area, and more than 330 small trawlers (3 - 7 GT) were operating in coastal waters with depth less than 4 m near the Mahakam Delta (Naamin, 1982).

In 1975 Penaeid shrimp landings totalled 3,336 tonnes and increased to 5,490 tonnes in 1979, with the primary species being *Penaeus merguensis* (Dwiponggo, 1987). One of the objectives of banning the trawler operations for all Indonesian

Table 5.8 The Production (landing) of Marine Fisheries in the Study Area and East Kalimantan by Fish Name, 1987.

Groups and name of fish	Kutai	Samarinda	Other four districts	East Kalimantan
(1)	(2)	(3)	(4)	(5)
A. Demersal	**4,499.1**	**1,016.5**	**15,405.2**	**20,920.8**
1. Indian Halibut	168.9	10.5	0.0	
2. Tonge Soles	-	11.2	0.0	
3. Pony Fishes	222.3	-	316.0	
4. Marine Cat Fish	329.5	72.0	2,281.8	
5. Goat Fish	220.4	44.2	0.0	
6. Grunter	242.0	102.1	396.4	
7. Red Snapper	314.0	74.8	998.5	
8. Groupers	152.2	48.7	403.8	
9. Barramundi Bream	270.5	176.5	1,517.0	
10. Threadfin Bream	-	-	230.9	
11. Big Eyes	-	-	148.0	
12. Croackers Drums	435.1	32.3	1,198.0	
13. Sharks	283.7	43.9	781.6	
14. Rays	255.9	22.6	397.3	
15. Black Pomfret	306.7	68.6	959.3	
16. Silver Pomfret	248.6	57.6	1,057.4	
17. Jacks, Trevallies	-	32.3	461.9	
18. Queen Fish	-	-	952.5	
19. Mullet	542.9	141.3	951.1	
20. Thread Fin	506.4	55.9	2,211.7	
21. Hair Tail	-	22.0	134.0	
B. Pelagic	**3,459.7**	**2,282.2**	**15,174.4**	**20,916.3**
1. Yellow Tail	-	-	319.5	
2. Barracuda	-	68.3	680.6	
3. Scads	-	96.7	1,105.1	

marine waters in 1980 (Presidential Decree No. 39/1980) was to prevent the continuous overfishing of shrimp stocks so that they may return to the sustainable condition. However, based upon the catch figure of shrimps in the province as discussed above, the overfishing condition still exists.

Table 5.8 (Continued)

(1)	(2)	(3)	(4)	(5)
3. Scads	-	96.7	1,105.1	
4. Trevallies	36.8	92.4	615.9	
5. Hardtail Scad	-	-	161.0	
6. Garfish	-	157.5	0.0	
7. Anchovy	465.1	351.5	1,006.8	
8. Sardine	239.2	61.9	462.0	
9. Fringe Scale Sardine	-	50.9	856.5	
10. Oil Sardine	-	-	210.0	
11. Wolf Herring	428.2	28.6	337.7	
12. Indo Pac. Mackerel	699.4	439.6	2,698.1	
13. Toli Shad	-	-	34.0	
14. Ind. Pac. Sp. Mackerel	222.0	36.6	590.9	
15. Spanish Mackerel	280.4	39.3	1,404.4	
16. Tuna	-	-	55.0	
17. Skipjack Tuna	-	-	39.1	
18. Eastern Little Tuna	341.2	59.3	947.1	
19. Others	746.4	799.6	3,988.4	
C. Crustaceans	1,570.9	634.8	5,574.8	7,780.5
1. Crabs	-	23.5	470.2	
2. Spiny Lobster	-	-	138.0	
3. Tiger Prawn	414.7	108.8	868.1	
4. Banana Prawn	439.4	176.8	1,933.2	
5. Other Shrimps	716.8	325.7	2,165.3	
D. Mollusk	-	60.7	778.3	839.0
1. Clams	-	-	262.5	
2. Squids	-	60.7	383.8	
3. Octopus	-	-	132.0	
E. Turtle Eggs	-	-	70.8	70.8
Total	9,529.7	3,994.2	37,003.5	50,527.4

Source: Dinas Perikanan Propinsi Kalimantan Timur (1988)

Economic and Ecological Significance

Fisheries commodities harvested from the pelagic and demersal ecosystems play a considerable role for the people's life and the economy of the province. In terms of fish consumption, East Kalimantan is the highest among all provinces in the country, with 30 kg per capita. The national average was 18 kg per capita in 1987. This means that the total fish consumption of the province in 1987 was 49,000 ton (Dinas Perikanan Propinsi Kaltim, 1987).

With the total fish production from both marine and fresh waters as much as 75,384.5 ton in 1987, the province is exporting its fisheries commodities both to other provinces within the country and overseas. In 1987, the total export volume of shrimps amounted to 2,581 tonnes with a value of US$ 17.1 million. At the same time, the amount of fish products traded to other islands, particularly Java, was as much as 6,050 tonnes.

For the entire province, the total number of households that engaged directly in marine fisheries, which is based primarily on pelagic and demersal ecosystems, was 8,807 families in 1987. In the study area (Kutai and Samarinda) the number was 2,349 families (Dinas Perikanan Propinsi Kaltim, 1988). As the average size of a family in the province is five, the number of people whose livelihood relies directly on marine fisheries is almost forty five thousand. The number is much greater when those who are engaged in the backward and forward linkages of marine fisheries industries, such as fish processing, fishing gear and fishing boat production, and retailers, are included.

The demersal and pelagic ecosystems can be very productive in areas of localized upwelling, where nutrient-enriched deeper waters are carried into shallow water and stimulate phytoplankton growth. High productivity is also found in nearshore coastal waters. Examples of such areas in the region are off the Mahakam Delta, South Bontang Bay, and off the Sangatta river.

Intersectoral and Interregional Linkages

As with other natural resource systems, the pelagic and demersal ecosystems are essentially impact takers. Their sustainable capacity in the area has been threatened by three major factors: overfishing, pollution, and habitat degradation. Marine water pollution include oil wastes generated by oil and gas related activities (e.g. oil spills, continuous discharge of oily water from oil production plants, drilling mud, and transportation); thermal wastes from the LNG plant; and toxic chemicals from industrial and domestic discharges, both within the coastal zone and adjacent areas.

Demersal ecosystems, especially those closer to the shore, are also more vulnerable to sedimentation due to soil erosion and the discharge of mine tailing, such as coal surface mining in the Sangatta area. As will be discussed in further detail in the next chapter, rivers like Mahakam and Sangatta bring a heavy load of sediments into their respective coastal waters as a result of poor upland management. The question as yet unresolved is whether these sediments, mainly originating from fertile top soil of upland areas, will harm the demersal (benthic) ecosystems or fertilize the ecosystem.

5.5. NON RENEWABLE RESOURCE-BASED DEVELOPMENT

Exhaustible (non-renewable) resources, which consist of oil and gas, coal, limestones, kaolin, phosphate, quartz sands, calcite, clay deposits, and pyrite deposits, are the primary basis for mining and industrial development in the study area.

Oil and Gas

Indonesia, a member of OPEC (Organization of Petroleum Exporting Country), is one of the major oil producers in the world, with a production capacity of 1.35 to 1.5 million bpd (barrels per day). Although there is no official data on oil reserves, the industry estimates that the proven reserve is 8.5 bbl (billion barrels) and the unproven recoverable reserve is 50 bbl (GTZ/TAD-PPS, 1990 b). However, many of the country's oil fields are quite small and the maintenance of production levels demands continuous exploration and development.

In response to the weakening of the world oil market in 1980s, the country has generally adhered to the oil production quotas imposed by OPEC. In late 1986, Indonesia produced 1.13 million bpd, and in late 1989 it increased the production to 1.374 million bpd (GTZ/TAD-PPS, 1990 b).

The exploration and production of oil in the Coastal Kutai and Samarinda area started in 1888. There are no official data on the potential of oil and gas reserves in East Kalimantan. However, the production trend from 1980 to 1988 (Table 5.9) indicates that the oil reserves in the region are

Table 5.9 The Production Trend of Oil and Gas in East Kalimantan Province, 1980-1988.

Year	Oil ('000 brl)	Gas ('000 brl)
1980	131,407	10,750
1981	127,008	10,135
1982	104,343	9,443
1983	103,698	10,002
1984	107,999	14,981
1985	104,872	15,304*)
1986	100,447	15,833*)
1987	89,222	15,380*)
1988	75,036	17,843*)

Source: Kantor Statistik Propinsi Kalimantan Timur (1987, 1989)

already declining. This propensity is strengthened by some assessments of oil and gas reserves made by Total Indonesie and Unocal oil companies (Total Indonesie, 1989 and Unocal, 1990). It has been reported that for the Mahakam contract area of Total Indonesie, the production of oil will economically be feasible until 1993 with a production rate of 27,000 barrels oil per day (Total Indonesie, 1989).

East Kalimantan's share in the total country's oil production is currently in the range of 20 per cent (GTZ/TAD-PPS, 1990c). It is noteworthy that 90 % of the province's total oil production originates from various oil fields, both onshore and offshore, within the coastal Kutai and Samarinda area (Bappeda Propinsi Kaltim, 1987). It is also estimated that by the turn of this century, the current oil fields in the area will be exhausted (Total Indonesie, 1989).

Because oil deposits are frequently associated with natural gas, areas of oil reserves also provide gas potentials. In addition, there are several gas fields currently being explored and exploited. The spatial distribution of oil and gas fields in the study area is presented in Table 5.10 and Figure 5.2.

As can be seen from Table 5.10., except for the Sangatta oil fields, the exploitation of oil and gas in the province, as elsewhere in the country, is undertaken through the production- sharing contract agreement between Pertamina (the state oil company) with one or more foreign companies. Under this agreement, all exploration, investment, and production costs are financed by contractors (foreign companies). These investment and expenses are considered as a loan to Pertamina that are reimbursable only when oil and/or gas are discovered. Pertamina retains ownership of the oil fields and installations. Meanwhile, depending on the condition of an oil and/or gas field, the allocation of oil and gas products can be 85 % : 15 %, 80 % : 20 %, and 75 % : 25 % for Pertamina and the foreign contractor respectively (Warta Pertamina No.10, 1989; Total,1990).

Natural gas from various fields in coastal Kutai and Samarinda area are exported to Japan, South Korea, and Taiwan in the form of LNG through the Pertamina-owned Bontang Natural Gas Liquefaction Plant P.T. Badak NGL). The gas is also supplied to the Kaltim Fertilizer Plant. The mechanism of sending natural gas to these two plants is through the

Table 5.10 The Distribution of Oil and Gas Fields in Coastal Kutai and Samarinda

The name of fields	Location	Products	Operating company	Country origin
1. Sangatta	Onshore	oil	Pertamina	Indonesia
2. Melahin	Offshore	oil & gas	UNOCAL 76	USA
3. Kerindingan	Offshore	oil & gas	UNOCAL 76	USA
4. Attaka	Offshore	oil & gas	UNOCAL 76	USA
5. Badak	Onshore	oil & gas	VICO	USA
6. Pamaguan	Onshore	oil & gas	VICO	USA
7. Nilam	Onshore	oil & gas	VICO	USA
8. Mutiara	Onshore	gas	VICO	USA
9. Sambera	Onshore	gas	VICO	USA
10. Bekapai	Offshore	oil & gas	Total & Japex	French & Japan
11. Tambora	Onshore	oil & gas	Total & Japex	French & Japan
12. Tunu	Onshore	oil & gas	Total & Japex	French & Japan
13. Handil	Onshore	oil & gas	Total & Japex	French & Japan
14. Sanga-Sanga	Onshore	oil	Tipco	USA
15. Anggana	Onshore	oil	Tipco	USA

Source: Huffco (1989), Total (1989), and Unocal (1989).

pipeline system.

Oil from various fields in the area is partly exported and the other portion is sent to the Balikpapan oil refinery through the Teluk Lombok, Santan, and Senipah terminals. The exported oil from these terminals is in the form of crude oil that has been processed at the first and/or second steps. Oil refined in the Balikpapan refinery is sold domestically and for export purposes in the form of finished products such as premium, avture (airplane fuel), kerosine, naphtha, and LPG (liquefied petroleum gas).

Coal Mining

The production of coal in the coastal Kutai and Samarinda area was launched in the 1890s, but continued only on an intermittent basis. Prior to World War II, annual production

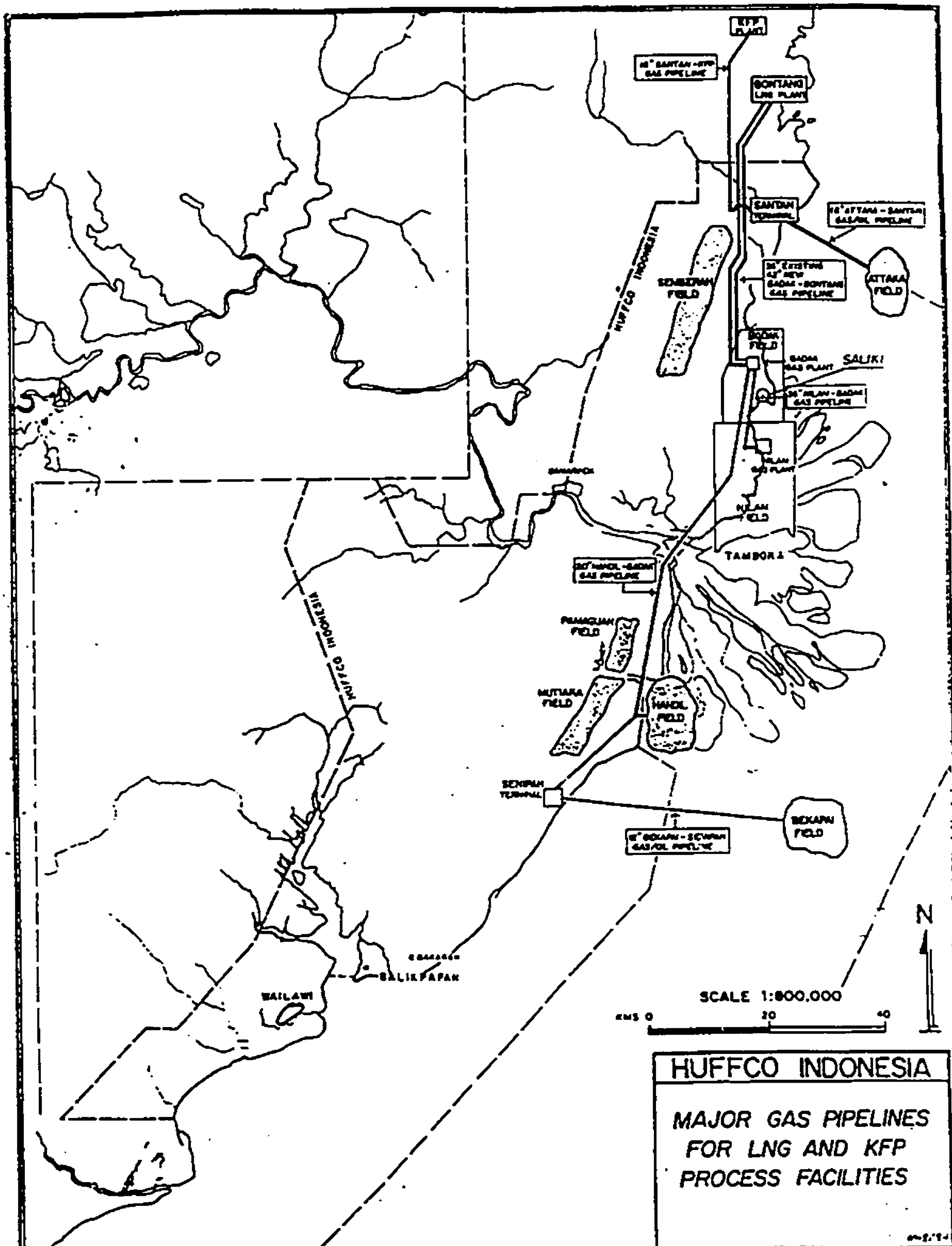


Figure 5.2. Spatial Distribution of Oil and Gas Fields in the Study Area (Huffco, 1988)

averaged 160,000 tonnes, then came to a virtual standstill during the post-war years. Following promising results of the Kalimantan Geological Expedition of 1963/1964, limited productions of coal started again. In the 1980s as a part of the government effort to entice more private investment into coal exploration and production, nine foreign contractors have been granted 30 year exploitation concessions in East, South, and Central Kalimantan provinces.

The potential of coal in these three provinces is almost 6 billion tons, about 61 per cent of which is found in the coastal Kutai and Samarinda area (Table 5.11). At present there are five national private companies (PT. Bukit Baiduri, PT. Fajar Bumi Sakti, PT. Kitadin, PT. Tanito Harum, and P T. Multi Harapan Utama) and one State Coal Company (PT. Kaltim Priarum, and Coal) which are extracting coal resources in the area. Private companies operate in the Lower Mahakam region, nearby Tenggarong, while the State Company is operating in the Sangatta area.

Table 5.11 The Potential of Coal Deposits in the Study Area; and East, South and Central Kalimantan (in million tonnes).

Location	Reserve category			Total
	Proven	Possible	Probable	
Three provinces	1,613.147	1,425.700	2,657.700	5,896.600
Study area	1,017.557	721.100	1,867.700	3,606.400
Percentage (%)	63	51	70	61

Source: after (GTZ/TAD-PPS, 1990)

According to GTZ/TAD-PPS (1990 b), the production of coal from the area was 20,700 tons in 1980 (6.1 % of the national coal production). Since then the production has been increasing year by year, and reached up to 800,000 tons (25.5 % of the national production) in 1989.

Table 5.12 Potentials in Mining of Various Minerals in Coastal Kutai and Samarinda.

Mineral	Location	Reserves (million tons)	Quality
1. Limestone	1.Mt.Sekerat, Sangkulirang	105 - 17,000	very good
	2.Sempaja, Air Putih, Samarinda	1.0	very good
	3.Sanggulan river, Sebulu	0.6	unknown
	4.Suara, Muara Kaman	unknown	unknown
	5.Separi, Tenggarong	unknown	unknown
	6.Lok Tuan, Bontang	unknown	unknown
2. Kaolin	South of Muara Badak city	2.7	good
3. Phosphate	Tenggarong and Sebulu sub-districts	unknown	unknown
4. Quartz sands	1. Five km southeast of Muara Badak city	unknown	good
	2. South of Sanga-Sanga	2.3	very good
5. Calcite	1. The western urban fringe of Samarinda	unknown	unknown
	2. East of the Loahaur river, Loa Janan	unknown	unknown
6. Clay deposits	1. Near Samarinda city	unknown	unknown
	2. Near Muara Badak city	unknown	unknown
7. Pyrite deposits	North of the Sangkulirang - Muara Wahau road, Sangkulirang	unknown	unknown

Source: GTZ/TAD-PPS (1990).

Other Minerals

Besides the leading three (oil, gas, and coal) mining activities, the area also contains a great potential in other mineral resources, i.e. limestone, kaolin, phosphate, quartz sands, calcite, clay deposits, and pyrite deposits (Table 5.12).

Limestone can be used for the raw materials of cement manufacturing and ornamental stonework (pottery). It can also be utilized for reducing the acidity of soils which is the dominant characteristic of most land areas in the province. Additionally, the lack of rocks within the area makes limestone in high demand for building and road constructions. This is particularly true with regard to the Government's plan for road networking and expansion.

Kaolin deposits are reported to have high commercial quality for the ceramics industry. Quartz sands in the area are of excellent quality, and are in high demand for the glass industry in the country. Phosphate is of critical important for agricultural development in the province since many areas have infertile soils.

Intersectoral and Interregional Linkages

Unlike the resource systems previously discussed, most activities associated with the exploitation of mineral resources are basically "impact makers". Through the spatial displacement of natural ecosystems and pollution, the mining and processing of minerals could degrade the integrity of those ecosystems which, in turn, will negatively affect other development activities (e.g. agroecosystems and fisheries in the coastal area). In some cases, this development may endanger the human health itself.

Depending on the degree of disturbance caused by such spatial displacement and pollution as well as on the carrying capacity of the receiving environment (natural ecosystems) in adapting to these disturbances, the deterioration occurring on those natural ecosystems can either be reversible or irreversible. The implications of the latter occurrence will certainly foreclose the use of the respective ecosystem for other human purposes, which may be more beneficial than mining itself. Reversible deterioration of the ecosystem may be tolerable so long as the cost of rehabilitating the system is economically feasible.

When these implications of mining and processing of minerals are put in the context of the development of the province and the country, the challenge is how to plan and carry out these development activities without endangering the sustainable capacity of the area being developed. This will be a basic theme for the remaining chapters of the dissertation.

VI. PROBLEMS AND ISSUES OF COASTAL RESOURCE MANAGEMENT

Chapter VI elucidates problems and issues facing any attempt at managing the utilization of the coastal environment and its natural resources on a sustainable basis. First of all, the Chapter describes the main symptoms which indicate the unsustainable pattern of coastal development and management in the study area. Furthermore, this Chapter traces and analyzes likely causes of such problems. The result of this analysis is a basic prerequisite for planning and management of sustainable coastal development, which is the central theme for the remaining chapters, particularly Chapter IX.

6.1. SYMPTOMS OF THE UNSUSTAINABLE UTILIZATION OF COASTAL RESOURCES

As pointed out in Chapter III, the reference used to analyze the problems threatening sustainable utilization of the coastal environment and its resources should be the sustainable development concept itself. Since most development activities (e.g. oil and gas production, fertilizer, coal mining, forestry, estate crops, and transmigration) occurring in the study area have both provincial and national linkages, this problem analysis will be based not only on provincial interests but also on national perspectives.

From a sustainable development point of view, problems arise as a result of natural phenomena or human actions, individually or collectively, which could bring about the unsustainable use of environmental goods and services. Thus, problems of sustainable development may be identified from symptoms that indicate unsustainable utilization of the environment and resources. Within the coastal zone under study, four main symptoms of unsustainable coastal resource utilization occur, namely: (1) physical degradation of coastal ecosystems; (2) pollution; (3) resource use conflicts and economic inefficiencies; and (4) insidious, downward spiralling effects of development.

6.1.1. Physical Degradation of Coastal Ecosystems

Tropical coastal ecosystems such as mangroves, coral reefs, and seagrass meadows have valuable socioeconomic, ecological, and protective functions. These three ecosystems are among the most productive ecosystems in the world and they are capable of providing a variety of products and environmental services, ranging from fisheries resources to the stabilization of shorelines. Mangroves, for instance, produce more than 70 direct and indirect uses, many of which have non-market value that support the subsistence economy of coastal communities throughout tropical coastal states (Hamilton and Snedaker, 1984).

In the study area, coral reefs harbour various economically important marine species including crustaceans, mollusc, finfish, algae, and echinoderms. The beauty of the coral reefs, particularly around Beras Basah island (about 6 km in front of the LNG plant), have made them one of the most famous tourist and recreational destinations in the area. In addition, coral reefs also provide sturdy protection for the shoreline and coastal infrastructures against erosive wave and current action. Thus, it is no coincidence that the site of the LNG and Fertilizer Plants is placed behind the coral reef formation of South Bontang Bay.

In the study area, coastal communities along the coastline have been using mangroves as a source of firewood, construction materials, and fishing grounds for centuries. The communities have also used coral reefs and seagrass for fishing grounds, particularly ornamental fishes, and most recently as recreational and tourist destinations (direct observations and personal communications with several senior coastal dwellers in Muara Jawa, Tanjung Santan, Bontang, Sangatta, and Sangkulirang, 1990). Therefore, coastal ecosystems in the study area have played a role as basic life-support systems for both the resource base and coastal communities. Any major destruction of these ecosystems, which is beyond their tolerable capacity, is a form of unsustainable development.

Rapid development activities since the early 1970s in the Province of East Kalimantan have brought about economic benefits, but they also have resulted in environmental degradation, particularly in tropical rain forest and coastal ecosystems. Two coastal ecosystems that have been severely affected by these developments are mangroves (including Nypa palm ecosystems) and coral reefs.

The most noticeable damage to these two ecosystems can be found in the coastal area between the Mahakam Delta and Lhok Tuan (about 7 km north side of Bontang). Oil and gas development and its associated activities are believed to be the major contributors to the degradation of mangroves and coral reefs.

Activities of the Total Indonesie oil company within the Mahakam Delta have felled an area of mangrove forest of some 1,400 hectares. Mangroves in the Delta that have been cut for 'tambak' development are estimated at 342 hectares (Total Indonesie, 1989). In addition, the 'Mutiara Gas Facilities' belonging to Vico Oil Company in Delta has cut mangrove, particularly Nypa, in an area as large as 50 hectares (Huffco Indonesia, 1988). In relation to the total mangrove area within the Mahakam Delta (25,305 ha), these cuttings are relatively small. There is no account of the area of mangrove which has been opened for other uses such as settlement and agricultural development. However, the author's field observations (1990) suggest that the use of mangrove area for settlement and agricultural purposes is relatively insignificant. In other words, the mangrove forest in the Mahakam Delta so far has not been significantly affected by development activities.

In contrast to the condition in the Mahakam Delta, the mangrove ecosystems between the Delta and Lhok Tuan of Bontang sub-district have been severely damaged by various human activities. The gas pipeline system which connects hundreds of gas fields to the LNG plant and Fertilizer plant in Bontang (Figure 5.2) has caused significant destruction to coastal ecosystems, mainly mangroves.

Oil and gas related activities along the coast between the Mahakam Delta and Lhok Tuan (see Chapter IV) have attracted people from outside who are trying to make a better life in this coastal area. The spatial needs of these newcomers, such as for settlement, 'tambak', and other agricultural development, have considerably reduced the areal coverage of the mangrove ecosystem along this portion of coastline. Again, there is no record of the changes in mangrove area within this area over time. However, the author's field observation reveals that the condition of the mangrove ecosystems in this area is very poor. Most mangrove colonies have a width of less than 100 meters.

Although many fish farmers in the area are aware of the importance of mangroves for their business, some have left only a 50 m width because they believe that with this width, the mangrove can function to protect their fish/shrimp ponds from wave or minor storm actions (interviews with several farmers in Muara Badak and Tanjung Santan area, 1990). Yet some mangrove forests, such as in the area along Marangkayu river between Tanjung Marangkayu and Kampung Terusan and in Tanjung Santan within the vicinity of Santan River mouth, are still relatively healthy.

The coastal area between Teluk Sekambing and Lhok Tuan, where the LNG plant and Fertilizer factory exist, is also characterized by poor mangrove conditions. The Badak LNG Plant, occupying a 2,060 hectare site on South Bontang Bay, has practically removed almost all the mangrove forest (PT. Badak NGL Co. and Pertamina, 1990). Furthermore, the fertilizer plant of PT. Pupuk Kaltim located 10 km north from the LNG Plant has also deforested parts of the mangrove ecosystem. The area for PT. Pupuk Kaltim is entirely within Kutai National Park and occupies an area of about 1,246 hectares (PT. Pupuk Kaltim, 1986). Unfortunately, the extent and degree of damage to the mangrove ecosystem as a result of these two development projects has not been recorded yet.

Within Kutai National Park, there is about a 7,000 hectare of dense and healthy mangrove forest which extends from the location of the Kaltim Fertilizer Plant to the Sangatta River (Wirawan, 1985). Since the 1970s, however, some parts of it have been used both legally and illegally for other purposes. Around the Sangkimah river and along the southside of the Sangatta river, migrants (especially from South Sulawesi) have developed about 200 hectares of tambak production . In Teluk Lombok, legal Pertamina activities related to the storage and shipment of oil have also caused disturbances to the integrity of the Park's mangroves. Additionally, new small fishing villages, such as Kampung Baru at the mouth of Teluk Lombok and some in Tanjung Sangatta, are developing within the mangrove forest of the Park (Field Observations, 1990).

From the north side of the Sangatta river up to the northern border of the study area, the mangrove ecosystem is still relatively untouched. Yet due to the high price of shrimp, some attempts to develop tambak production have been underway in several locations, such as at the mouth of the Rambut river (about 4 km to the north of the Sangatta river) and at the mouth of the Bengalon river, since the early 1980s.

The coastal ecosystems also have been under great stress from the negative impacts of development activities. This is true especially for the reef located in front of the LNG and Fertilizer plants. The dredging of coral reefs for navigation channels and construction materials for these two mega projects has physically destroyed a significant coral coverage. For the LNG activities alone, approximately 8.2 million m^3 of coral materials were dredged in 1974 - 1975 and 1982 - 1984 (Nontji, 1986). There has been no information concerning the amount of coralline materials dredged for fertilizer plant activities, but a massive degradation of coral reefs in front of this plant is obvious.

Siltation of coral reefs as a result of dredging activities, and the movement of LNG and fertilizer tankers as well as other ships have also adversely affected these ecosystems. Because of siltation, the light penetration into the sea is inhibited. This reduces the photosynthetic activities of coral algae which are the primary builder of the reef formation. Moreover, many coral animals also have very limited tolerance to such siltation and suffer suffocation.

Coral mining by local people further amplifies its destruction.

6.1.2. Coastal Pollution

In addition to physical destruction, coastal ecosystems in the study area have also been loaded by various pollutants. This has occurred as by-products of a variety of development activities both within the coastal zone and in adjacent upland areas. To date, four types of pollutants have been identified in the coastal water.

Approximately a half million barrels of oily water with average oil concentration of 50 mg/litre are discharged into coastal waters continuously on a daily basis by onshore processing facilities of three oil companies operating in the coastal area between Muara Badak and Tanjung Santan (Table 8.1 of Chapter VIII). Oil pollution of the coastal waters may be caused by oil spills from sea transportation, offshore activities (oil rigs and platforms), and cleaning operations of oil, LNG and fertilizer installations (Universitas Mulawarman, 1983; UNOCAL, 1990).

Oil wastes that enter the coastal water have increased the concentration of oil in several locations, particularly in front of discharge points of oil processing facilities, to a level higher than that recommended as an environmental standard (see Section of Chapter IV). This condition has brought about the tainting and coating of mangroves and marine organisms in the area within the vicinity of oil waste discharge points, such as in Kampung Terusan (nearby UNOCAL), Handil II (near Total Indonesie), and Saliki (near Vico Indonesia). The high concentration of oil in several localities of the study area's coastal water can also be revealed by complaints of some fishermen in Sebuntal village (the site of UNOCAL activities) regarding the smell of oil on their fish landings (interviews, 1989).

Thermal waste originating from the LNG Plant is the second pollution problem in the coastal water of the study area. To liquify the natural gas, seawater is used as the cooling agent. After the liquefaction process, heated water is discharged through a 4 km winding canal and finally into the marine environment of South Bontang Bay. Each LNG train requires cooling water of about 9.75 m^3 / second. Thus, with current production level of nine trains, the LNG Plant needs seawater at a rate of approximately 90 m^3 / second.

Water temperature at the intake ranges between 29°-31° C, and at the plant discharge point it increases to 45° C. After flowing through the 4 km cooling canal, the water is discharged into the marine environment with a temperature of about 36° - 38° C. Depending on the local tides and current, the hot water is dispersed as a plume over the sea water. A larger area will be affected by this plume during low tide. Given that the ambient temperature is 29° - 31° C, a water temperature higher than that of the ambient was still observed as far as 1650 m east of the outfall (Universitas Mulawarman, 1983).

The above describes the situation in 1983 when the Plant operated only two trains. It is, therefore, expected that with the current production level, the effects of this thermal pollution on the receiving marine ecosystem will be elevated. Indeed the author's observation in 1989 indicated that during low tide, a water temperature higher than ambient is still noticeable about 3.5 km offshore.

The impacts of thermal pollution on tropical coastal ecosystems, mainly coral reefs and mangroves, have been well documented in various publications, such as Zieman and Wood (1975), Johannes (1975), and Endean (1978). Unlike marine organisms in the temperate region, tropical marine organisms typically live within temperatures only a few degrees below their upper lethal limit. So, when the temperature is increased abruptly, they will be under great stress, if not killed.

The condition of coral reefs affected by thermal discharges of the LNG Plant were examined through a series of field observations (Widya Pertiwi Engineering and NEDECO, 1985; Nontji, 1986). Right at the outfall area, no benthic organisms were observed. Within a radius of a half kilometer from the outfall, the living conditions of coral reef biota were generally poor. Most of the stony corals were dead and their skeletons were overgrown by filamentous blue-green algae, which is more tolerant to heat stress. Some tenacities were also found growing on the dead corals. Meanwhile, fishes, crustaceans, echinoderms, macro algae, and seagrass were hardly found within this vicinity. However, mud skippers

(*Periophthalmus sp*) have adapted to this heated water environment. The thermal plume also destroyed an area of mangroves around the outfall as large as 4 hectares (field observation, 1989).

Other potential negative impacts of the LNG Plant operation on the South Bontang Bay environment are plankton mortality from entrainment, temperature-induced migrations of nekton (larger organisms), and the discharge of chlorine into the Bay. Chlorine is used in the cooling system of the LNG Plant operation to kill fouling organisms, which are mostly plankton. These three negative impacts on coastal ecosystem have not been documented yet in the study area. However, information from other tropical regions may shed some light on this matter.

A study of the impacts of power plant operation, which has a similar operation system in that it uses sea water as a cooling agent and discharges heated water into marine environment, on the coastal bay ecosystem on the west coast of Florida revealed that such an operation exerted considerable effects of plankton entrainment and migrations of nekton due to the thermal plume (McKellar Jr., 1977). Meanwhile, Marsh and Gordon (1975) observed that a power plant outflow in Guam has shown that chlorine has killed fishes in the receiving marine environment. These observations, are actually in agreement with the condition in South Bontang Bay.

Heavy metal contamination is another potential environmental hazard found in the coastal water of the study area. The measurement of the concentration of seven heavy metals in the South Bontang Bay in 1981 is presented in Table 6.1. Although the concentrations of all heavy metals were still under the recommended environmental standards, they are certainly much higher than the ambient concentration commonly found in natural marine environment. This implies that these heavy metals may originate from human activities, most likely oil and gas activities. The danger of heavy metal pollution will not only endanger marine life but also harm human health. The severity of the hazard to human health as a result of biomagnification of Mercury (Hg) and Cadmium (Cd) has been well documented in 'minamata' and 'itai-itai' diseases that took place in Japan in the early 1960s (Carson, 1963).

In the production of LNG, before the gas is precooled and partially condensed using propane refrigeration, it must pass through a mercury removal absorber (Anonymous, 1989). The use of this mercury agent in this process is most likely the source of mercury contamination found in South Bontang Bay. With the increase in production levels, from two trains in 1981 to nine trains at present, the threat of heavy metal pollution should be carefully monitored.

The operation of the Fertilizer Plant has caused pollution of coastal water, mainly with NH_3 (ammonia). The concentration of this compound in coastal water at 1 km distance from the outflow ranges between 0.1 - 0.3 mg/l in 1981 (Encona, 1981), and in 1986 the value increased to 0.4 - 0.8 mg/l (PT. Pupuk Kaltim and UGM, 1986). The latter value

Table 6.1 The Concentration of Some Heavy Metals in South Bontang Bay

Heavy metals	Measurement (ug/l)			Environmental standard *) (ug/l)	
	Min.	Max.	Mean	Desired	Allowable
1. As	0.2	1.0	0.55	2.6	10.0
2. Hg	< 1	< 1	< 1	0.1	3.0
3. Cd	0.7	1.7	0.93	0.02	10.0
4. Ni	<0.5	<0.5	<0.5	2.0	7.0
5. Pb	3.5	6.5	5.6	0.02	10.0
6. Cr	<10	<10	<10	0.04	10.0
7. Cu	< 1	4.0	-	1.0	60.0

Source: (Widyia Pertiwi Engineering - Nedeco, 1982).

Note:
*) based on Governor Decree of East Kalimantan Province No.339/1988
\- can not be averaged

has already exceeded the desired environmental standard, which is 0.3 mg/l. With the increase in production level from two trains in 1984 to three trains in 1989, higher ammonia pollution of coastal water is likely to happen. Massive fish kills have also taken place, at least three times, in the adjacent coastal water during the last two years (interviews with local residents in Bontang Kuala and Lhok Tuan, 1989).

The pollution of the coastal waters becomes more complex when the negative externalities of a host of development activities in upland areas are taken into account. The surface coal mining in Sangatta may have increased the sediment load, and the frequency and magnitude of flooding of the Sangatta river. This, in turn, has changed the sediment deposition pattern of the coastal environment (interviews with local people; and field observation, 1990). The sedimentation rate in the Mahakam Delta is increasing due to poor upland management. In 1988, the sediment materials that were dredged out from river mouths of the Delta were about 1.8 million m^3, and in 1989 the volume became 2.0 million m^3 (personal communication with Kanwil Perhubungan Propinsi Kaltim, 1989).

The river systems in the province are not only responsible for carrying the water and its contents, such as silt and chemical compounds, from upland to coastal areas, but also for supporting the daily life of the majority of people through such important functions as transportation, household purposes (e.g. bathing, washing, defecating, and drinking water), and waste reception. In the case of the waste receptacle function, the Mahakam river is a sink for wastes of more than 50 wood processing factories which are scattered along the river bank, as well as of other industries and domestic activities (BKLH Dati I Kaltim, 1990).

6.1.3. Resource Use Conflicts and Economic Inefficiencies

The development pattern in the Province of East Kalimantan has led to some resource use conflicts as well as economic inefficiencies in resource utilization. Within the study area, these phenomena are particularly observable in the coastal area between the Mahakam Delta and the Sangatta river.

Three main developmental interests can be identified as being frequently in conflict with each other, namely: (1) the high technology sector including the oil and gas industry, coal mining, the timber industry, and state plantations (crop estates); (2) the traditional and small scale sector, including rural agriculture and aquaculture which are directly related to the common people's livelihood; and (3) conservation programs such as national parks and protected forests.

Spatially, the coastal zone under study has mostly been allocated for forest and mining uses (see Chapter VII). Following the national guidelines (The Decree of Forestry Minister No. 628/1984), forests in the province are classified into four main categories: (1) protected forest (e.g. nature reserves and research forest); (2) limited-production forest; (3) production forest; and (4) conversion forest. From a legal stand point, the only forest category that can be used for non forest uses is the conversion forest. Accordingly, only a very limited area is available for other development activities. In reality the implementation of this Ministerial Decree is relatively flexible. For example, the mangrove forest between the Mahakam Delta and Bontang, which is classified within the production forest category, is now mostly used for oil and gas activities, small-scale agriculture, and brackishwater fish/shrimp ponds.

Direct conflicts of use most frequently occur among the oil and gas industry, agriculture, aquaculture, and nature reserves. Depending on the status of land ownership, conflict resolutions between agriculture or aquaculture vis a vis the oil and gas sector are usually done through a 'compensation mechanism'. If it is legally proved that a portion of land belongs to a farmer or fish farmer, then she or he will be paid with cash by the involved oil company. The price of the land depends on its productivity and the amount of capital being invested. If the farmer can not show such an ownership, he must leave the cultivated or cultured land, with a very minimum compensation. Cases like this are numerous in the area. For example, in Muara Badak sub-district there was one fish farmer who got compensation of Rp 85,000,000,- (Eighty five million rupiahs) for his six hectare shrimp pond from Huffco (Field Observation, 1990).

There have been cases where some farmers take advantage of this compensation mechanism. When these farmers learned that a certain coastal land would be used for oil and/or gas exploration and /or exploitation, they planted crops or developed the land for fish/shrimp ponds prior to such oil and gas development, with the expectation of getting higher compensation. On the other hand, there also have been cases where farmers, usually the weaker ones, lost out from such a compensation mechanism (personal communication with the village head of Muara Badak Hilir, 1990).

The worst situation with regard to resource use conflicts between the high technology sector and the traditional sector is in fisheries. Because fishermen do not have an ownership right over their fishing grounds, they can not claim any compensation from high technology development projects (e.g. oil and gas, and fertilizer) when these fishing grounds are, in one way or another, used for these projects. Such conflicts are, for example, occurring in coastal waters just in front of the LNG Plant, the Fertilizer Plant, and the discharge canal of the Unocal oil and gas processing plant in Sebuntal village.

The coral reef ecosystem adjacent to the LNG and Fertilizer Plants is one of the most productive fishing grounds in the Province (interviews with local fishermen and a staff of Dinas Perikanan Dati I Kaltim, 1989). However, since the operation of these two giant projects began, fishermen in this area, for safety reasons, are not allowed to operate within this coastal water (Interviews with some fishermen in Tanjung Laut, Bontang Kuala, and Lhok Tuan villages of Bontang Sub-district, 1989). In the case of Unocal, the resource use conflict is rather indirect. The coastal water near the discharge canal of the Unocal processing plant, which is in front of Kampung Terusan and Tanjung Kersik, is endowed with Penaeid shrimp and milkfish larvae that are collected by local fishermen to be sold to fish farmers. Due to oil pollution, supposedly by Unocal oil and gas activities, their catch is declining (Interviews with fishermen and fish farmers in Kampung Terusan and Tanjung Kresik, 1989).

This is, in a way, a dilemma for most fishermen in the area. Prior to oil and gas development, the prices paid for fish caught in the area were very low. Since then, the price of all sea products has significantly increased. But, at the same time, their catch is either declining or they have to go out further in order to get the same amount of catch, in which case the production cost is much higher than before.

Another alternative that has been pursued by some fishermen in Tanjung Laut and Brebas in response to decreased accessibility to their fishing grounds is the part-time or full-time mining of the coral reef. Coral is used for road and building construction which usually occurs in cities like Samarinda, Balikpapan or Bontang.

The conflicts between oil and gas industries versus nature reserves (i.e. Kutai National Park) can be direct or indirect. The former is manifested in terms of spatial use conflicts e.g. the location of Pertamina in Sangatta and of the Fertilizer Plant just inside of the Park. From a conservation point of view, placing these two projects inside the Park might appear to be an unwise decision. However, since the economic significance of these two projects arguably far outweighs those conservational losses, then such a decision is considered tenable.

The question is why was the location for the Fertilizer Plant not just outside the park? Perhaps, it should have been closer to its raw materials (gas), which is toward Muara Badak Sub-district where gas fields exist. However, there was no environmental assessment when the construction of the Plant was initiated in 1979. Two EIA studies of this project were only carried out in 1981 (Encona, 1981), and in 1986 (PT. Pupuk Kaltim and UGM, 1986), and the Government Act No.

29/1986 concerning EIA, as mentioned in Chapter I, was not enacted until June 1986.

The more threatening elements of these high technology development projects is their indirect impacts. They open up access to the Park through the development of roads and other facilities. In addition, these development projects have also attracted people from Samarinda, Balikpapan, and other provinces or islands. Since the majority of these migrants have low skill and/ or education levels, they are usually employed by these high-technology projects only in land clearing or construction phases. Once the production process of these projects began, they lost their job.

After losing their jobs, most of these migrants remain in the area by engaging in informal sector livelihoods (e.g. trade and services) or opening the surrounding land areas (which are mostly within the Kutai National Park) for agricultural and aquacultural activities. There are numerous examples of such situations. Almost all agricultural land and settlement sites for people who come from Tana Toraja, South Sulawesi, are located within the administrative boundaries of the Park. Uncontrollable settlements and agricultural activities are occurring in Kampung Guntung and Lhok Tuan near the Fertilizer complex, and in Teluk Lombok near the site of Pertamina Sangatta. Moreover, brackishwater shrimp/fish ponds have also been developed along Sangkimah river and the southern side of Sangatta river, which are within the park.

Such indirect negative impacts on the Park have also been brought about by coal mining (P.T. Kaltim Primacoal) which is located just north of the Park, and logging companies that surround the Park, namely P.T. Kayu Mas Timber in the south, P.T. Sylva Duta in the west, P.T. Georgia Pacific Indonesia in the north-west, and P.T. Porodisa in the north. It is also reported that these logging companies sometimes take timber from the Park's area. For example, P.T. Kayu Mas had done this on the southern border of the Park near the Santan river (Team Survey Balai Planologi III, 1983).

In 1987 the total area of the Park that has been converted to settlements, agriculture, and aquaculture is 5,582 hectares (about 3 % of the total Park's area), sixty four hectares of which are for tambak (brackishwater fish/shrimp ponds). However, the author's field observation in 1989 revealed that the total area of tambak was about 200 hectares. The number of people who reside within the Park's boundaries in 1987 was about 19,653 people (4,094 families), which constitutes 32 % of the total population of Bontang sub-district (Taman National Kutai, 1988).

By the recent opening of the Trans Kalimantan Road between Samarinda and Bontang, and in the next construction of the segment of this road system between Bontang and Sangatta that crosses the Kutai National Park, could exacerbate the condition of the Park and other coastal ecosystems. The existence of this road will likely to increase the opening of new lands for settlements, miryad economic activities, and other infrastructures and facilities. Thus, proper planning and monitoring of the development of this road and its concomitant activities should carefully be applied.

6.1.4. A Downward-Development Spiral

In spite of rapid development in those high-technology sectors, the majority of the population in the Province (including the study area) is not able to obtain the maximum benefits from such development efforts. It is true that the RGDP of East Kalimantan is one of the three highest in the country. However, when the RGDP is calculated by excluding the oil and gas sector, the figure is reduced drastically (Table 4.6). Furthermore, it is well known that the contribution of the oil and gas sector to the RGDP does not accrue to the rural and less educated people who are the majority of the population in the province.

Comparison between Table 4.6 and Table 4.7 (concerning the distribution of employment) clearly indicates that the distribution of wealth in the Province (including the study area) is highly skewed. The contribution of the mining and quarrying sector to the RGDP is 67.72 %, while the sector only absorbs about 2 % of the total labor force. On the contrary, the agricultural sector, which employs 80 % of the total labor force, only contributes as much as 9.63 % to the RGDP. For those who do not work in the high-technology sector, this condition is even worse since prices for basic human needs (e.g. food, clothing, and housing) are relatively higher due to the influence of a part of society that is working in much more highly paid employment, i.e. oil and gas, mining, and timber industries.

Since oil, gas, and other minerals are exhaustible resources, which are predicted to be exhausted by the year 2020, then after the oil and gas period the economic condition of the Province may deteriorate. This is particularly serious, if, after the exhaustion of oil and gas reserves, other economic bases have not been developed. People at that time would exploit whatever resources are available to maintain their life. This propensity might lead to further degradation of fragile ecosystems, such as mangroves, coral reefs, and the national park. As another option, people might go back to urban areas such as Samarinda, Balikpapan, Surabaya, and even Jakarta, which means, as described in Chapter III, placing more burdens on Java.

6.1.5. Sea Level Rise and its Potential Impacts

As most areas of the coastal zone under study are flat with a slope no more than 3 % elevation, the sea level rise could potentially threaten the sustainability of some coastal ecosystems and associated development activities. The possible physical impacts of the sea level rise include coastal erosion and inundation of low-laying areas, flooding due to storm surges and high tides as well as habitat loss, and salt intrusion (Paw and Chua, 1991). Areas which will be vulnerable to erosion due to sea level rise are deltas (e.g.

the Mahakam and Sangatta); sandy beaches (e.g. Teluk Lombok and Tanjung Limau); small and flat islands (e.g. Beras Basah and Melahin - Kerindingan); and mudflats. Estuaries and tidal swamps are especially prone to inundation or frequent flooding during storm surges as well as backwater flows.

The potential socio-economic impacts of the sea level rise on the region may be in the form of the destruction of coastal settlement and industrial infrastructures and facilities, the loss of brackishwater shrimp/fish ponds, and changes in spatial (land and sea) use patterns. The existing industrial facilities of PT. Pupuk Kaltim (fertilizer) and PT. Badak NGL, Co., which are located just on the tip of coastline, and the facilities of Total Indonesie in Handil II of the Mahakam Delta are particularly prone to the sea level rise.

The intensity of these impacts, certainly, depend on the degree and the rate of climatic change and the ensuing sea level rise but under prevailing circumstances even a moderate rise may have serious implications, particularly if it happens faster than anticipated. In order to minimize the possible negative impacts of the sea level rise, the anticipatory measures should properly be in place.

6.2. CAUSES OF UNSUSTAINABLE COASTAL DEVELOPMENT

From the above discussion, it can be seen that environmental problems, which may bring about unsustainable economic development, have essentially been a result of both endemic poverty and the high-technology sectors. While poverty can be a factor that causes environmental degradation (unsustainable development), it is also a product of current development policy. These two main factors are compounded by poor institutional arrangements and sectoral egoism (self interest), lack of regional government capacity, and poor knowledge of the resource systems.

6.2.1. Development Policy Bias

Currently, the economic structure of the province relies heavily on the high-technology sectors of oil and gas, mining, and timber industries. In the meantime, the traditional sector involving such activities as agriculture, aquaculture, fisheries, and home-industry, which are the main livelihood for the majority of the people, has not yet undergone a significant improvement. This is due mainly to three biases in current development policy.

First, the goal of economic development in the area seems to place too much emphasis on export-oriented products such as oil and LNG, timber, and coal. This type of development orientation is not bad in itself in so far as the benefits of such export-oriented development can be accessed by local and needy people. Unfortunately, as discussed above, the share of these benefits going to local people is still relatively small.

The response of the government to such issues is that the local people do not have enough skill and expertise to engage in those high-technology projects. However, this actually can be overcome by providing necessary training to local young people prior to the development of such projects, so that once the project is running, the involvement of local people in production phases of the projects could be maximized. Unfortunately, this high-technology sector requires only few employees during the production phase. P.T. LNG Badak and P.T. Pupuk Kaltim, for example, with US $ 186 million and US$ 525 million investment only employ 1,500 and 2,398 workers respectively (PT. Pupuk Kaltim and UGM, 1986; PT. Widya Pertiwi Engineering and Nedeco, 1986). This condition is well understood by local people.

Contributing further to social discontent among local people is the fact that even support services (e.g. food catering and ground transportation) for the oil and gas industries, which could have been handled by local expertise, are still managed by companies from Jakarta (field observation, 1989; interviews with the Head of several villages in Bontang and Muara Badak sub-districts, 1989; interview with Secretary of KUD Hidup Baru in Bontang Baru, 1989). It could enhance sustainable economic development in the area, if these supporting services were given to local cooperative organizations. Through such an avenue, the 'trickle-down effects' of development can be maximized and, at the same time, the skill and entrepreneurship of local people can be harnessed so that the diversification of economic bases in the region could also be strengthened, and thereby the sustainability of economic development would be ensured.

Second, the local poor people have not been the main target group of development policy. This can, for instance, be seen from the lack of public services, such as sewerage systems, health services, and education, in the region. Indeed, as discussed earlier, the larger portion of benefits generated by high-technology projects does not stay in the region. According to a senior staff of the Regional Development Planning Board (BAPPEDA) of East Kalimantan Province (1989), the Provincial Government of East Kalimantan only receives 10 % of the net benefit generated by the oil and gas sector, while the rest of it goes to the Central Government.

Lastly, the short-term targets appear to preoccupy the majority of development planners and policy makers, both in the provincial and central government. Massive mechanical logging of lowland tropical forest in the study area prior to the establishment of Kutai National Part in 1982, deforestation in upland areas, and dredging of coral reefs, for example, indicate such a development policy orientation.

6.2.2. Poor Institutional Arrangements and Sectoral Egoism

Sustainable development, as elaborated in Chapter II, requires the consideration of cross-sectoral/interregional impacts in every development project. This prerequisite certainly calls for coordination as well as consultation among the various agencies involved in a given development project, from the planning up to the implementation stage. In order for such a condition to be achieved, each sectoral agency (department) should recognize that other departments also play a role in achieving the objectives of national development.

Theoretically, the Government of Indonesia has actually promoted the implementation of the coordination-integration-synchronization-simplification motto since the beginning of Pelita II (1975). This can be seen from the development planning process both at national and regional levels, which can succinctly be described as follows.

The development planning process in Indonesia has three major dimensions: time, sectors, and regions (Watson et al., 1990). In terms of timing of plans, the GBHN (State Policy Guidelines) are reviewed and revised every five years by MPR (Supreme Governing Council), and are accompanied by the preparation of a new Repelita (Five Year Development Plan). The existing plan period (1989/90 - 1994/95), for instance, is the fifth period to be covered by such a plan. In terms of sectoral coverage, planning is broken down into sectoral groupings (bidang), sectors, programmes, and individual projects. As far as regions are concerned, plans are prepared at the national level, provincial (first autonomous regional) level, and district (second autonomous regional) level.

At central government level, an annual planning process translates the GBHN and the Repelita into action. Each year Ministries prepare project proposals (Daftar Usulan Proyek = DUP) based on submissions from their regional offices (Kanwil) in order to prepare the draft annual development budget at the national level (RAPBN = Rancangan Anggaran dan Pendapatan Negara). After approval by the DPR (Parliament), the RAPBN becomes the APBN (the annual development budget) for the year in question, and development projects within it becomes the list of projects (Daftar Isian Proyek = DIP).

The regional equivalent of this process comprise the preparation every five years of the regional version of the GBHN (the Pola Dasar), from which a regional Repelita (Repelitada) is prepared, leading to annual development plans (Repetada), made up of development projects (DUPDA before approval by the regional assembly, the DPRD, and DIPDA thereafter). This process takes place at both provincial and district levels.

In practice, however, the procedure for making medium-term plans (i.e. the Pola Dasar and Repelitada) or annual development plans (Repetada) in the Province does not provide adequate opportunities for inter-agency discussion and consultation on development objectives; intersectoral linkages, issues, and strategies; programme priorities; or strategic areas. This is the case regardless of which agency was responsible for leading the creation of the Plan, the Bappeda (the Regional Development Planning Board) or the local University. Draft Chapters of the Plan prepared by an appointed team are usually distributed shortly before interagency meetings, which in the time available can do little more than "rubber stamp" the drafts (personal communications with several staffs of Bappeda Dati I Kaltim and University of Mulawarman, 1990).

This undesired condition of the current institutional arrangements could stem from sectoral egoism (sectoral self interest) that still dominates the attitude of most sectoral departments at both national and regional levels.

Scrutiny of most resource use conflicts in the study area indicates that they have their roots in sectoral self interests. Government Act No.2/1975. concerning the mining authority area states that a piece of land which contains strategic minerals, such as oil and gas, should be left aside from other development activities. Such a government act reflects a flavour of sectoral egoism. It disregards any opportunity for other sectors (e.g. aquaculture and agriculture) that may be able to generate more benefits to human beings, particularly local people.

From a financial point of view, the oil and gas sector could generate more profit than others, but a multiple-use strategy of using a piece of land might be wiser. There have been various technologies, such as directional drilling and oil waste treatment, which permit oil and gas activities to coexist with other development activities. The multiple-use strategy for a resource use not only reduces the vulnerability of the economy to external forces like international oil and gas prices, but also strengthens other economic bases which foster sustainability of economic development as a whole.

Another example of sectoral egoism includes permits given by the district fisheries department of Kutai to fish farmers to develop tambak within the area of Kutai National Park. This occurred without any consultation with the Park's management. With these permits, fish farmers along Sangkimah river and the south side of the Sangatta river open hectare by hectare of the Park's mangrove forest for tambak cultivation without fear of the Park's Police Guards (penalties).

6.2.3. Lack of Managerial Capacity in Resource Management

Sustainable development of coastal resources, which commonly demands an integrated management approach, could only be achieved through a strong commitment from both government officials and the communities that utilize a certain resource base. Since coastal resource issues cover a wide variety of disciplines (e.g. oceanography, marine and terrestrial ecology, engineering, environmental planning, economics, policy analysis, systems analysis and modelling, and sociology), the success of any CRM also requires a combination of such skills and expertise in an interdisciplinary perspective.

Even on the national level, let alone at the provincial and local levels, there is an overall shortage of personnel with the skills to conduct marine and coastal resource inventories and environmental assessment, formulate improved management approaches, enforce regulations, and monitor development progress (Canada/ Indonesia MTPSP, 1988). The

Bappeda, which is supposed to be a coordination agency in planning and implementation of development projects within the region, seems unable to provide guidance, facts and leadership in the form of overviews of resource development issues, problems and potentials that could offer a frame of reference for sectoral contributions. The Bappeda, practically, depends on sectoral agencies (dinas) or national departmental agencies and their Kanwils for data and information as well as plan proposals. Moreover, in the study area, local community organizations and private businesses suffer from a lack of such expertise in integrated resource management.

Two main factors can be identified as a cause of such a shortage in resource management skills: (1) the education and training system, and (2) the top-down approach in the management of development. These two factors eventually determine the managerial capacity of the provincial (local) government in resource management. Most higher education institutions (universities) in Indonesia do not provide: an integrated and interdisciplinary approach in marine-related sciences; programs that focus specifically on coastal resource management; and strong preparations in the basic sciences, such as mathematics, physics, chemistry, and biology.

The top-down approach, which up to the present dominates development planning and management in the country, has been a primary factor in making regional government offices dependent on their central government superiors in Jakarta. Most important decisions with regard to provincial resource development and management are still in the hands of the central government. This condition has not only created an inefficient and ponderous bureaucracy, but has also suppressed the creativity and ingenuity (managerial capacity) of most regional government officials.

The condition becomes worse, if expression of creativity and ingenuity in delivering management programs by an official of a lower ranking governmental structure (e.g. district to province, and province to central government levels) is considered as 'trouble making'. This may lead to difficulties in getting promoted. No wonder that a famous motto 'ABS' (the abbreviation of 'Asal Bapak Senang' which literally means as long as the master is happy) has been consistently applied by most government officials. By following this principle (motto) they could not only maintain, or even promote, their current position but also frequently get financial benefits from clients, especially private businesses (Hannig, 1988).

Fortunately, during the last five years the condition has been improving. Through a variety of policies and programs, which have been implemented since the beginning of Repelita IV, the basis has been established for a more efficient development of coastal and marine resources. Three main initiatives are (1) deregulation measures in a number of important sectors of the economy adopted in May and October 1986, including the streamlining of investment regulations and customs procedures; (2) improvements of provincial (local) infrastructures through funding provided by the INPRES (abbreviation of 'Instruksi Presiden' or the Presidential Instruction which by-passes the long administrative channels and reaches the target group directly) program; and (3) the advancement of cooperatives to foster greater self-reliance in development efforts at the local levels.

If it is not carefully planned and implemented, increasing the efficiency of development process may also cause further environmental degradation. Therefore, the Government of Indonesia has enacted several laws and regulations, as already mentioned in Chapter I, which are an effort to harmonize between environmental considerations and development needs.

6.2.4. Lack of Information

Information as a basis for making decisions and planning of coastal resource development and management is scarce in the region (see also Chapter V). There are inadequate baseline data on fundamental biophysical parameters that determine the sustainability of resource production. Examples are regenerative rate of mangrove forests, recruitment rates in fisheries, the capability of the coastal environment to receive wastes.

At present, available information on the nature and extent of coastal resources as well as their economic importance is neither sufficient nor reliable. Little work has been carried out to assess the value of environmental goods and services provided by different combinations of resource uses. Furthermore, most existing data are stored in manual systems that make retrieval, dissemination, and analysis difficult. Analysis is also complicated by the lack of segregation of data into consistent geographic areas, and by the fact that most data are not georeferenced.

Problems in lack of information have also become worse because of restricted access to data. In the country, military agencies, for instance, restrict or classify the dissemination of strategic maps, aerial photography and other remotely sensed data. Private companies, such as oil, gas, and coal industries, also restrict the dissemination of most valuable information on the coastal environment and its resources.

6.2.5. Lack of Governmental Resources

Within the Indonesian government administration, financial resources of a provincial government rely on three main sources: routine budget, development budget, and local taxes and duties. The first two sources are from the central government in Jakarta in which their amount depends on the size of the province's population. The routine budget pays the salary of government officials, and the development budget is allocated for development projects. While the former is increasing, the latter in terms of per capita budget has been declining since the government income from oil and gas sector dropped in the early 1980's due to the decline in world's oil price.

The provincial government can also generate income from its own territory through taxation and fees levied on business, trade, and service sectors in the region. In comparison, however, the amount of money generated from this source is small. The overall lack of a provincial government budget has been believed to be a major hindrance to effective and sustainable development.

6.3. CONCLUSION

Four major problems and issues involving physical degradation of coastal ecosystems, coastal pollution, resource use conflicts and economic inefficiencies, and a downward-development spiral have been identified as symptoms leading to unsustainable development of coastal resources in the region. The threat of these problems on sustainable development of coastal resources may be compounded by the sea level rise and its potential concomitant effects by the turn of this century.

These problems and issues are believed to have their roots in the current setting of planning and decision-making processes of resource development and management that include: development policy bias, poor institutional arrangements and sectoral self interests, lack of managerial capacity in resource management, lack of information, and lack of governmental resources. This problem analysis will be used as one of main building blocks for the management framework of sustainable coastal development offered in Chapter IX.

VII. SPATIAL PLANNING OF THE COASTAL ZONE

As described in the previous chapters, there are a variety of present and potential development activities which compete for space within the coastal zone of Kutai and Samarinda districts. Some of the on-going development activities are partially incompatible. For instance, fertilizer and LNG industries must compete with coastal fisheries and aquaculture for space and water quality requirements. In addition, some current development activities, such as shrimp ponds in Bontang Kuala, were located in areas which are biophysically not suitable for such uses.

These examples underscore the need for spatial planning of the coastal zone if sustainable and efficient development is expected. Broad spatial planning of a given region (e.g. coastal zone) commonly divides the region into three major zones: development, conservation, and preservation zones (Odum, 1976).

Development zones are spatial units (areas) of the coastal zone where potentially environmentally dangerous development activities (e.g. oil drilling and refineries, fertilizer and LNG plants, intensive agriculture and aquaculture, and settlements) should be located. Conservation zones should be allocated for development activities that are based upon the principle of maintaining and utilizing renewable resources, such as coastal fisheries and sustainable mangrove harvesting. Other activities like low density settlement and recreation may be compatible and placed within this zone. Preservation zones are essentially coastal areas which need strict protection due to their unique and significant ecological endowments and other natural values. Examples of preservation zones in the study area are the Kutai National Park and the Bontang Protected Forest.

There is no guarantee, however, that all development activities which can be located within one zone, particularly in the development zone, are compatible with each other. For example, tambak and the oil industry in the study area (as mentioned in Chapter V and VI) have, for several reasons, been incompatible. Hence, a further sub-division is needed to accommodate these finer conflicts. Furthermore, a systematic, efficient, and more quantitative (objective) framework is required to arrive at such a zonation.

This Chapter, by using GIS technology, provides this systematic and efficient framework to spatially allocate the coastal zone into various compatible resource uses. The first section presents the result of a suitability classification of the coastal zone for fourteen types of development activities based upon biophysical criteria. The agricultural and aquacultural uses are emphasized because the majority of the population in the area is engaged in these activities. The reliance on these sectors will be even more prominent when oil and gas reserves are exhausted.

The second section analyzes resource use conflicts in the area. Based on the comparison of the results of these two sections and the current land use, the third section proposes a spatial planning framework of the coastal zone. The last section identifies weaknesses and strengths of the framework, and suggests means of improvements.

7.1. SPATIAL SUITABILITY OF THE COASTAL ZONE

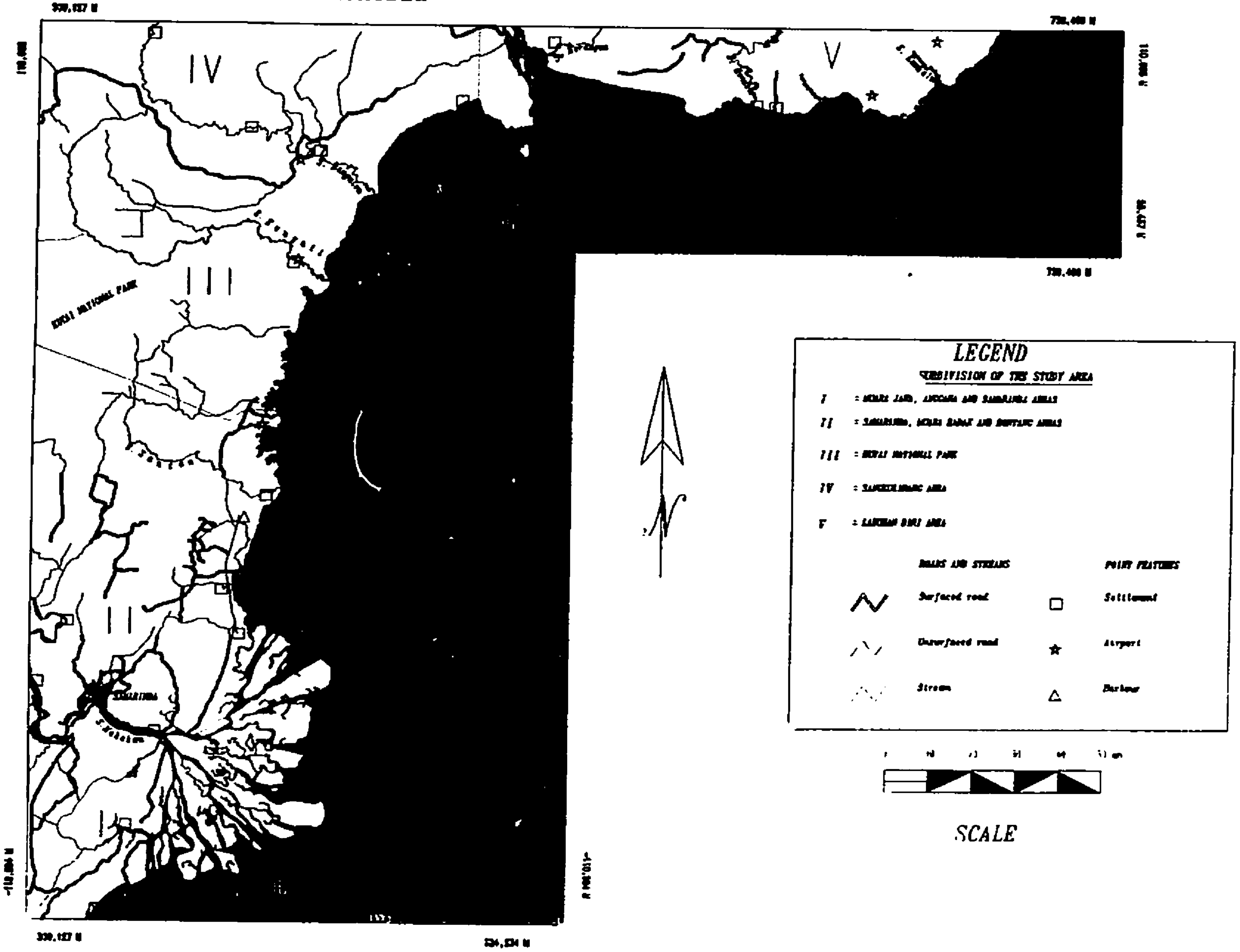
The total area of Coastal Kutai and Samarinda that was digitized using the ARC/INFO GIS for this study amounts to 26,199.55 km^2, about 66 per cent (17,282.93 km^2) of which consists of land area (Table 7.1 and Figure 7.1).

Table 7.1. Digitized Areas of Land and Sea Units within the Study Area.

Code	The name of sub-area	Area (in km^2)		
		Land	Sea	Total
I	Muara Jawa, Anggana, and Samarinda	2,445.60	2,456.67	4,902.27
II	Samarinda, Muara Badak, and Bontang	5,949.96	0.39	5,950.35
III	Kutai National Park	2,164.62	764.72	2,929.34
IV	Sangkulirang	4,758.37	920.80	5,679.17
V	Labuhan Bini	1,964.38	4,774.04	6,738.42
	Total	17,282.93	8,916.62	26,199.55

This means that only about 48 per cent of the total land area of Coastal Kutai and Samarinda (as defined by the provincial government in Chapter IV) has been considered for the spatial planning analysis of this study. This is simply because the required data for the spatial planning analysis are available only for this smaller area. It should be noted that the area of the sea depicted on the map of Figure 7.1 and

Figure 7.1. Kutai and Samarinda Coastal Areas, East Kalimantan, Indonesia



the following maps does not represent the actual areal boundaries stated officially.

The suitability map for the study area, which is divided into five sub-areas, is presented in Figures 7.2, 7.3, 7.4, 7.5, and 7.6. Each map in these Figures is accompanied by tabular information containing suitability classes of land systems within the respective sub-area for fourteen development activities. In this case, suitability classes refer to the current suitability, the suitability class of a land system in its natural conditions without man-made improvements such as fertilizer and liming inputs (CSR/FAO, 1983). In addition, each land system polygon is given its abbreviated name (e.g. BKN, KHY, and TWH) and is colour coded according to its suitability class. For example, a polygon with yellow shading means that such a land system is suitable for ten types of development activities. Information regarding the types of development activities that are suitable on such a land system, and the suitability class for each development activity, can be obtained from the associated tabular information.

The table also provides information with respect to the total road length that passes through each land system polygon and the number of settlements which exist on it. This is valuable information for planners and resource managers when they have to make a priority scale in executing development projects on those land systems. To make the map more informative, point features (i.e. settlement, airport, and harbour), and roads and streams are also included complete with a legend.

Figures 7.2 to 7.6 show clearly that no single land system in the study area has a level 3 suitability class (S_1 or highly suitable) for all fourteen development activities. Appendix 7.1 to 7.14 indicate that, for agricultural uses, the limiting factors that cause land systems in the study area to not have the S_1 suitability level are mostly rooting conditions (soil drainage and texture), nutrient retention (soil pH), nutrient availability, and toxicity (salinity). This is understandable, because soils in the area are generally characterized by low fertility with poor nutrient status (Voss, 1983; LRDC/Bina Program, 1987; and GTZ/TAD-PPS, 1990 c). Consequently, to achieve optimal agricultural yields, most areas need fertilizer and liming inputs as well as drainage improvements.

Major limiting factors for agricultural uses of land systems that are located on relatively higher altitudes (i.e. KPR, TWH, TWB, GBJ, MPT, MTL, LHI, PDH, and OKI) are terrain aspects (slope and rock outcrops), temperature regime, and soil pH. The suitability criteria of most crops evaluated in this study require a land system with a slope condition of less than 8 % and rock outcrop of less than 5 % (Appendix 3.2), while these land systems have a slope of more than 8 % and rock outcrop of more than 5 %. The steepness of the terrain combined with strong erosional effects make any human use of these land systems not viable.

Looking at the suitability on the sub-area basis (Figure 7.2 to 7.6), areas south of the Kutai National Park (Figure 7.2 and 7.3) offer more suitable development activities than areas north of the Park (Figure 7.5 and 7.6). This is apparently due to the steepness (more than 8 %) of most land systems occurring within these two sub-areas. Moreover, these two sub-areas are also dominated by a limestone landscape, particularly within KPR, GBJ, and OKI land systems (LRDC/Bina Program, 1987). Sheer limestone cliffs rising abruptly for several hundred metres from usually flat or undulating adjacent land suitable for cultivation are also common in these sub-areas (GTZ/TAD-PPS, 1990b).

Another interesting finding from those five suitability maps is a pattern which indicates that most agriculturally productive land systems, such as BKN, KHY, LWW, MGH, and TWB, occur within the proximity of rivers or streams. This is presumably because, along the course of river systems, soils are generally characterized by depositional sediments of varying grain sizes (alluvial) that are relatively fertile (Voss, 1983).

As expected, land systems that are suitable for tambak production systems are those which are close to coastal waters, as the tambak requires both freshwater and seawater (brackishwater) to rear the cultivated organisms, i.e. shrimps and /or milkfish. According to the suitability maps (see Figure 7.2 to 7.6), tambak production is suitable on KHY and KJP land systems. Although the PTG land systems occur along the coastal fringe of the study area, they are not suitable for tambak production mainly because of their excessive soil drainage (LRDC/Bina Program, 1987). Thus, once the drainage problems are overcome, tambak development on this type of land system may be possible. This has been proven by local fish farmers who have utilized PTG land systems for tambak production with a certain degree of success in Kampung Terusan, Marang Kayu, and Muara Badak (field observations, 1989-1990).

In order to know which area of a land system is suitable for a certain type of development activity, the suitability maps (Figures 7.2 to 7.5) and their respective tabular information concerning the land system area by suitability classes for various development activities (Appendix 7.14 to 7.18) should be consulted simultaneously.

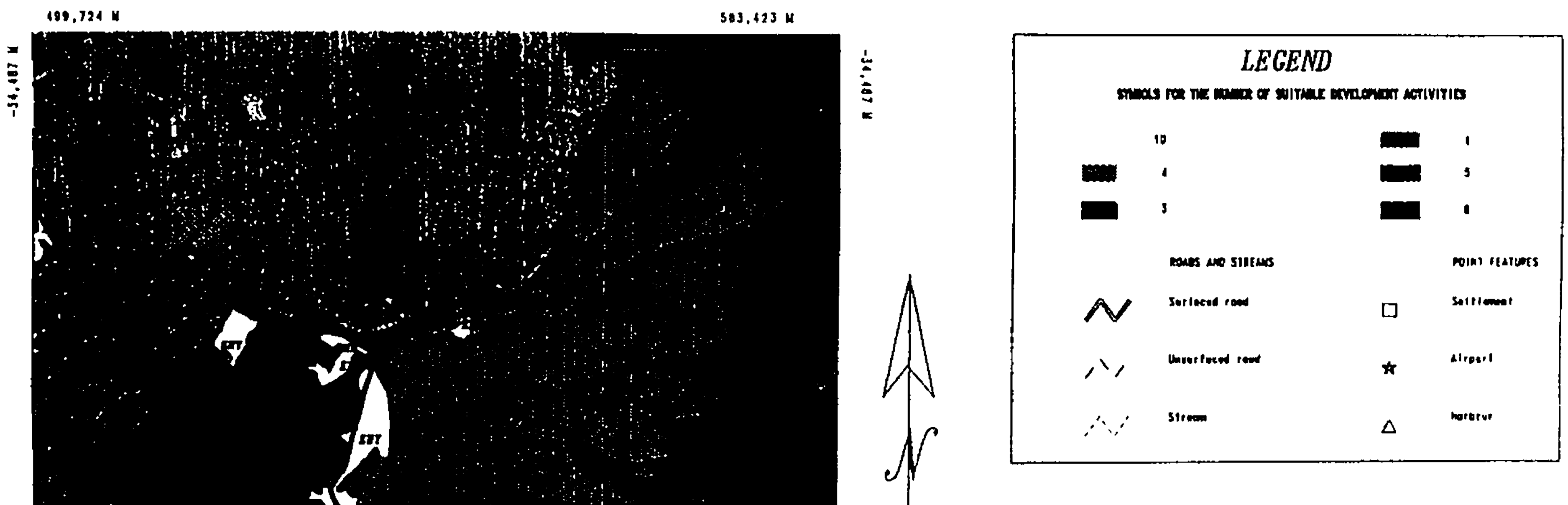
If planner or a farmer, for instance, would like to inquire about suitable locations for growing wetland rice in Muara Jawa, Anggana, and Samarinda areas, they should, first of all, look at the table on the suitability map (Figure 7.2). From this table, they will know the types of land systems that are suitable for wetland rice cultivation as well as their associated suitability classes. Then, the location of these land systems can be seen on the map of the same Figure, and the information about their respective area can be obtained from Appendix 7.14. To this end, detailed information regarding suitable locations and their associated area (in km^2) for fourteen development activities in five sub-areas can easily be retrieved.

Figure 7.2 and Appendix 7.14 present types of land systems, their locations, and their area that are suitable for fourteen development activities in the Muara Jawa, Anggana and Samarinda sub-region. Only three development activities (i.e. dryland rice, oil palm, and pasture) gain the suitability of level S_2 (moderately suitable) in this sub-region. Land systems that are moderately suitable for dryland rice cultivation are BKN and MGH with an area of 3.156 km^2 and 27.462 km^2 respectively. The same land systems are also categorized as moderately suitable for growing oil palm. As much as 201.351 km^2 consisting of BKN, KHY, and MGH land systems offer a moderate suitability for pasture.

More land systems and area have the suitability class of S_3 (marginally suitable) for a variety of development activities. At this level of suitability, pasture, wetland rice, and agroforestry, in descending order, occupy the largest land area, i.e. 1655.593, 1412.100, and 1395.068 km^2. In other words, they respectively represent about 68 %, 58 %, and 57 % of the total area of Muara Jawa, Anggana, and Samarinda area. It is also worth noting that more than 75 % of the marginally suitable area for each of these three development activities consists of KJP and KHY land systems, which are located on the entire Mahakam Delta and fringe of the coastline (Figure 7.2 and Appendix 7.14).

In terms of biophysical requirements, pasture and agroforestry (*Leucaena leucocephala*) are less demanding compared to agricultural crops. Hence, it is natural for

Figure 7.2. The Suitability Map for Muara Jawa, Anggana and Samarinda Areas



SUITABILITY CLASSES OF LAND SYSTEMS FOR VARIOUS DEVELOPMENT ACTIVITIES

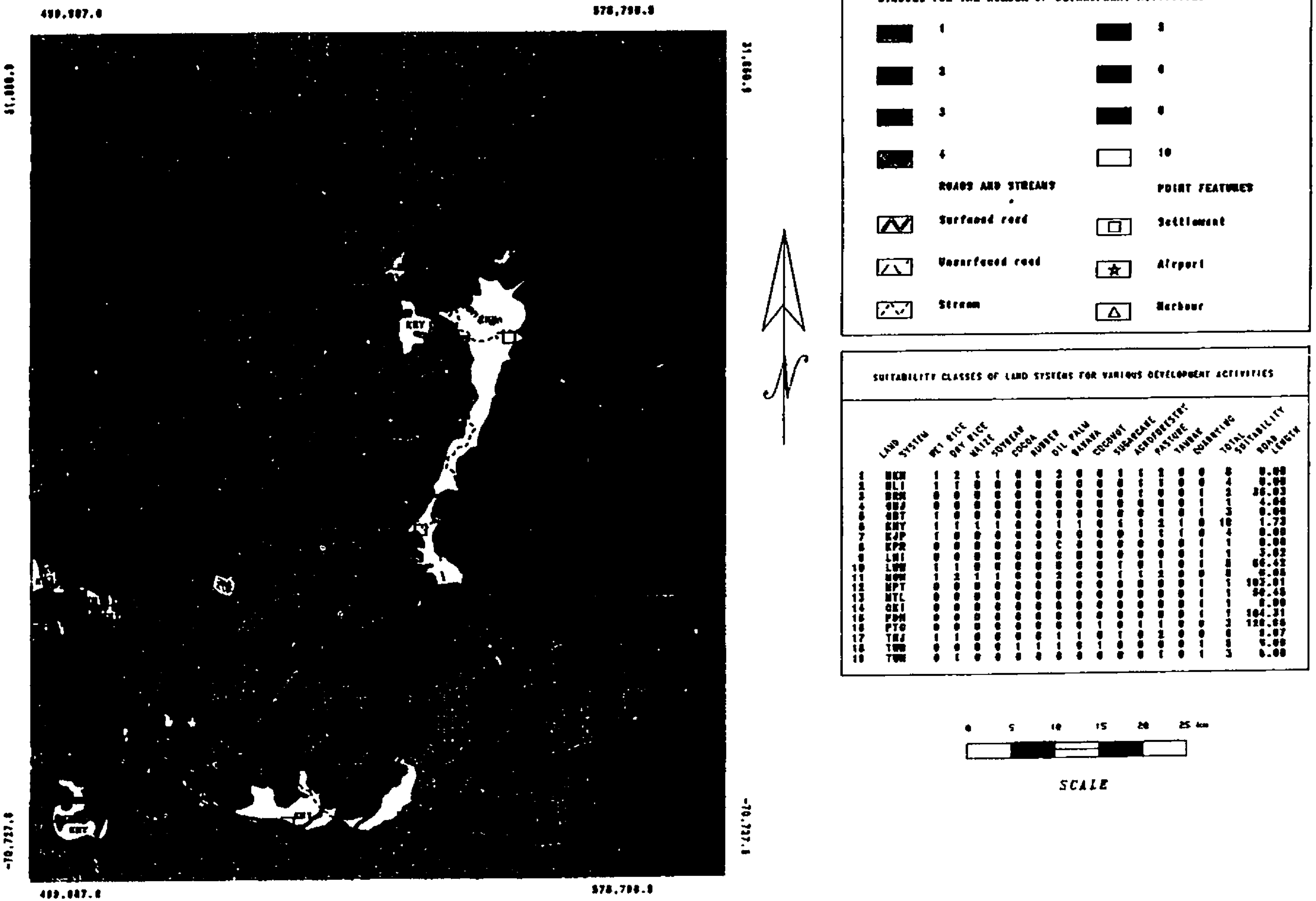
	Land System	Wet Rice	Dry Rice	Maize	Soybean	Cocoa	Rubber	Oil Palm	Banana	Coconut	Sugarcane	Agroforestry	Pasture	Timber	[illegible]	Total Suitability	[illegible]	[illegible]	[illegible]
1	BKN	1	2	1	1	0	0	2	0	0	1	1	2	0	0	8	0	50	0
2	BLI	1	1	0	0	0	0	0	0	0	0	1	1	0	0	4	8	74	0
3	KHY	1	1	1	1	0	0	1	1	0	1	1	2	1	0	10	35	35	2
4	KJP	1	0	0	0	0	0	0	0	0	0	1	1	1	0	4	0	60	0
5	LHI	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	22	30	0
6	LWW	1	1	0	0	0	0	0	0	0	1	0	1	0	1	5	2	45	0
7	MGH	1	2	1	1	0	0	2	0	0	1	1	2	0	0	8	0	50	0
8	MPT	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	30	43	0
9	MTL	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	41	50	0
10	PTG	0	0	0	0	0	0	0	0	1	0	1	1	0	0	3	0	50	0
11	TWB	0	0	0	0	1	1	1	0	1	0	0	0	0	1	5	18	46	0
12	TWH	0	1	0	0	0	0	0	0	0	0	0	1	0	1	3	78	43	0

these two land uses to have larger area at the suitability level of S_3 on this sub-study area. Except for the expensive economic and ecological costs, the KJP and KHY land systems of the Mahakam Delta are biophysically suitable for tambak development. This is supported by the results of feasibility studies conducted by PT. INFISH CONSULT (1985) and Dinas Perikanan Propinsi Kaltim (1988).

The result of the suitability classification for the Samarinda, Muara Badak, and Bontang sub-region is presented in Figure 7.3 and Appendix 7.15. As in the Muara Jawa, Anggana, and Samarinda sub-region, class N (not suitable) also dominates this sub-study area. Yet several land systems are amenable for some development activities at a suitability level of S_3 or S_2. Three development activities (i.e. dryland rice, oil palm, and pasture) can be carried out on the BKN land system at the S_2 suitability level. Meanwhile, at the same suitability level, pasture can be developed on three land systems, namely BKN, KHY, and TNJ with a total area of 363.791 km^2.

At the S_3 suitability level, each of fourteen development activities has some areas for their existence. Five of them, quarrying, dryland rice, pasture, wetland rice, and sugarcane, in descending order, occupy the largest area. Among these five potential development activities, quarrying occupies the largest area. According to LRDC/Bina Program (1987), raw materials for quarrying in this sub-study area are quartz (may be found in BRH and PDH land systems), limestone (in GBJ and

Figure 7.3. The Suitability Map for Samarinda, Muara Badak and Bontang Areas



SUITABILITY CLASSES OF LAND SYSTEMS FOR VARIOUS DEVELOPMENT ACTIVITIES

	LAND SYSTEM	WET RICE	DRY RICE	MAIZE	SOYBEAN	COCOA	RUBBER	OIL PALM	BANANA	COCONUT	SUGARCANE	AGROFORESTRY	PASTURE	TAMBAK	QUARRYING	TOTAL SUITABILITY	ROAD LENGTH
1	BKN	1	2	1	1	0	0	2	0	0	1	1	1	0	0	8	0.00
2	BLI	1	1	0	0	0	0	0	0	0	0	1	1	0	0	4	0.00
3	BRH	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	36.03
4	GBJ	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4.06
5	GBT	1	0	0	0	0	0	0	0	0	0	0	1	0	1	3	0.00
6	KHY	1	1	1	1	0	0	1	1	0	1	1	2	1	0	10	1.73
7	KJP	1	0	0	0	0	0	0	0	0	0	1	1	1	0	4	0.00
8	KPR	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.00
9	LHI	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3.02
10	LWW	1	1	0	0	0	0	0	0	0	1	0	1	0	1	5	66.42
11	MPN	1	2	1	1	0	0	2	0	0	1	1	2	0	0	8	6.06
12	MPT	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	103.01
13	MTL	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	50.48
14	OKI	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.00
15	PDH	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	104.31
16	PTG	0	0	0	0	0	0	0	0	1	0	1	1	0	0	3	120.66
17	TBJ	1	1	0	0	0	0	1	1	0	1	0	2	0	0	6	1.07
18	TWB	0	0	0	0	1	1	1	0	1	0	0	0	0	1	5	5.00
19	TWH	0	1	0	0	0	0	0	0	0	0	0	1	0	1	3	6.00

KPR), felsic (in LHI, LWW, MPT, MTL, PDH, and TWB), peat (in GBT), and sand (in TWH).

While the product of other quarrying materials is self explanatory, peat as a quarried item demands a bit of description. Peat is increasingly used in many countries as a source of energy, particularly for power generation. Because of growing environmental concerns over continuing use of fossil fuels, peat has several advantages compared to coal as a source of energy. Peat is more reactive than coal and usually has a much lower sulphur content, which is one source of acid rain (GTZ/TAD-PPS, 1990c).

The spatial suitability of Kutai National Park is depicted in Figure 7.4 and Appendix 7.16. Compared to the previous two sub-regions, the Park area has less productive land systems with respect to agricultural uses. In fact, in the context of the whole study area, Kutai National Park is the second poorest after the Labuhan Bini sub-region that will be discussed later in this section. Only the KHY land system has the suitability level of S_2 for pasture. The rest of land systems within the Park are classed either as marginally suitable (S_3) or not suitable (N) for a variety of land uses. Even so, the area of the KHY land system is insignificant for any commercial agricultural development.

Figure 7.5 and Appendix 7.17 provide the information on the spatial suitability of the Sangkulirang area. Only one land system, KHY, is identified as having a moderate suitability level (S_2) for pasture. Five land systems (i.e.

Figure 7.4. The Suitability Map for Kutai National Park

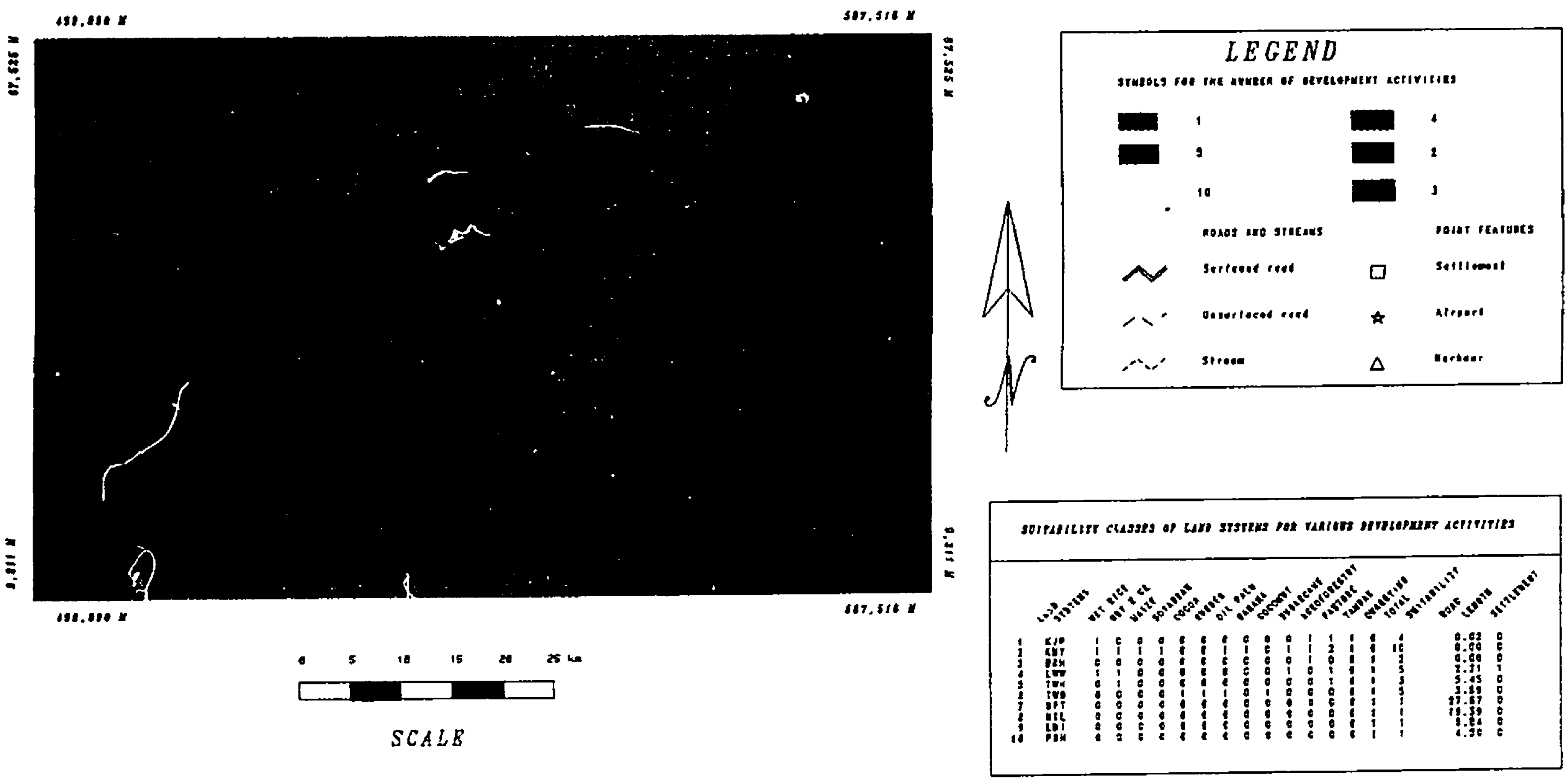
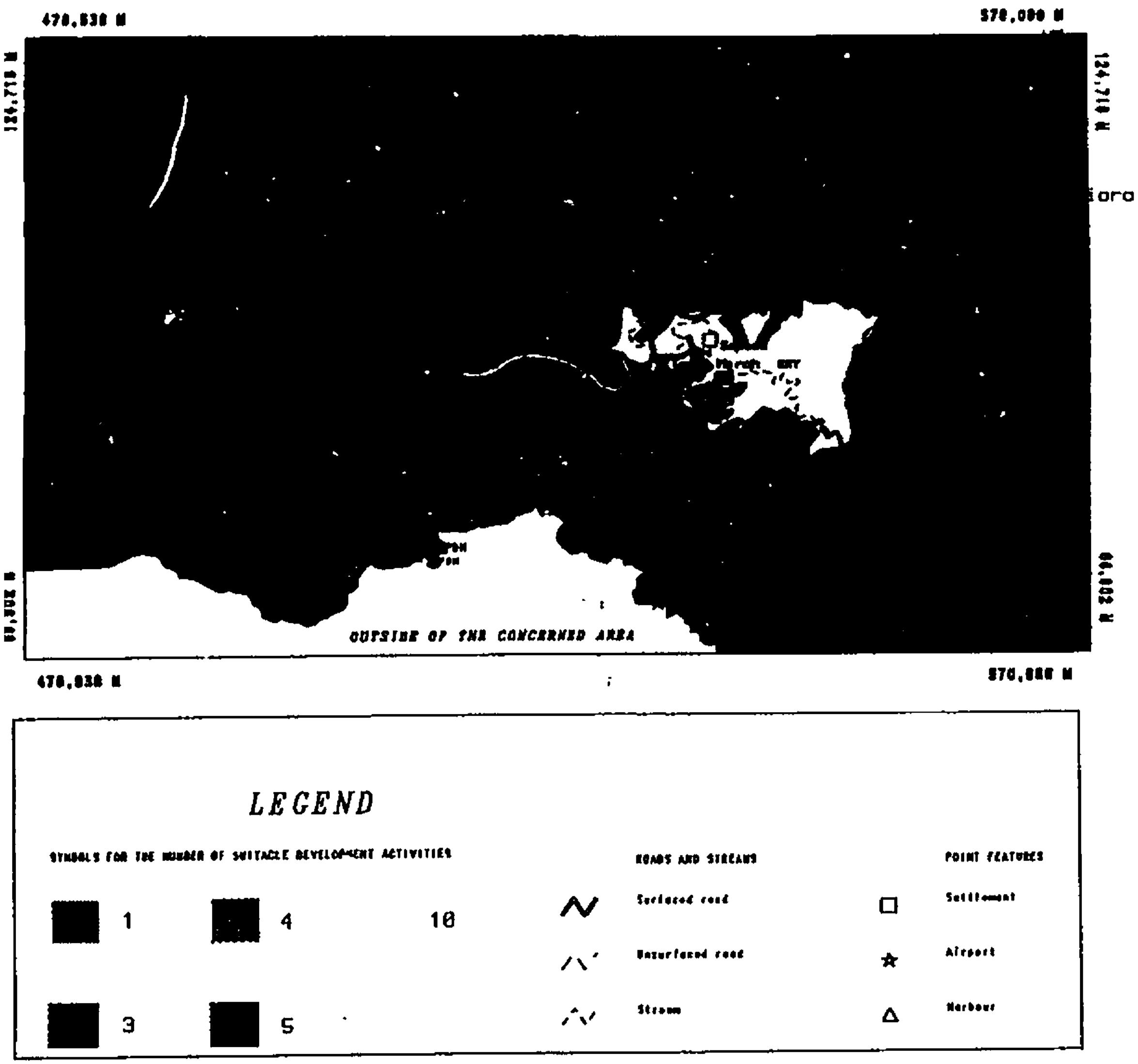
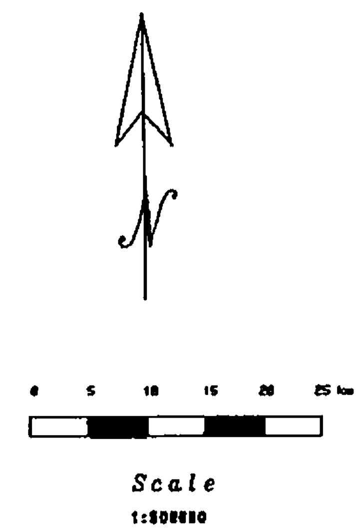


Figure 7.5. The Suitability Map for Sangkulirang Area





SUITABILITY CLASSES OF LAND SYSTEMS FOR VARIOUS DEVELOPMENT ACTIVITIES

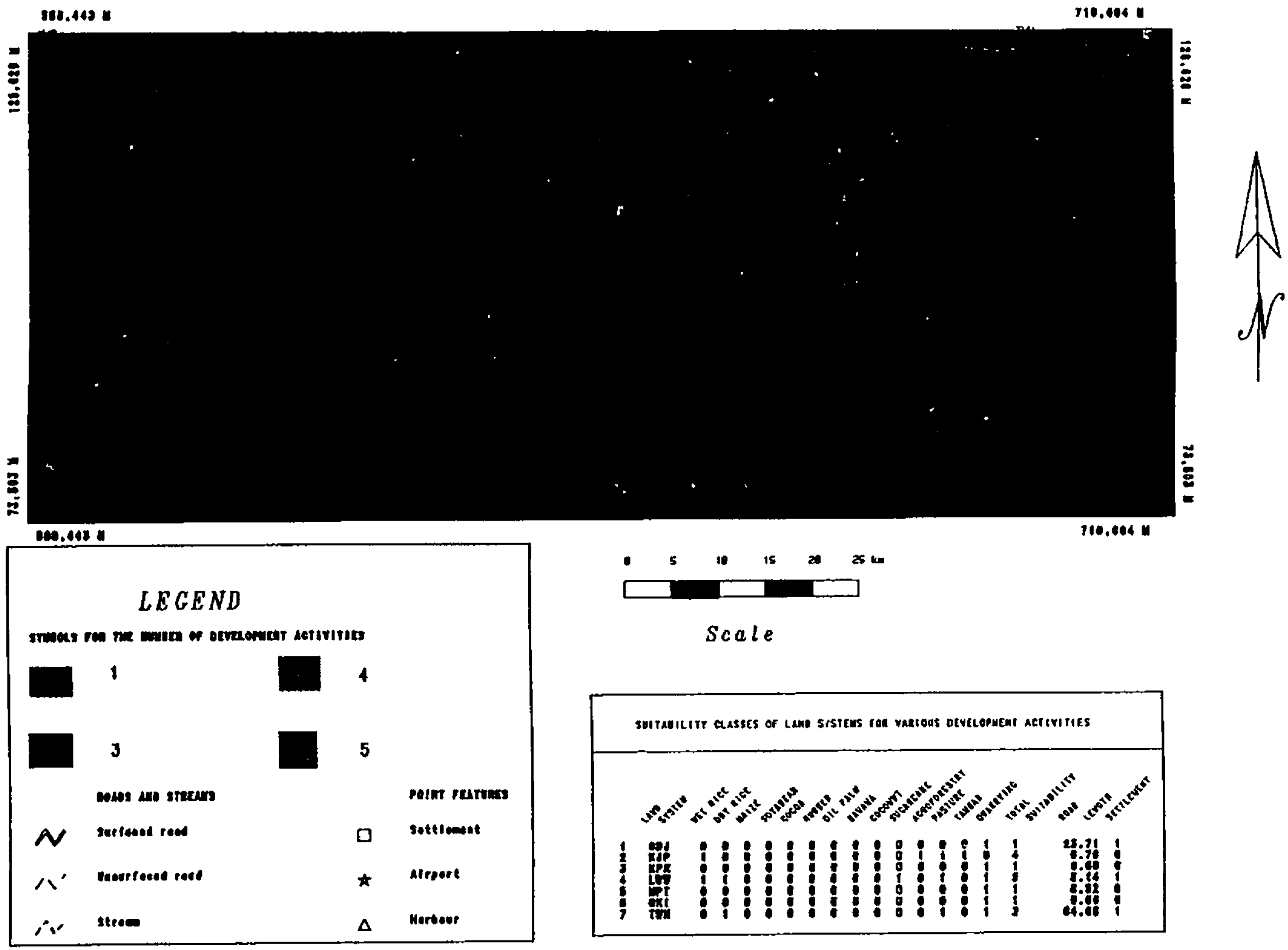
	LAND SYSTEM	WET RICE	DRY RICE	MAIZE	SOYABEAN	COCOA	RUBBER	OIL PALM	BANANA	COCONUT	SUGARCANE	AGROFORESTRY	PASTURE	TAMBAK	QUARRYING	TOTAL SUITABILITY	ROAD LENGTH	SETTLEMENT
1	BRJ	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	20.71	0
2	KKY	1	1	1	1	0	0	1	1	0	1	1	1	1	0	10	12.10	1
3	KJP	1	0	0	0	0	0	0	0	0	0	1	1	1	0	4	0.00	0
4	KPH	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.00	0
5	LHF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2.84	0
6	LWW	1	1	0	0	0	0	0	0	0	1	0	1	0	1	5	10.88	0
7	MPT	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	88.38	0
8	MTL	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	77.61	1
9	OXI	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.12	0
10	PDH	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	24.61	1
11	TWB	0	0	0	0	1	1	1	0	1	0	0	0	0	1	5	28.80	0
12	TWE	0	1	0	0	0	0	0	0	0	0	0	0	0	1	[illegible]	88.34	1

KHY, KJP, LWW, TWB, and TWH) offer a marginal suitability level for several agricultural crops. Tambak production will be suitable only on two land systems, namely KHY and KJP. It should be noted, however, that tambak development on the KHY land system further inland (far from the coastline) might not be suitable, as the supply of saline water for tambak production will decrease significantly (see Figure 7.5). To determine how far from the coastline tambak production can be located, a detailed field research should be carried out prior to any construction works.

Approximately 70 % (3,300.283 km^2) of the total land system area is identified as suitable for quarrying. The quarrying potentials occur on ten land systems (Appendix 7.17). It is also obvious from Figure 7.5 and Appendix 7.17 that, except for quarrying, the majority of land system areas (more than 60 %) within this sub-region are not suitable for other development activities as analyzed in this study.

The sub-region of Labuhan Bini provides the least suitability for agricultural development (Figure 7.6 and Appendix 7.18) compared to the other four sub-regions. No single land system within this sub-study area has a moderate suitability level for agricultural crops. Four land systems (GBJ, KPR, MPT, and OKI) out of seven existing within the sub-region have rock outcrops of 60, 10, 5, and 90 per cent respectively. Whereas, for ten agricultural crops which were analyzed in this study, just to reach a marginal suitability level (S_3) requires the percentage of outcrop to be less than

Figure 7.6. The Suitability Map for Labuhan Bini Area



2 or 3 %. The slope conditions of these four land systems (see Appendix 3.5) also makes them unsuitable for any agricultural crops analyzed in this study.

Quarrying potentials of this sub-study area are enormous. About 97 % (1,914.05 km^2) of the total land system area possesses quarrying materials, such as limestone, quartz and felsic. However, the most promising quarrying potential in the sub-study area is limestone, occurring on GBJ, KPR, and OKI land systems.

7.2. SPATIAL USE CONFLICTS

For planning purposes, information regarding conflicts in the use of the space (land and water) of the coastal zone may be more useful if it covers both actual and potential conflicts. In this context, actual conflicts over spatial use refer to the existing use of a land system and/or water system (a spatial unit) for more than one type of development activities (spatial uses) which are incompatible with each other. Potential use conflicts may arise on a spatial unit that has biophysical suitability for a certain type of development activity, but has been designated for another type of spatial use.

One of the illustrations of actual space use conflicts is the recent use of the KJP land system within Kutai National Park for tambak production. As already mentioned, the KJP land system is suitable for tambak development (Figure 7.4). Prior to 1980, this land system, which is vegetated by mangroves, was not used for any kind of development activities. At the end of 1979, a Buginese farmer, with his three family members, started to clear some 10 hectares of mangroves for tambak production. Initially, it was done secretly by trial case knowing the status of land under the national park.

Since the first harvest (the middle of 1980) gave them quite reasonable economic benefits, they opened other adjacent mangrove lands incrementally and also invited their other relatives from South Sulawesi to join them in the same business. This illegal activity was known by the Park guards in 1986, when the area of tambak had grown to about 40 hectares. The farmers have been strongly warned by the Park management since then. Yet, the total area of tambak on this KJP land system currently amounts to approximately 150 hectares (field observation, 1989; interviews with local fish farmers in Sangkimah and the Park police guard in Teluk Lombok, 1989).

This example demonstrates that a spatial unit, which has a biophysical suitability for a certain type of use, when it is allocated for different uses, may sooner or later create conflicts. This, however, does not mean that the designation of the aforementioned KJP land under the national park status is wrong. It rather exemplifies the importance of incorporating biophysical suitability into any spatial planning work.

Other actual conflicts of spatial uses within the study area, as indicated in Chapter VI, occur mainly along the coastal zone between the Mahakam Delta and Bontang. The continuous discharge of oil waste (oily water) from the Unocal oil processing plant at Tanjung Santan has deteriorated the quality of coastal water in front of Kampung Terusan, which is one of the productive spawning and nursery grounds for Penaeid shrimps and milkfish in East Kalimantan (field observations, 1989 and 1990; interviews with fish farmers and fishermen, 1989 and 1990; Unocal, 1990).

The use of South Bontang Bay for the source of cooling water for the LNG plant, the receiving environment for thermal waste (heated water) from the LNG plant, and the LNG's sea transportation networks has also been in conflict with the Bay's use for coastal fisheries. The coastal water of Lhok Tuan has been competed for the discharge of the fertilizer plant's waste as well as its marine transportation activities on the one hand, and for the coastal fisheries on the other hand.

On the land side, the rapidly growing number of population in Bontang and Muara Badak sub-districts has also created many land use conflicts. The uncontrollable development of settlements and agricultural activities (e.g. tambak, tidal rice cultivation, and horticulture) often occur within the areal boundary of Kutai National Park, oil and gas concessions, or forest concessionaires.

Without proper planning and adequate control, the recent opening of Trans Kalimantan Road between Samarinda and Bontang, and future development of the segment of this road that connects Bontang and Sangatta crossing the Park will potentially result in more spatial use conflicts. As activities related to the timber, coal, oil and gas industries increase combined with a strong political will of both provincial and central governments to promote regional development in the area, the construction of the road that passes through the Kutai National Park may be unavoidable.

To minimize negative impacts of this road development on the integrity of the Park, the alignment of the road should be put in such a way that the potential environmental degradation can be avoided. Three major environmental and economic objectives should be given a high priority in the development of the road: (1) to avoid potential damage to the aquifer outcrop, the main freshwater source for two giant industries (PT. Pupuk Kaltim and PT. Badak NGL., Co.); (2) to halt further destruction on the biodiversity (habitat and wildlife) of the Park; and (3) to locate the road on a more stable ground so that a more economically efficient construction and maintenance of the road can be achieved. Based upon these three considerations, the alignment of such a road proposed by Wirawan (1985) is worth considering.

Safeguarding the integrity of Kutai National Park from the threats of the road development will also require a strict banning (control) of other human activities (e.g. settlements and agricultural activities), which usually take place along the road as already happened along the road between Samarinda and Bontang, during and post construction phases.

7.3. PROPOSED DEVELOPMENT AREAS

Potential development areas are those spatial units which are not only suitable biophysically but are also available for development. Spatial units that are considered as unavailable for development activities within the coastal zone under study, in this case, are protected areas (including various kinds of nature reserves), built-up areas (e.g. permanent settlements and urban areas), mineral (e.g. oil and gas, and coal) production sites, existing or proposed tree crop estates, and settled and allocated transmigration sites.

Proposed development areas (the optimum use of land systems), however, are determined not only by such biophysical criteria but also by socio-economic and political factors (McRae and Burnham, 1981). Socio-economic factors range from easily quantifiable geographical circumstances, such as position in relation to transportation networks, settlements, and other human activities, to political and administrative decisions like eligibility for planning permission or for subsidies and land ownership boundaries, and such unquantifiable factors as the availability of managerial skills or the existence of religious constraints such as the sacred cow or the unclean pig.

In addition to such factors, conservation values of a certain land system should be taken into account into spatial planning of the coastal zone, if the development is to be sustainable. One element of conservation values is biological diversity which is a diversity in species, habitats, or ecological functions that exist in a particular ecosystem. Biodiversity can provide substantial economic values for the genetic feedstock which it provides for foodcrop, cashcrop, pharmaceutical, and other products (McNeely, 1988). After all, the suitability classification and the delineation of available space are only an input to the overall development planning of any region, such as the coastal zone under study.

As far as the mineral production sites are concerned, they may be available for other development activities once their reserves are exhausted. In fact, the current coastal development practices in the study area demonstrate that oil and gas production can coexist with other resource uses (e.g. tambak, rice cultivation, and animal grazing) so long as they do not take place right on oil and gas wells, and infrastructures as well as facilities of the mineral production. Problems arise, however, when there are cross-sectoral impacts (e.g. pollution), as described in Chapter V and VI. Thus, some portions of existing mineral production sites may also be available for other development activities through a well coordinated and disciplined management approach of all involved parties. For instance, the oil and gas related activities have to be managed effectively to prevent environmental degradation, such as oil and gas leaks and spillage.

The Kutai National Park is not analyzed, in terms of proposed development areas, simply because of its status as a protected area, making it unavailable for other development activities. Tropical rain forest and mangrove within the Park, as well as coral reef located in front of the Park, are believed to exhibit high biodiversity (Ashton, 1982 and Wirawan, 1985). The Sangkulirang and the Labuhan Bini sub-study areas are also not included in the spatial planning analysis because of time and resource constraints occurring in this study.

With the assumption that mineral production activities can coexist with other development activities analyzed in this study, areas available for development activities in the sub-study area of Muara Jawa, Anggana and Samarinda are presented in Figure 7.7 and Tables 7.2 and 7.3. The total area that is not available for other development activities within this sub-study area amounts to 235.75 km^2 (see Tables 7.2 and 7.3), which is only about 10 % of the total area of land systems.

Available development areas within the sub-study area of Samarinda, Muara Badak and Bontang can be seen from Figure 7.8 and Tables 7.4 and 7.5. The total land area which is unavailable for development activities in this sub-study area is as large as 351.56 km^2, comprising approximately 8 % of its total area.

Table 7.2. Area of Land Systems Polygons within Forest Status Polygons for Samarinda Sub-study Area

Forest Code	Land System	Number of Polygon	Area (km square)
HPK	MTL	8	4,975.32
	KHY	8	59.46
	IRB	1	7.85
	MPT	9	130.42
	LHI	4	37.72
	BLI	8	53.87
	MGH	5	29.37
	TWB	14	141.64
	LWW	2	29.02
	TWH	21	411.11
	KJP	3	25.57
	BKN	1	3.03
Sub-total HPK		84	5,904.38
HPB	KJP	19	1,068.94
	KHY	8	108.17
	PTG	1	9.94
	TWB	1	5.71
	TWH	3	21.94
Sub-total HPB		32	1,214.70
HL	MTL	5	65.65
	LHI	3	26.04
	MPT	3	68.70
	TWB	1	14.35
	TWH	1	20.58
Sub-total HL		13	195.32
Sub-total (HPK+HPB+HL)			7,314.40
ISL	KJP	1	11.53
SEA	SEA	1	2,469.98
Grand Total			9,795.91

Note:
- HPK/HK : Convertible forest
- HPB : Normal production forest
- HL : Protection forest.

Table 7.3 Area of Land System Polygons within Land Use Polygons for Samarinda Sub-study Area.

Forest Code	Land System	Number of Polygon	Area (km square)
Hh	MTL	5	4,939.68
	LHI	2	21.85
	TWH	7	101.80
	TWB	3	26.27
	MPT	4	41.36
Sub-total Hh		21	5,130.96
Ht	KJP	23	1,106.04
	MPT	1	15.16
	TWB	8	80.84
	TWH	4	96.07
	MGH	1	3.12
	LWW	1	23.59
	LHI	1	3.59
	KHY	1	4.47
Sub-total Ht		40	1,332.88
Hr	KHY	3	35.08
	BLI	4	35.60
	BKN	1	3.03
Sub-total Hr		8	73.71
Hx	TWH	2	14.48
L	KHY	3	30.84
	MPT	7	142.60
	MTL	5	63.48
	LHI	3	30.61
	LWW	1	5.43
	BLI	2	8.31
	MGH	1	14.07
	TWB	2	16.06
	TWH	6	115.01
Sub-total L		30	426.41
L+S	KHY	3	39.99
	TWH	4	30.48
Sub-Total L+S		7	70.47

Continued

Table 7.3 (Continued)

Forest Code	Land System	Number of Polygon	Area (km square)
S	KHY	4	31.11
	MTL	1	7.7
	TWB	1	6.2
	MGH	1	3.9
	BLI	1	4.33
Sub-total S		8	53.24
B	TWB	2	32.33
	TWH	1	3.34
	MGH	1	3.9
Sub-total B		4	39.6
URB	MGH	1	4.35
PC	PTG	1	5.63
RA	BLI	1	5.63
HK	MTL	2	30.11
P	KHY	2	26.14
GRAND TOTAL		126	7,213.57

Note:
- Hh : Lowland forest usually <100 m altitude
- Ht : Tidal forest (undefferentiated) includes mangrove, nipah, and palm.
- Hr : Swamp forest
- L : Shifting cultivation
- L+S: Shifting cultivation with wetland agriculture
- S : Wetland agriculture (irrigated wetland rice, rainfed wetland rice, tidal wetland rice, and deepwater rice)
- B : Bush, scrub, normally regrowth following cultivation
- URB: Urban areas
- PC : Coconut estate
- Ra : Reafforestation
- Hk : Health forest
- P : General estate

The development of agricultural crops, tambak, agroforestry, pasture, and quarrying as analyzed in this study, can essentially be located on land systems that are suitable as well as still available for them. The next question is how to choose which development activity should be given a priority on a land system that is suitable for more

Table 7.4 Area of Land System Polygon within Forest Status Polygons for Bontang Sub-study Area

Forest Code	Land System	Number of Polygon	Area (square km)
HPB	BRH	4	38.80
	GBT	1	11.08
	ISL	6	2.65
	KHY	10	127.24
	KJP	9	144.45
	LHI	3	32.51
	LWW	16	225.97
	MPT	5	142.94
	MTL	8	94.28
	PDH	1	37.96
	PTG	3	13.84
	TWB	4	59.98
	TWH	3	17.33
Sub-total HPB		73	949.03
HPK	BLI	5	23.74
	BNK	4	24.41
	BRH	3	43.31
	GBJ	2	2.11
	GBT	3	21.99
	KHY	18	132.18
	KJP	3	20.28
	KPR	1	48.19
	LHI	7	52.28
	LWW	38	467.62
	MPT	33	482.07
	MTL	44	1,009.42
	TNJ	8	70.81
	TWB	19	202.79
	TWH	45	565.21
Sub-total HPK		233	3,166.21
HSA	BRH	1	8.51
	KJP	1	2.44
	MTL	1	134.67
Sub-total HSA		3	145.62
Total (HPB+HPK+HSA)		309	4,261.06

Note:
- HPB : Normal production forest
- HPK : Convertible forest.
- HSA : Natural forest reserve and tourism forest

Table 7.5 Area of Land system Polygons in Landuse Polygons for Bontang Sub-study Area

Forest Code	Land System	Number of Polygon	Area (square km)
B	BNK	1	5.46
	BRH	1	2.92
	KHY	2	16.41
	LHI	1	14.18
	LWW	6	46.67
	MPT	4	60.26
	MTL	10	58.96
	PTG	1	5.27
	TWB	2	29.95
	TWH	5	73.69
Sub-total B		33	313.77
Hc	MTL	1	1.58
	PTG	2	8.57
Sub-total Hc		3	10.15
Hg	BRH	7	87.71
	GBT	4	33.08
Sub-total Hg		11	120.79
Hh	BNK	1	2.21
	KHY	4	34.61
	KJP	2	9.13
	LHI	5	54.14
	LWW	20	345.48
	MPI	17	410.00
	MTL	30	768.28
	PDH	1	179.63
	TNJ	2	10.68
	TWB	12	177.90
	TWH	21	241.37
Sun-total Hh		115	2,233.43

Continued

than one development activity. From the biophysical than one development activity. From the biophysical perspective, the development activity that should be given first priority is the one that has the highest suitability level on the respective land system. In the case where all development activities have the same suitability level on a particular land system, if they are all agricultural crops or pasture and

Table 7.5 (Continued)

Forest Code	Land System	Number of Polygon	Area (square km)
Hi	GBJ	1	2.11
	KPR	1	48.19
Sub-total Hi		2	50.30
Hr	BNK	1	4.92
	KHY	1	23.22
	KJP	1	5.77
	TNJ	1	29.01
Sub-total Hr		4	62.92
Ht	TSL	4	2.02
	KJP	6	131.41
	LWW	3	39.73
	MTL	1	67.89
	TWB	2	26.84
	TWH	3	23.06
Sub-total Ht		19	290.95
Hx	BLI	1	3.55
	BNK	1	11.82
	LHI	1	2.30
	LWW	3	77.52
	MPT	8	70.94
	MTL	10	216.94
	TNJ	1	1.84
	TWB	3	9.75
	TWH	5	68.39
Sub-total Hx		33	463.05
K	KHY	1	8.22
	KJP	2	12.87
	LWW	3	9.38
	MPT	3	10.48
	MTL	4	11.83
	TNJ	1	1.81
	TWH	3	14.08
	URB	1	33.39
Sub-total K		18	102.06

Continued

agroforestry, they may be planted on a rotational basis or a mixed-farming system.

In the project implementation, however, the actual choice between alternative uses will depend on other factors, such as socioeconomic, culture, and politics, as previously mentioned.

Table 7.5 (Continued)

Forest Code	Land System	Number of Polygon	Area (square km)
L+K	KHY	3	26.27
	KJP	1	2.20
	LWW	5	73.91
	TWH	1	1.50
Sub-total L		10	103.88
Rr	KHY	1	16.96
	LWW	1	2.25
	MPT	1	3.13
Sub-total Rr		3	22.34
S	KHY	6	94.05
	LWW	3	26.11
	MTL	1	6.41
Sub-total S		10	126.57
Sr	KHY	3	12.51
UN	ISL	2	0.63
Grand total		327	4,443.95

Due to a lack of socioeconomic and political data with regard to land development, this study focuses mainly on the biophysical aspects of land systems as a basis for their development.

Nonetheless, some of socio-economic and political information, which has been gathered during the field study, may be used as a consideration as well.

Based on biophysical aspects alone, tambak production could be proposed on the KJP land system, which occupies almost the entire Mahakam Delta, and a part of the KHY land that is located along the coastline as far as sea water can easily be obtained. However, in actual project development of these two land systems for tambak production, there are two major factors worthy of consideration. First, because the whole area of the Mahakam Delta and the coastal fringe areabetween Muara Badak and Bontang is under the status of oil and gas concessions belonging to Total Indonesia, Unocal, Tesoro, and Vico (Humas Vico and Humas Total Indonesia, 1990), any tambak development should not interfere with oil and gas wells as well as infrastructures and facilities of oil and gas activities.

Second, as the land condition of the Delta is relatively unstable, the opening of mangroves should be undertaken carefully leaving the major portion of the mangrove for conservation and physical protection purposes. According to the mangrove green-belt regulation, the area of mangrove that should be left aside is as wide as 130 times the local average vertical tidal range, which for Samarinda area is about 200 m width (Soerianegara, 1989; Janhidros, 1989). Given the conservation values (see Chapter IV) and physical protection functions of the Delta, a 200 m width of green-belt is absolutely too narrow under this circumstance. The determination of optimal location and its area that should be developed on the deltaic KJP land system requires a more detailed field study covering both biophysical and socioeconomic aspects.

Although pasture and agroforestry are suitable for the KJP land system, their development is not recommended because of the high economic and ecological costs of converting a large area of mangroves for these two uses. Meanwhile, the

Figure 7.7. Available Development Areas for Muara Jawa, Anggana and Samarinda

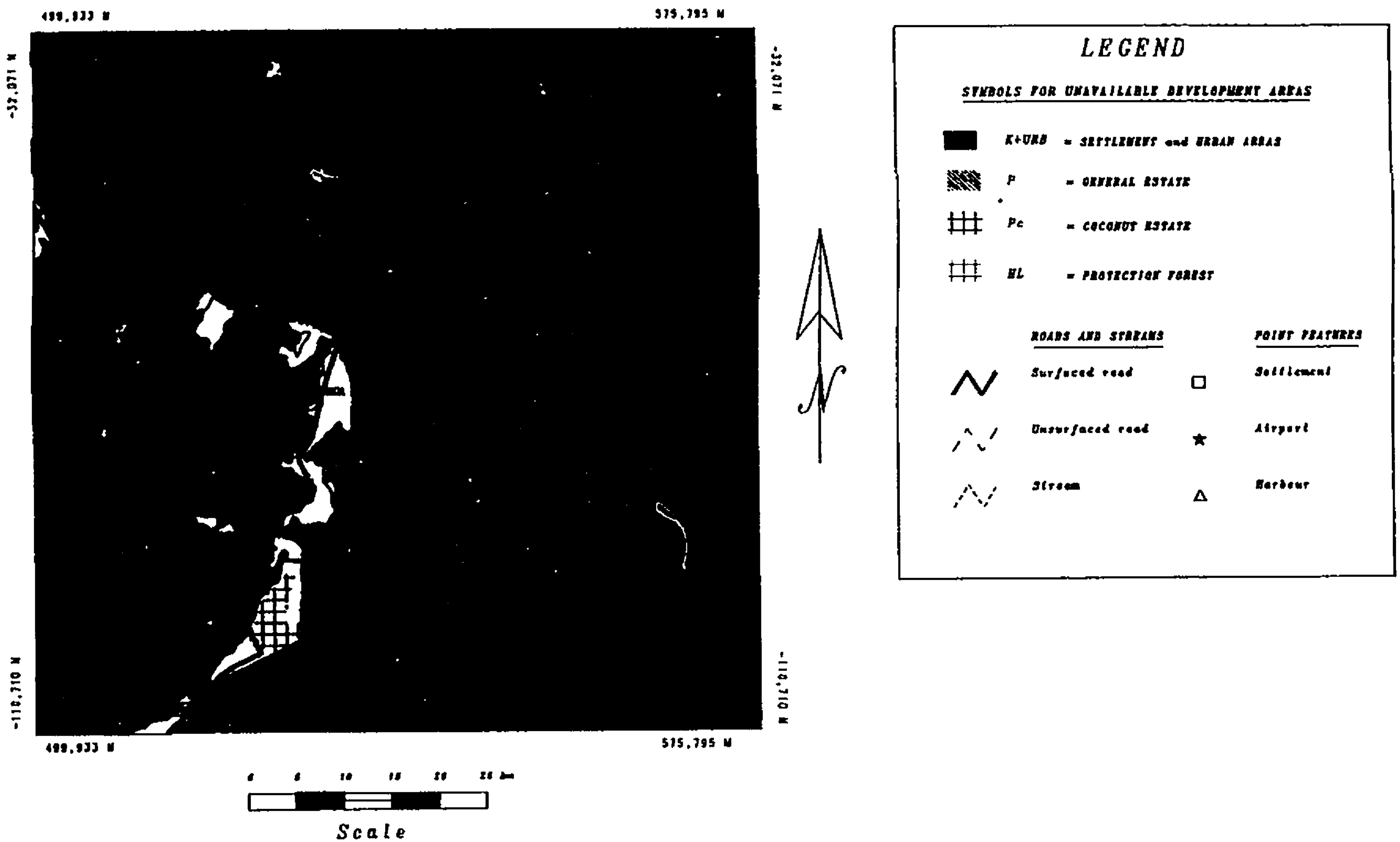
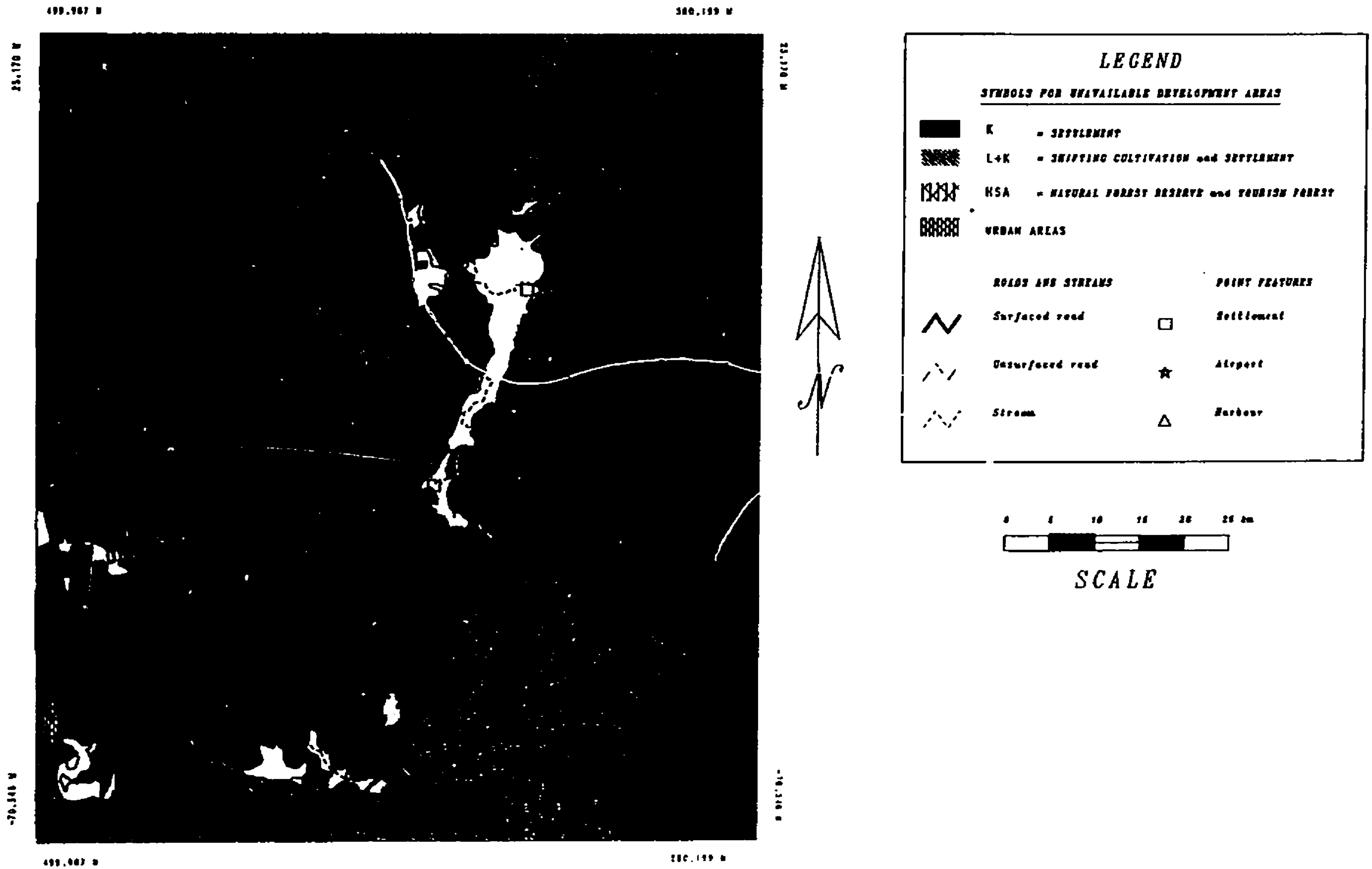


Figure 7.8. Available Development Areas for Samarinda, Muara Badak and Bontang



economic benefits that may be gained through pasture or agroforestry are generally much lower than those from tambak production on such a land system (interviews with the Head of Dept. Agriculture in Muara Jawa sub-district, 1989).

Wetland or dryland rice cultivation can be developed on BLI, KHY, and LWW land systems (see the Table on Figure 7.2). As wetland rice cultivation requires more water supply than dryland rice, the choice between these two may be determined from the availability and accessibility of water within these land systems. There is a possibility that wetland and dryland rice cultivation occurs on one land system polygon. In such a case, wetland rice may be located closer to water sources (e.g. rivers and streams) while dryland rice is placed further upland.

Besides wetland and dryland rice, the KHY land system is also suitable for maize, soyabean, oil palm, banana, sugarcane, agroforestry, pasture, and tambak. In this case, multiple land use (a condition in which more than one type of development activity is carried out simultaneously on the same land system polygon) can be developed. The KHY land system polygons that are located near the coastline, for instance, may be developed for tambak, wetland rice, and dryland rice on an ascending order from the coastline further upland. In the meantime, maize, soyabean, banana, pasture, and agroforestry (*Leucaena leucochepala*) may be planted with wetland or dryland rice in as a mixed-farming system or a rotational planting system.

Oil palm and sugarcane are not recommended to be developed on the KHY land system because in order to be economically and technically feasible, the development of these two cash crops needs a large area of at least 15,000 ha (LRDC/Bina Program, 1987 and interviews with the Head of Department of Agriculture of East Kalimantan Province, 1990). Within these two sub-study areas, the largest KHY land system area is 12,535 ha that is located along the coastal fringe between Muara Badak and Bontang (see Figure 7.3).

Cocoa and rubber, from the biophysical suitability perspective, can only be planted on the TWB land system. The TWB is also suitable for oil palm, coconut, and quarrying. Since these five development activities all have the same suitability level, again the actual choice between these uses also depends on socio-economic and political factors. For the actual choice between those four kinds of crops, more detailed information on essential biophysical factors such as soil characteristics, topography, micro-climate, vegetation, and water availability will help the planner to make the best choice.

Oil palm has a suitability level of S_2 on BKN and MGH land systems. However, the largest of the BKN land system polygons in the two sub-study areas is 2,031 ha, and for the MGH land system polygons is 2,017 ha. Hence, the large-scale development of oil palm on these two land systems may not be feasible. Another alternative is growing oil palm on KHY and TWB land systems which have suitability level of S_3. The largest of KHY and TWB land system polygons in the sub-study area I (Muara Jawa, Anggana and Samarinda) is 6,966 ha and 5,753 ha respectively, while in the sub-study area II (Samarinda, Muara Badak, and Bontang) the largest are 12,535 ha and 3,850 ha respectively. The largest available of TWB and KHY land system polygons occur side by side in the sub-study area I (see Figure 7.2 and 7.7) and such a coincidence, therefore, provides an opportunity for large-scale development of oil palm estate in the area. Interestingly, a part of the KHY land systems in Tanjung Santan area (the sub-study area II) has been used for an oil palm nucleus estate during the last four years (field observation, 1990).

Sugarcane has a suitability level of S_3 on five land systems, namely BKN, KHY, LWW, MGH, and TNJ. The best possible site for a large-scale development of sugarcane estate is on the largest LWW land system polygon just beside the natural forest reserve in the sub-study area II (see Figure 7.3 and 7.8).

A coconut estate has been located on the KHY land system, which is unsuitable according to the current suitability classification (see Figure 7.7 and 7.2). The major limitation making the KHY land system unsuitable for coconut cultivation is its soil drainage class. For a land system to have a suitability level of S_3 (poorly suitable) for coconut cultivation, it must have a soil drainage class of 5 (somewhat poorly drained) or 1 (excessively drained) (see Appendix 3.2). On the other hand, the KHY land system has a soil drainage class of 6 (poorly drained) (see Appendix 3.5).

The quality of drainage could be the result of two factors. First, the drainage condition of such a land system has been improved to the level required by coconut. Indeed, local people have been continuously using the KHY land system in the sub-study area for decades, and along the road they have improved its drainage condition (interviews with several coconut farmers in Muara Jawa and the Head of Dept. Agriculture in Muara Jawa sub-district, 1990). Second, because the biophysical data of land systems and the biophysical requirements for development activities are collected and established by different agencies, an inadvertent error in classification may easily occur.

Having delineated proposed development areas, which are based primarily on the biophysical suitability and spatial availability for a variety of development activities, the next inquiry required by any practical regional planning (coastal resource management) is how to execute a sequence (phasing, priority scale) among various land systems (spatial units) for a certain development activity. This can be approached by considering the accessibility for supporting services and transport networks within a given land system. According to LRDC/Bina Program (1987), supporting services include distributive services for production inputs and consumer goods, trade (market) services, financial services (credit), and extension services. The transpo_t network constitutes roads and, possibly, navigable streams (rivers).

On the suitability maps (Figures 7.2 through 7.6), supporting services are represented by the number of settlements, while transport network is by the length of roads. Furthermore, information regarding the availability of roads and settlements within a land system is presented on their associated tabular information (table). Accordingly, land systems in Muara Jawa, Anggana, and Samarinda areas, which will have higher priority for a given suitable development activity, are TWH, KHY, MTL, MPT, and LHI (Figure 7.2). For land systems in Samarinda, Muara Badak, and Bontang areas that will be prioritized for a given suitable development activity are PTG, PDH, MPT, LWW, MTL, and BRH (Figure 7.3).

To sum up, as there are a limited number of land systems suitable and available in a large area (more than 15,000 ha), except for sugarcane and oil palm, the successful food and cash (estate) crops production will rely, as it does now, on small-scale holders who have been able to cultivate smaller land systems and provide additional irrigation. Although some land system polygons (i.e. KHY and KJP) suitable for tambak development exist for large areas, because of the presence of oil and gas production activities and ecological considerations, the best possible future for tambak is also in the form of small-scale development.

7.4. THE STRENGTHS AND WEAKNESSES OF THE SPATIAL PLANNING FRAMEWORK USING GIS FOR COASTAL RESOURCE MANAGEMENT

An attempt to establish spatial planning for the coastal zone through the suitability classification of coastal space, the identification of potential and existing spatial use conflicts, and the identification of available development areas, as described above, reveals both the advantages and disadvantages of using GIS technology in such a management task.

7.4.1. Advantages

(1) Accurate and Rapid Data Analysis

Most decisions in the development and management of coastal resources must be made on a timely basis. The dynamic nature of the coastal ecosystem itself (Chapter II), as well as the planning and decision-making environment within both government and private agencies, normally require a quick decision-making process. Thus, the accurate and rapid analysis of diverse natural resource data sets, which is a typical feature of coastal resource management tasks, has been perceived as a prerequisite for more effective planning.

The spatial planning for the coastal zone, such as the one in this study, has been based essentially on the suitability map and the available development area map. The suitability map was generated by matching the biophysical characteristics of land systems against biophysical requirements of development activities, and then each land system was assigned a suitability class for those development activities. The available development area was derived by overlaying the suitability, the present land use, and forest status maps.

Conventionally, such an overlay was conducted by superimposing transparent copies (e.g. mylar) of the various maps at the same scale so that they can present the areas of coincidence which can be plotted to produce a new composite map (McHarg, 1969). The conversion of diverse data sets into maps of similar scale and the delineation of the areas that meet the criteria, however, has been proven not only tedious and time-consuming but also highly susceptible to errors (Aronoff, 1989; Subaryono, 1990). Furthermore, as the number of map layers and criteria increased, a practical limit was quickly reached.

Once the data have been inputed into a GIS database and the required criteria have been specifically defined, such an overlay task can be generated by a GIS (e.g. ARC/INFO or SPANS) in a matter of hours. In addition, the GIS provides a more accurate way of deriving information on the area of land systems suitable for each development activity.

(2) Powerful and Convenient Database Management System

One of the major stumbling blocks faced by planners and decision-makers in the arena of coastal resource management is a lack of relevant information on which decisions are based. Three typical conditions have caused such a problem.

First, data sets are dispersed among many agencies and/or locations, often not in a desired format and difficult to access. For example, data about soil properties are held by the Soil Research Institute, mangrove information in the hand of the Department of Forestry and Directorate General of Fisheries, and water quantity and quality data are held by the Department of Public Works. On the other hand, most management decisions (e.g. creating spatial planning, and the maximum area of a mangrove forest that can be cleared for other uses) need all data sets to be integrated on a timely basis.

Second, optimal decisions on management and development of coastal resources frequently require information on a time series basis. Yet, most existing data and information are not available in the time frame required by planners and decision makers. To determine optimal spatial planning of a coastal zone, one needs to know, for instance, the relationship between the changes in spatial use of the coastal zone versus the productivity of each resource use as well as the quality of coastal water over time. Apart from the weaknesses of data collection, the lack of time series data is also a result of the existing manual data handling that negates the storage of large amounts of data over a long period of time. Unfortunately, due to space constraints, documents, maps or reports containing data older than 5 years are usually thrown away.

Third, many resource data, such as that for coastal land use, coastline dynamics, productivity of tambak and wetland rice, and concentrations of pollutants in the coastal water, are changing rapidly. Consequently, information derived from such data will quickly become outdated.

Under a manual information management system, it would be impossible, as it is now, to provide relevant and timely information to aid coastal planners and decision makers under such circumstances. Standard GIS technology is able to overcome such information management problems in several ways.

It can quickly incorporate data of various types and from various sources, like aerial photography, satellite imagery, and conventional maps of different scales. GIS are integrative because they can take data of different types in different formats from different sources. These data are transformed into a consistent internal format and scale within the GIS (Pheng and Kam, 1989). This means that when more accurate data become available, the resulting database can easily be updated and expanded to provide more relevant information. The GIS also has an ability to store, manipulate, analyze, and display data of various types (biophysical, socio-economic, and cultural) pertaining to the coastal zone in an integrated and comprehensive manner in any format desired by users. Such an ability has been made possible with the relational database management built into most standard GIS.

The ability to rapidly update the database combined with the fast and cheap production of maps and their associated descriptive data (e.g. in the form of tables) means that a hard copy map can be used as a snapshot of a continuously changing resource database (Aronoff, 1989). Because re-analyzing the data is relatively rapid and inexpensive, complex planning scenarios can be progressively refined by re-analyzing the plan to assess proposed changes. Planners and decision makers can propose various alternative plans and assess each outcome by re-running the analysis and comparing the results. This iterative approach would be prohibitively expensive with manual methods.

The storage of data in digital format combined with the power of the relational database allows the GIS the capability of storing data in very large quantities and over a longer period of time, which is impossible for any manual database management systems.

Thus, once better data and information related to marine (water) and socio-economic aspects of the coastal zone under study are available, more integrated and comprehensive spatial planning of it could easily be created. With GIS technology, the creation of a suitability map for all development activities is also possible once the biophysical requirements of them are clearly defined and the biophysical characteristics of the coastal space required are available.

(3) A Flexible, Dynamic, and Informative Presentation of the Results

The presentation of any planning scenario of natural resource development which relate to spatial aspects would be cumbersome and tend to be biased if it was in the form of a descriptive report. Thus, a map is usually used in the spatial planning of the resource development of a particular region because it is a more informative way of describing objects related to geographical areas. Maps convey information easily and readily to the reader (ESRI, 1990). On a physical (conventional) map, geographic (resource) data were represented as points, lines, and polygons (areas) depicted on a piece of paper or film. They were coded using symbols, textures, and colours that were explained in the map legend or accompanying text. The map and its documentation constitute the geographic database.

However, according to Aronoff (1989) and ESRI (1989), conventional maps have a number of limitations. The data used to make the map usually have to be aggregated (i.e. the data must be presented in less detail) for the map to be legible. Areas that are large relative to the map scale have to be represented by a series of maps. Problems arise when maps do not match correctly at the edges and areas of interest extend across map edges. While it was relatively easy to store and retrieve small amounts of data or to calculate the spatial relationships of a few elements, the physical map became unwieldy when a large volume of data was involved. Finally, updating a map can be an expensive and time-consuming procedure. For changes to be made, the master films of the map sheets must be manually edited and the map reprinted. Consequently, a physical map is a relatively static document.

All these impediments can essentially be resolved, however, through the use of GIS. The GIS can store and manipulate a large and diverse number of data sets in a computer. Once maps are in the computer, the users can manipulate, analyze, and display geographic (natural resource) information at a speed with a number of options not otherwise possible. The suitability maps produced in this study, for example, would be extremely unintelligible if all thirteen biophysical characteristics of each land system were to be displayed on the physical map. In the GIS, with the power of its relational database, such a task is handled easily because only spatial data (points, lines, and polygons) are displayed on the map while their associated descriptive data are stored within the GIS' database (or INFO in the ARC/INFO GIS, and dBASE IV in the SPANS GIS) in tabular forms.

The representation of data on the table is easy to understand because it is the same as a conventional table in which data items and records are displayed in columns and rows respectively. Depending on the power (Random Access Memory or RAM) of the computer being used, several tables containing descriptive data can be linked to one another and to their associated spatial data on the map as far as they have a common item, which in this study is land system codes (Figure 3.2). The RELATE command under INFO, for example, is used to establish the relation between INFO data files. Once related files are created, items from either the selected file or one of the related files can be used.

The maps produced by the GIS are as informative as the physical map produced manually. In this study, for instance, each land system was colour shaded according to its suitability for the various development activities being analyzed. This process was done by creating a look-up table and MAP COMPOSITION in the ARCPLOT sub-system. The look-up table is an independent file within INFO. It stores items that have relatively fixed values. MAP COMPOSITION is an interactive method allowing the user to manipulate map elements which can be moved, scaled and altered according to the user's specification.

7.4.2. DISADVANTAGES

Despite the usefulness of the GIS for planning and managing of coastal resources, there are some practical and philosophical problems associated with it.

(1) Inherent Errors of Data Sources and their Conversion

Data consisting of biophysical characteristics of land systems and biophysical requirements of each development activity used in this study came from two different agencies. They exist in a different format and occasionally with different definitions. For example, dry months in the data file of the biophysical characteristics of land systems are defined by LRDC/Bina Program (1987) as those months that have average rainfall of less than 100 mm, while the CSR/FAO (1983) in the biophysical requirements of development activities defined it as those months with the average rainfall of less than 75 mm.

Seven out of thirteen of the biophysical characteristic data of land systems, such as annual mean temperature, mean annual rainfall, and slope, are presented as a range (Appendix 3.4 and 3.5), while most of biophysical requirements of development activities are required in a range. This caused great difficulties in conducting the matching process between these two sets of data with INFO conditional checking commands to arrive at the suitability classification. To carry out such a matching process using the INFO conditional checking command requires the biophysical data in the form of a single (point) value. Consequently, the suitability classification produced in this study was done manually by the author, which might be less objective than if it could have been done through the INFO conditional checking command.

Another practical problem arose while entering the data sources to the GIS. Because data sources exist in physical maps (for land systems, present land use, and forest status, and base maps), the data input was carried out by manual digitizing using a digitizer. Because of computer and operator limitations, such an operation is error-prone and needed a substantial amount of time and resources to trace and edit these errors.

The philosophical problem with the result of the spatial planning analysis of the study was the lack of input data. As indicated earlier, the spatial planning of the coastal zone should have included the allocation of uses for both land and water sides of the coastal zone. Until now, there has been no comprehensive and accurate data on the marine aspects of the coastal zone with geographical references. Most water quality and other oceanographic measurements (e.g. current and tides) conducted through EIA studies were on a snapshot basis and without georeferences. This condition makes any serious spatial analysis of the coastal water virtually impossible at the present time. Even the geographical distribution of one of the most critical coastal ecosystems, the coral reef, is still unknown.

The shortage of biodiversity data in terms of the spatial distribution, the extent, and the amount of species, habitats and their functional processes (ecosystems) also reduced the usefulness of any spatial planning for sustainable development. As Lovejoy (1986) argues that failure to conserve biological diversity is dangerous not only in ecological but also in human terms. Biological diversity is closely linked to the welfare of human inhabitants, because it is a storage of myriad essential human needs ranging from agricultural to pharmaceutical purposes.

(2) Expensive and Demanding Information Management System

Although the use of GIS in planning and management of coastal resources is technologically feasible, the acquisition and development of new tools like the GIS in the management system is prohibitively expensive, and there is a shortage of trained personnel to operate it. In addition, since the GIS technology is being improved constantly, users must also keep up with newer versions of the technology. This may pose difficulties for developing countries which can not afford capital intensive technology. Furthermore, the GIS technology can become an end in itself in developing countries except when people are properly trained and have a broad enough perspective to apply such a technology to the real-world problem.

(3) Overestimation of the Utility of GIS Products

The use of the GIS in planning and management of coastal resources may cause additional problems by creating false perceptions regarding the quality of the results. Instead of considering the GIS as only a planning tool that has to be supported by thoughtfulness and caution concerning the scope of use, scale of design and ultimate outputs, users may regard a sophisticated tool, such as GIS, as a panacea for the management of coastal resources.

7.5. GIS APPLICATIONS FOR COASTAL SPATIAL PLANNING

One of four basic ecological requirements for sustainable development (see Chapter II), as it is used as one of the hypotheses (operating assumptions) in this dissertation, is spatial planning (suitability) for development activities within the coastal zone. In other words, sustainable development of the coastal zone can only be achieved if all development activities therein are located on sites (spatial units) that are biophysically suitable for these activities.

Compared to the land-based (terrestrial) spatial planning, spatial planning for the coastal zone is much more complicated, at least in three reasons. First, coastal spatial planning should include both land-based and marine-based components. Second, these two components are not separated to one another by the physical boundary of coastline. They are interacting on a continuous and dynamic basis through a host of physical and biogeochemical processes. Third, the landscape (geomorphology and physiography) of the coastal zone changes faster than that of terrestrial ecosystems as a result of dynamic interactions between land and sea components as well as influences of upland ecosystems.

Considering these three characteristics of the coastal zone, it is not surprising that the spatial planning for the Kutai and Samarinda coastal zone, proposed in this dissertation based upon the best available information, contains several weaknesses. However, this is due mainly to a lack of data and information, particularly for marine-based and socio-economic aspects.

This section provides some thoughts for developing spatial planning of coastal zone using GIS technology. In particular, it identifies data and information needed for the analysis of coastal planning, and suggests some approaches in resolving disadvantages of GIS for coastal spatial planning (as described in the previous section) with special reference for the context of developing countries.

To be more effective and rational, coastal spatial planning should be developed based on a hierarchial approach. At the first level, the coastal zone can be classified into three zones: developed, conservation, and preservation zones as proposed by Odum (1976). The developed (fabricated) zone includes cities, industrial sites, and transportation corridors like airports, roads, and railways. The conservation (cultivated) zone includes agricultural lands, artificial lakes and ponds (tambak and coastal cage nets), and managed woodlands and forests (mangroves). The preservation (natural) zone include natural landscapes such as forests, rivers, estuaries, coral reefs, lakes, and seas (Odum, 1989). The next level is to categorize these three zones into a finer classification as it was done in this Chapter, namely the allocation of spatial units into various development activities.

This approach is crucial for sustainable development of the coastal zone due to the following reasons. Although developed zones (e.g. Samarinda and Bontang cities) cover a small area of the total landscape of the coastal zone, they require so much energy and generate so much waste heat and pollution and, thereby, they have an enormous impact on the other two zones. When the fuel energy subsidized to the cultivated zone increases, such as through intensive aquaculture and agriculture, this zone will also exert considerable impacts on the other two zones due to soil, water, fertilizer, pesticide and organic runoffs. The only "self-supporting" and "self-maintaining" zone, which operates itself without energetic or economic flows directly controlled by humans, is the preservation zone. Natural systems within this zone function as both the waste treatment plant of myriads pollutants from the other two zones and the supplier of natural goods and services needed by systems within the other two zones. Thus, from the standpoint of energy use, sustainable functions of a regional unit (coastal zone) as a total ecosystem requires the maintenance of those three zones on a certain proportion.

Because of the fluid nature and connectivity of marine ecosystems (see Chapter II) as well as the difficulty in establishing detailed biophysical criteria for development activities on the marine environment, the spatial planning of the marine side of the coastal zone should be sufficient if it contains three zones of the first hierarchy. This zonation scheme should also consider land uses (based upon finer suitability classification) adjacent to marine ecosystems as well as their impacts on the marine environment.

Based upon the above considerations, data and information required for establishing coastal spatial planning include seven major categories: (1) critical ecosystems and processes, (2) natural resources and biodiversity of both marine and terrestrial systems, (3) biophysical characteristics of land systems, (4) biophysical characteristics of marine systems, (5) biophysical requirements of development activities (resource uses), (6) socioeconomic and cultural data, and (7) political and administrative boundaries. A detailed account for this information need is presented in Table 7.6.

Having identified the data and information need, the next step is to organize and manage them within a GIS framework so that they can be used by users (decision makers, planners, and

Table 7.6. Data and Information Requirements for Coastal Spatial Planning.

Category	Types of data and information
A. Critical Ecosystems and processes.	- The condition, extent and distribution of coral reefs, seagrass beds, mangroves, estuaries, and spawning and nursery grounds; - Upwellings, front areas, migratory routes, and ecological boundaries.
B. Natural resources and biodiversity of marine and terrestrial environments.	- The condition, extent, and distribution major fish, crustacea and mollusc species; - Marine mammals, and coastal and marine birds; - The condition, extent and distribution of major terrestrial animal and plant species, particularly protected species.
C. Biophysical characteristics of marine ecosystems.	- current; tidal patterns; major water properties (e.g. salinity and density, temperature, and nutrients); wave and wind condition, primary and secondary productivity, bathometry, marine physiography, geology, and bottom sediment.
D. Biophysical characteristics of terrestrial ecosystems.	- physiography, soil conditions (properties), drainage pattern and hydrology, climate type, vegetation formation, etc.
E. Biophysical requirements for development activities.	- Actual development activities, e.g. oil and gas exploitation both onshore and offshore, settlements, industrial activities, and agricultural activities; - Potential development activities, e.g. ecotourism, marine aquaculture, marine park, ceramics and glass industries, Nipa palm utilization, and home industries.
F. Socioeconomic and cultural aspects.	- Land and sea uses; - Resource ownership; - Demographic data; - Community-based management systems.
G. Political and administrative boundaries.	- Provincial, district, subdistrict, and village boundaries; - International and resources (e.g. fisheries) boundaries.

other stakeholder) in a useable format, reliable, and on a timely basis. To be able to develop such an information management system for coastal spatial planning, two major considerations: the specification of user needs, and control of data quality.

An initial design framework for developing the information management system for coastal spatial planning requires the identification and analysis of user needs, i.e. information needed for planning and decision-making processes (Ricketts, 1991). This step is important to ensure that data are available format for analyses required by all users. The difference in format between data of several biophysical characteristics and requirements used in this study (see the previous section) is a good example of the importance of this step. The identification of user needs is also important for optimizing the future use of such a database management system.

It is noteworthy that GIS is only an analytical tool, it can not improve the quality and reliability of data. The quality of information provided by the database management system using GIS thus depends on the quality of data inputted into the system. It is very much the case that "garbage in garbage out". Accordingly, procedures for an evaluation of the quality and reliability of input data should be established. Roberts and Ricketts (1990) emphasized that it is important that the GIS process does not become a data scavenger with no control on data quality.

The provision of such information demands a considerable degree of cooperation and interactions between users, i.e. departments and agencies at all levels of government, academic and research institutions, and the private sectors (Ricketts, 1991). Finally, it may be more appropriate for such countries to use cheaper, albeit more limited GIS packages that are becoming more available commercially.

VIII. A MULTIPLE-RESOURCE USE MODEL OF THE COASTAL ZONE

8.1. INTRODUCTION

A coastal zone is a typical multiple-use natural environment providing a variety of goods and services to human beings. Some of these goods (e.g. oil and gas, fish and mangrove wood) and services (e.g. recreational values of beautiful beaches) are tangible and marketable. Others, such as nutrient flows, waste reception, and land stabilization functions are less tangible, and it is difficult, if not impossible, to quantify them monetarily. Biophysical interdependencies among the system's components abound in the coastal zone. A resource use that causes a change in one component of a certain ecosystem frequently affects other resource uses either within such an ecosystem or in other ecosystems.

Due to the above economic and biophysical complexities, economists and decision-makers have not been particularly successful in applying conventional economic principles to optimal decisions on sustainable, multiple uses of natural resources including the coastal zone. It is, therefore, not surprising that most decisions involving coastal resource uses are made on the basis of "intuitive decision-making processes". This does not mean that such management approaches are bad in themselves. They are appropriate only for simple environmental and resource management cases where the manager (decision-maker) has a full knowledge of the behavior and performance of the system under consideration. As the size and complexities involving various interactions, trade-offs, and uncertainties increase, more systematic and rational approaches are needed.

To this end, applications of systems analysis techniques have been successful in many environmental and resource management problems in assisting planners and decision-makers to arrive at optimal decisions (e.g. Jeffers, 1978 ; ESCAP, 1980; Dykstra, 1983; Braat and van Lierop, 1987; and Biswas, 1990). Contrary to the common perception, systems analysis is not a mathematical technique, nor even a group of mathematical techniques. In this context, systems analysis is defined as a holistic research strategy that involves the use of mathematical techniques and concepts, but in a systematic, scientific approach to the solution of complex problems (Jeffers, 1978). In other words, it is the orderly and logical organization of data and information into models, followed by the rigorous testing and exploration of these models necessary for their validation and improvement.

This study essentially employs systems analysis techniques right from the problem definition (Chapter III), spatial planning analysis (Chapter VII), a multiple-use model (Chapter VIII), to the implementation of the study results for designing an integrated coastal resource management plan for the coastal zone under consideration (Chapter IX). Once a proper spatial planning of the coastal zone has been established (Chapter VII), the next planning step is to determine an optimal rate of each development activity that has been planned spatially.

8.2. A DESCRIPTION OF THE MODEL

Development activities that have been arranged spatially based upon the spatial planning (Chapter VII) generally exert impacts on one another through labor (employment) flows, economic benefit flows, and wastes (residuals) they produced. For coastal resource development to be sustainable, therefore, a full understanding of these cross-sectoral impacts on both environmental quality (coastal ecosystem's response and performance) and sectoral development activities has to be acquired. Then, based upon this knowledge, a model that permits planners and decision-makers to determine an optimal rate of each development activity involved could be created.

There is a variety of models that can be built to approach such a management challenge, ranging from mathematical programming to simulation models. Furthermore, the complexity of models also varies from simple to very complicated. Indeed, choosing the right balance between complexity and simplification, while retaining sufficient relationships to the real problem for the analytical solutions to be recognizably appropriate, will almost certainly determine the success and failure of the modelling work (Jeffers, 1978 and High Performance Systems, 1990).

Since a model is essentially an abstraction of an object or phenomenon that exists in the real world system, it should not be as complete as the real world situation. A good model is the simplest that correctly and consistently predicts the behavior of the real world for the phenomena of interest. Models are used to deepen the human understanding of a real world system, or to predict how certain aspects of the real-world system will behave if there is a human impact on it (Mann, 1982; Aronoff, 1989). They assemble the relationships among the system's components in order to predict how events in the real world will occur. Therefore, a good model should represent all important components of the system and their relationships so that it will correctly provide answers to the problems defined by the user.

Based upon the above guidance, the following ecological-economic model, to determine an optimal rate of some development activities in the coastal zone under study, was proposed (Figure 8.1). An optimal rate, as mentioned in Section 3.6, means that a development activity should be not only socio-economically beneficial but also environmentally safe, in the sense that its waste generation must not exceed the assimilative capacity of the receiving environment and its habitat displacement (e.g. the removal of mangroves and coral reefs by the oil and gas development) is "environmentally tolerable".

The model consists of three submodels: economic, ecological, and resource-damage assessment submodels. The economic submodel represents the dynamic of total profit, the discharge rate of pollutants (i.e. oil, thermal, ammonia, and BOD), and the degradation of mangroves as a function of the level of production of four major development activities, which are assumed to have significant economic and ecological impacts on the region within at least 25 years (the simulation time used in this modelling work). The ecological submodel simulates the fate of these pollutants in the receiving coastal water, in terms of their concentration over time and space. The resource-damage assessment (RDA) submodel simulates the associated measure of economic losses due to ecological damage as a result of the above coastal water pollution and mangrove degradation. These economic losses are used as a feedback to the economic submodel.

In principle, each activity produces benefits for human welfare (social benefits) in the form of "private" (production) profit and employment opportunities. At the same time, each of them also produces waste and, in one way or another, causes deterioration of spatial habitats of the coastal zone, particularly mangroves.

The presence of development activities in a given region (coastal zone) attracts people. As the population in the region grows, its spatial needs (for settlement and other infrastructures) and its waste generation will also increase. These spatial needs and waste generated by the population, as indirect negative impacts of development activities on the environment, will be included in the model in the form of mangrove displacement and organic waste discharge.

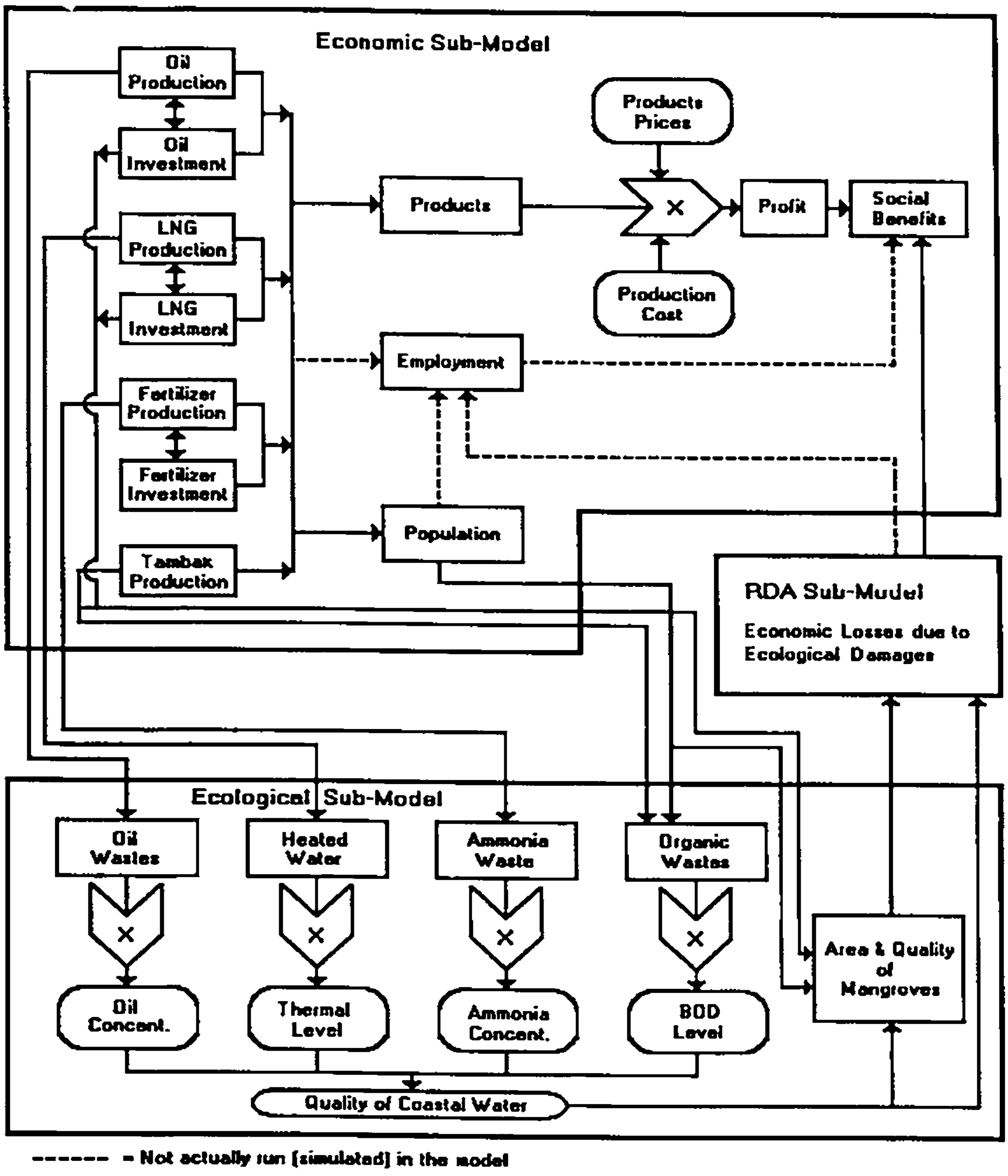


Figure 8.1. A Management Model for Sustainable Utilization of Coastal Resources

If economic development in the region is to be sustainable, then this environmental degradation should be kept within the capacity of the coastal environment to accommodate these burdens while maintaining the profitability of those development activities.

The discharge of wastes into coastal water and mangrove degradation will be an input to the ecological submodel. This submodel, which is basically the physical fates model of wastes in the coastal water, provides an estimate (prediction) of the concentration of each waste generated by each activity (i.e. oil, thermal, ammonia, and BOD) and its affected area over time with respect to the source strength (discharge rate) of each waste. In this case, the affected area is defined as the area of coastal water in which the concentration of one or more of these wastes exceeds the environmental standard concentration stipulated by the environmental regulation. Since this discharge rate is a function of the level of each development activity, the concentration of wastes and the affected area can be used as an indicator of sustainable development.

It is assumed that sustainable development of these four activities may be achieved when they produce positive net social benefits while generating wastes at levels below the allowable environmental standards. One of the difficulties of this policy approach is that the environmental standard does not prescribe the extent of the affected area.

As an alternative approach, attempts may be made to place monetary values on environmental degradation (i.e. coastal water pollution, and the degradation of area and quality of mangroves). This value of environmental degradation (economic losses due to ecological damage) will, then, be used as a feedback to the economic submodel that reduces the social benefit generated by development activities.

Environmental degradation may also indirectly reduce the employment opportunities through, among others, the closure of fishing grounds and the loss of mangrove's traditional uses. Unfortunately, due to a lack of data and technical difficulties (time and research resources), the employment component and its relationships to other components (represented by dotted lines in Figure 8.1) were not simulated in the present model.

8.3. THE ECOLOGICAL SUBMODEL

8.3.1. Purpose

The ecological submodel is basically a preliminary evaluation of environmental impacts (in the form of coastal water quality and mangrove degradation) as side-effects of the above four development activities through their steady-state effluent discharges as well as the removal and destruction of mangroves.

These environmental impacts along approximately a 150 km length of coast (between Muara Jawa and Lhok Tuan) constitute economic feedbacks that will be incorporated into the economic submodel. The first step in this process is to evaluate the magnitude of the loads with respect to the quantity and required quality of the coastal water as stipulated in the existing environmental regulation. Since little data on water properties, current, and bathymetry of the coastal water are available, only crude estimates of the potential impacts are possible at present.

In spite of this, it may be possible to identify the relative importance of the various effluent discharges, and formulate analytical expressions for the extent of the physical impacts. These expressions should provide a preliminary basis on which to evaluate the potential economic effects due to environmental degradation generated by deleterious activities associated with economic development in the coastal zone.

8.3.2. **The Analytical Approach**

For discharges (especially point discharges) near the shore, even the simplest analysis requires separate treatment of near-field and far-field processes. Near-field initial mixing results in dilution of effluent over short time scales (seconds to hours) while far-field processes operate on longer time scales and typically mix effluent over larger distances. The potential effect of processes on these scales may be assessed by assuming that effluent streams undergo an initial dilution typical of coastal discharges and then allowing the resulting effluent "cloud" to advect and diffuse in a manner consistent with larger scale processes.

This two stage process is modelled analytically by assuming a simple geometry and uniform along-shore current as inputs to a advection-diffusion balance (steady-state) of annual mean loads. The coast is assumed to be straight and depths uniform in the along-shore direction.

The following routine, written with the assistance of Mr. Mark Mac Neil's expertise (ASA Consulting Ltd., Dartmouth, N.S., Canada) using the METLAB programming language, is used to simulate the temporal and spatial distribution of the concentration of a typical pollutant (as a representative for oil, thermal, ammonia, and BOD that are modelled in this simulation) as a function of the discharge rate of pollutants:

```
%%%%%%% CONSTANTS

C0=1;                      % Normalized concentration
STEP=600;                  % Time step in seconds
V=10;                      % Volume discharge rate in
                             cubic metres per second
Tv=V*STEP;                 % Total volume flow during step
d=1;                       % Layer depth in metres
a=sqrt(2*Tv/pi/d)          % Initial radius after STEP
D=0.5;                     %   Diffusion   coefficient   in
                            -metres*metres/second (Okubo,1971)
U=0.1;                     % Drift velocity in metres/second
down_str_bdy=20000;         % Down stream boundary (metres from
                             the source)


%%%%%%% INDEPENDENT VARIABLES
x=-5000:200:20000;          % Along-shore grid spacing in metres
y=0:200:2000;              % Offshore (cross-shore) grid spacing in
                             metres


%%%%%%% INITIALIZE VARIABLES AND BEGIN LOOP
Ctot=zeros(y'*x)                     %   Initialize   cumulative
                                       effects to zero
for t=STEP:STEP:1.5*down_str_bdy/U     % Run length allows
                                         centre of initial
                                         cloud to advect
                                         beyond  down  stream
                                         boundary
```

```
%%%%%%% COMPUTE C(x,y,t);    % based on Csanady (1973)

E=sqrt(4*D*t);
x_prime=x-U*t;

C=C0/4*(erf((a/2-y)/E)+erf((a/2+y/E)).'*..
      (erf((a/2-x_prime)/E)+erf((a/2+x_prime)/E));
C=flipud(C);
Ctot=Ctot+C;                % Sum cumulative effects of all
                              clouds
end                         % End loop
```

The calculation in the routine was based on the assumed normalized concentration of a conservative pollutant from a point source in a uniform along-shore current, constant depth layer on a straight coast. Accordingly, the result of this analytical simulation can be applied for four types of waste (oil, thermal, ammonia, and BOD). In the formulation of the routine, the effects of initial cloud size was included, but this does not affect the result appreciably. Thus, the results (in the form of concentration of waste in the coastal water and the affected areas) can be scaled to the discharge rate, as can be seen from Table 8.3 and Figures 8.2 to 8.4.

8.3.3. Waste Loads and Water Quality Objectives

Four development activities (i.e. oil production, LNG production, fertilizer production, and tambak production) are currently exerting negative environmental impacts on the coastal ecosystem under study. These negative environmental impacts are in the form of physical displacement of mangrove areas and the generation of wastes by these activities. In addition, the population through its domestic activities also generates wastes, particularly organic wastes (reflected as the BOD-5 load), that could cause deterioration of the quality and sustainable capacity of the coastal ecosystem under consideration.

The load of wastes on the coastal water as a result of those activities is listed in Table 8.1. While oil wastes, heated water, and NH_3-N are coming out from point-source discharges, BOD-5 originates from non-point source discharges. The value of concentration of waste loads listed on Table 8.1 is the average value.

Ambient standards of the above four water quality parameters for marine organisms (fisheries), to which this portion of the coastal water of East Kalimantan province allocated for, are listed in Table 8.2.

Table 8.1 The Load of Wastes generated by Four Development Activities and the Population.

Activities	Waste Types	Load	
		Concentration	Discharge
1. Oil Production	Oil Waste	50 ppm	0.55 m^3/s
2. LNG Production	Thermal	45°C	23.30 m^3/s
3. Fertilizer	NH_3-N	400 ppm	0.61 m^3/s
4. Tambak	BOD-5	200 ppm	7.75 m^3/s
5. Population	BOD-5	250 ppm	1.16 m^3/s

Sources:
- Total (1989), Huffco (1989), and UNOCAL (1989) for oil;
- Universitas Mulawarman (1983) for LNG;
- SEATEC (1990) for fertilizer;
- Twilley (1989) and field observation (1990) for BOD of tambak;
- NAS (1970) and ENCONA Engineering (1983) for BOD of the population.

Table 8.2 The Environmental Concentration Standard of Four Water Quality Parameters for Maritime Organisms.

Parameter	Unit	Critical values		Sources of information
		Allowable	Desired	
1. Oil	ppm	≤ 5.0	≤ 0.0	Governor Decree
2. Ammonia	ppm	≤ 1.0	≤ 0.3	Governor Decree
3. Temperature change	°C	≤ 5.0	≤ 0.0	Zieman & Wood (1975)
4. BOD-5	ppm	≤ 45	≤ 25	Governor Decree

Note: Governor Decree of East Kalimantan Province No. 339/1988 concerning Environmental Standard in the Province of East Kalimantan.

8.3.4. Results

The ecological submodel runs three scenario of the discharge rate: (1) 0.1 cubic metre/second, (2) 1.0 cubic metre/second, and (3) 10.0 cubic metre/second. Contours of the normalized concentration of a pollutant and its spatial distribution resulted from these three runs are presented in Table 8.3 and Figure 8.2, 8.3, and 8.4. As the normalized concentration of a pollutant (C_0) in the submodel routine is equal to 1 (unity), concentration values of the normalized pollutant in Table 8.3 and Figures 8.2 to 8.4 are also unitless. The normalized concentration has a scale from 0 to 1. The highest value (= 1) is the same as the concentration of a given pollutant in its outflow, while the lowest value (= 0) is normally the concentration of such a pollutant in the coastal water at the furthest distance from the outflow.

Table 8.3 also contains contours of concentration values of five pollutant types (oil, thermal, ammonia, BOD-T, and BOD-P) based upon contours of concentration values of the normalized pollutant under three different discharge rates. Concentration values of these pollutants in Table 8.3 are derived from the multiplication of concentration values of the normalized pollutant and the initial concentration of each pollutant in the outflow (see Table 8.1).

Table 8.3. Concentration of Various Pollutants on Three Contour Lines and Within Three Contour Areas Under Three Discharge Rates.

Discharge Rate in m^3/s	Concentration **)					
	Contour - 1 Area= 64 ha		Contour - 2 Area= 100 ha		Contour - 3 Area= 294 ha	
	Contour	Mean	Contour	Mean	Contour	Mean
A. Normalized pollutant*)						
0.1	0.001	0.0018	0.0008	0.0014	0.0006	0.00095
1.0	0.010	0.0180	0.0080	0.0140	0.0060	0.00950
10.0	0.100	0.1700	0.0800	0.1400	0.0600	0.09400
B.Oil						
0.1	0.05	0.09	0.04	0.07	0.03	0.048
1.0	0.50	0.90	0.40	0.70	0.30	0.480
10.0	5.00	8.50	4.00	7.00	3.00	4.700
C.Temperature Change						
0.1	0.045	0.081	0.036	0.063	0.027	0.043
1.0	0.45	0.810	0.360	0.630	0.270	0.430
10.0	4.50	7.650	3.600	6.300	2.700	4.230
D.NH^3-N						
0.1	0.4	0.72	0.32	0.56	0.240	0.38
1.0	4.0	7.20	3.20	5.60	2.400	3.80
10.0	40.0	68.00	32.00	56.00	24.00	37.60
E.BOD-T						
0.1	0.20	0.36	0.16	0.28	0.12	0.19
1.0	2.00	3.60	1.60	2.80	1.20	1.90
10.0	20.00	34.00	16.00	28.00	12.00	18.80
F.BOD-P						
0.1	0.25	0.45	0.20	0.35	0.15	0.238
1.0	2.50	4.50	2.00	3.50	1.50	2.380
10.0	25.00	42.50	20.00	35.00	15.00	23.50

Note: *) Normalized pollutant is a pollutant produced by the ecological submodel routine, which does not have unit. Concentration values of other pollutants are obtained by multiplying concentration values of normalized pollutant and of each pollutant at the discharge point (Table 8.1).

**) The unit of concentration is ppm (mg/l) in all cases, except temperature which is °C.

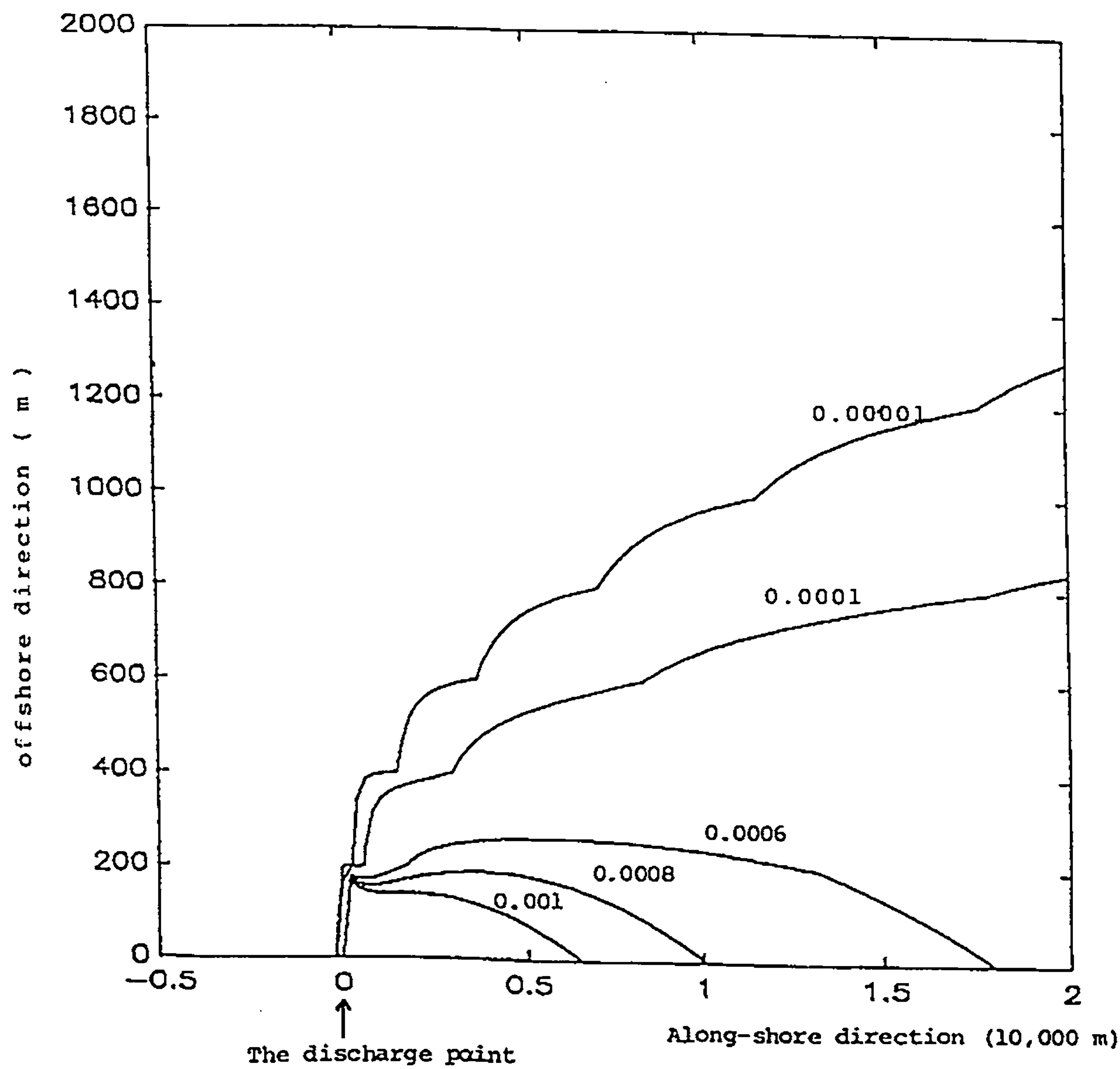


Figure 8.2. Contours of the Normalized Pollutant Concentration at a 0.1 cubic metre/second Discharge Rate

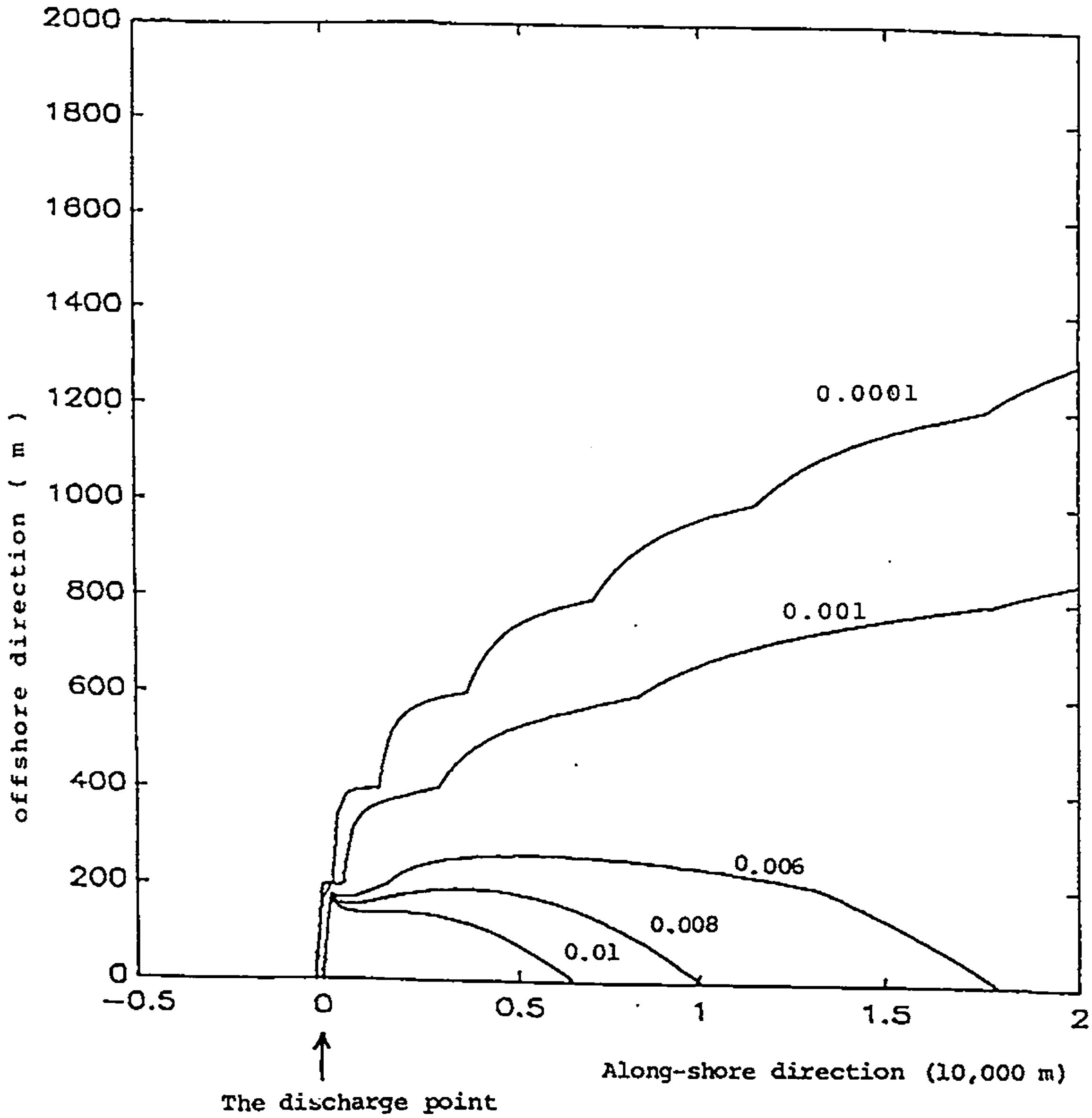


Figure 8.3. Contours of the Normalized Pollutant Concentration at a 1.0 cubic metre/second Discharge Rate

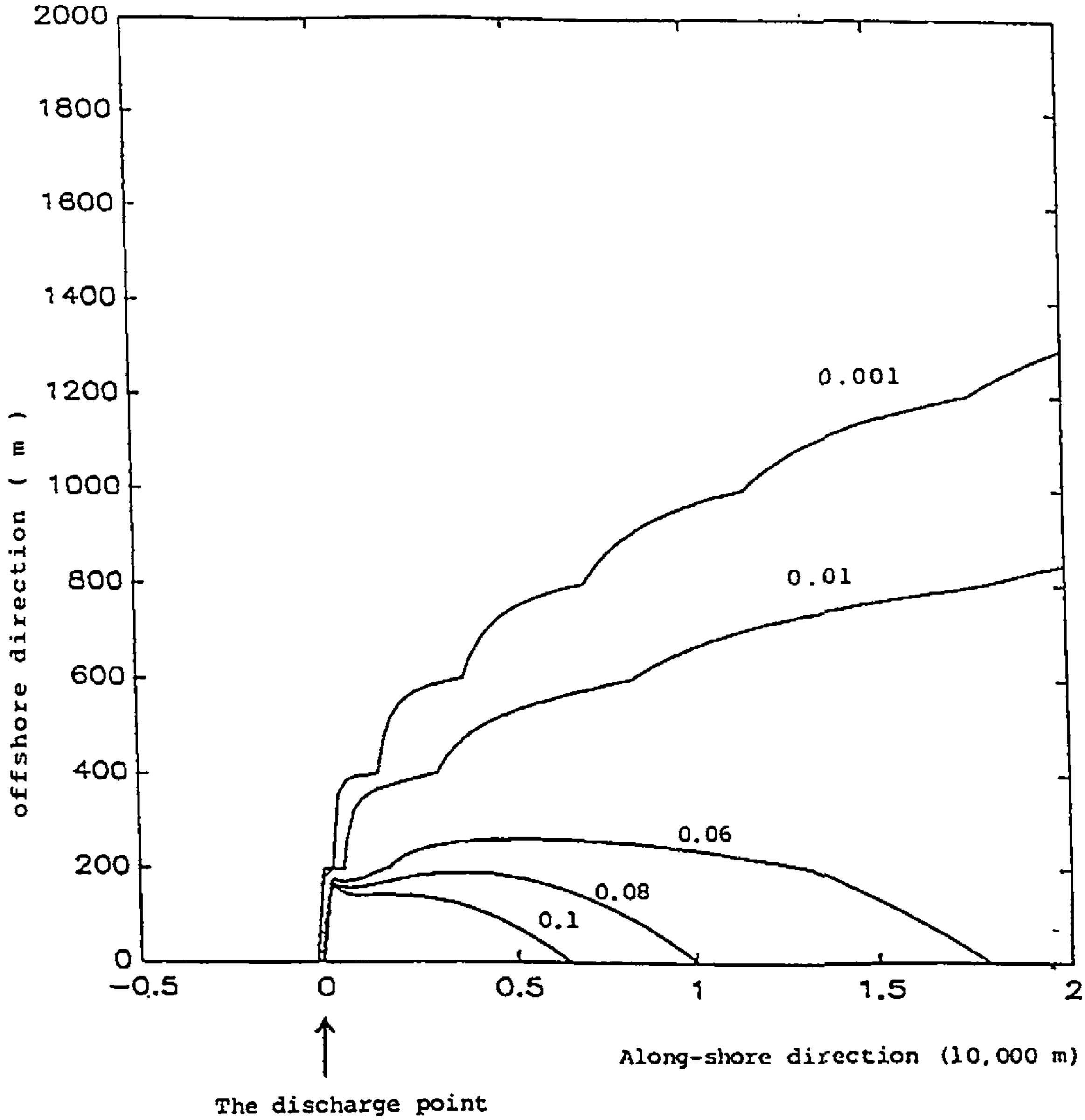


Figure 8.4. Contours of the Normalized Pollutant Concentration at a 10.0 cubic metre/second Discharge Rate

It is important to note that the concentration of pollutant in the coastal water area inside of a particular contour line (Figure 8.2 through 8.4) is higher than that of on the contour line (Table 8.3). This is because any point (x,y) on a certain contour line has the furthest distance among points within an area of such a contour from the discharge point of pollutants.

The upper two contour lines do not touch the shoreline and, therefore, their area and concentration values within it are undefined. This is because the METLAB program written for this study is only applicable for the near-field area (about 30 km down stream, along-shore direction). In order for the program to be applicable in both near-field and far-field areas, it must include the "lost factor" (die-off) of each pollutant in the marine environment (Csanady, 1973).

With worse case scenario (the layer depth of 1 metre, drift velocity of 0.1 m/second, and the discharge rate of 10 m^3/second which, except for the thermal discharge, is higher than the current discharge rate of all waste types listed in Table 8.1), the submodel run indicates that the highest average concentration of BOD originated from both the tambak production and the population (domestic activities) is still less than the allowable BOD concentration in the coastal water (compare Table 8.2 and 8.3). In the meantime, the average concentration of oil waste inside the contour area-1 and area-2 (8.5 and 7.0 ppm respectively) exceeds the allowable oil concentration as presented in Table 8.1. As the current discharge rate of oil waste is 0.55 m^3/second, it means that the concentration of oil waste within all three contour areas is predicted to be lower than the allowable oil concentration.

Under such a 10 m^3/second discharge rate, the thermal (temperature) change of the receiving coastal water inside the contour area-1 and area-2 is higher than the allowable value (Table 8.1). Since the current discharge rate of thermal waste (heated water) is 23.3 m^3/second, it is expected that the thermal change within contour area-1 and area-2 will be higher than that of with a discharge rate of 10 m^3/second. This is somewhat in agreement with the existing surface temperature profile of the receiving coastal water. According to Universitas Mulawarman (1983), within a coastal water area of 6 km along-shore by 0.5 km offshore, the temperature change due to thermal waste from LNG plant was in the range of 1 to 14^0 C.

For ammonia (NH_3-N), under a discharge rate of 0.1 m^3 / second, the average concentration of ammonia within all three contour areas is still lower than its allowable concentration. However, when the discharge rate is 1.0 m^3/second, the ammonia concentration within all three contour areas exceeds its allowable concentration (Table 8.2 and Table 8.3). Under the existing discharge rate, 0.61 m^3/second, it is expected that the concentration of ammonia within all three contour areas will be slightly higher than the allowable concentration. This is quite in agreement with the measured concentration of ammonia in the coastal water in front of the fertilizer plant (PT. Pupuk Kaltim and UGM, 1986).

Although the predicted concentration of the pollutant is not exactly the same as the existing condition, it is in a good agreement with the existing concentration of two waste types (oil and BOD) in the coastal water under consideration, which is also below the environmental standard (see Table 4.1 in Section 4.5; and Unocal, 1990).

The fact that there is an area as large as 10 km southward along-shore and 500 m offshore from the discharge point of Unocal oil processing plant in Tanjung Santan affected by oil waste (Unocal, 1990; field observation, 1989 and 1990; see also Chapter VI) may be caused by accumulative effects of the continuous discharge of oil waste since 1974 or some oil spills. These two aspects were not modelled in the present submodel. Similarly, massive fish kills in front of the fertilizer waste (ammonia) discharge point could be caused by accumulative effects and spills.

Another possibility about the discrepancy between the model result and the field measurement of waste concentration could be the discharge rate and the concentration of waste therein sometimes might be higher than that of when field measurements were conducted. This is a typical trick of many industrial companies in developing and "developed" countries.

8.3.5. Evaluation of the Analytical Approach

The analytical approach adopted includes the effects of initial dilution plus large scale turbulent diffusion and advection of the effluent cloud. This approach has the advantage of implicitly including many important processes while still resulting in an analytic, albeit complicated expression of the solution. More sophisticated models might include the effects of scale dependent processes, vertical dependence and temporally varying effects, such as waves, in a dynamic current field determined for the real bathymetry. Unfortunately, such models of the coastal environment are still unavailable although much progress has been made (Reed et al., 1989 and ASA, 1990). In addition, data required to run such a model for the coastal water under consideration are unavailable.

Along the coast of the study area, it is apparent that environmental effects are generally confined to regions south of point sources. The approach used here includes this observation by imposing a mean southward flowing along-shore current. An alternative explanation for these impacts involves occasional and intermittent advection of the effluent clouds by variable current. In this scenario the environmental damage results from infrequent occurrences of highly contaminated waters instead of persistent exposure to relatively less contaminated waters. Thus, instead of a steady southerly coastal flow, the area may experience little flow most of the time. The importance of variable current on coastal water quality has been recently recognized in a detailed study of the current in the outer region of Halifax Harbour (ASA, 1990). At this time, however, the lack of current data for the study area precludes inclusion of such effects.

Another important aspect that could improve the robustness of the submodel is the inclusion of the die-off (environmental loss) factor of pollutants in the coastal water. This will require a more sophisticated numerical modelling solution involving transport and fate of each pollutant (oil, thermal, ammonia, and BOD) through a variety of processes, i.e. surface spreading, advection, entrainment, and volatilization for a pollutant that has specific gravity less than that of sea water. A pollutant with specific gravity greater than that of sea water is modeled by a convective descent process which allows the pollutant mass to reach an equilibrium position in a stratified water column, or to sink to the seafloor (Myers, 1983; Reed et al., 1989).

In general, some fraction of any pollutant discharged (spilled) will exist in both the water column and the sediments. Furthermore, partitioning between the particulate adsorbed and dissolved states is also important, which is usually calculated based upon linear equilibrium theory (Reed et al., 1989). The pollutant fraction that is absorbed to suspended particulate matter is assumed to settle at a rate typical for the marine environment. Pollutants at the sea floor are mixed into underlying sediments according to a simple bioturbation equation (Reed et al., 1989).

The fate of a pollutant, particularly the non conservati-ve one, in the coastal water is also affected by various biological processes, such as ingestion, bioaccumulation, and biotransformation (Morel and Schiff, 1983; Boesch and Roberts, 1983). Unfortunately, the complete physical fate (ecological) model of a pollutant that include all of these factors is still under development and requires a high degree of numerical modelling expertise, which is beyond the capability of the present study. In addition, physical, chemical, and biological data to simulate such a complete model are also not in existence.

However, if the die-off factor was included into the present submodel, then the concentration of pollutant and the affected area as a function of the discharge rate produced by the submodel would be much smaller. Such a result deviates even farther from the reality (measured data). Thus, at this stage, the present submodel might be still appropriate.

8.3.6. Conclusion

Even though the predictive pollutant concentration and associated affected area of the submodel may not necessarily be accurate, it can be used as an approximation of the impact of four development activities and the population on the quality of the coastal water.

The results of the analytical solution shows that the size of the affected area (the area inside of a contour line) and the concentration of a pollutant therein are proportional to the discharge rate of the pollutant (see Table 8.3, and Figures 8.2 to 8.4).

This proportional relationship was incorporated into the ecological submodel using STELLA modelling software, as transfer functions from the discharge rate of each waste type to its associated concentration and affected area (Appendix 8.2). Such an incorporation will be dealt with in the next section.

8.4. THE INTEGRATION OF ECONOMIC, ECOLOGICAL, AND RESOURCE DAMAGE ASSESSMENT SUBMODELS WITHIN STELLA MODELLING FRAMEWORK

8.4.1. Purpose

This section integrates three submodels to become an integrated management model, which simulates the dynamic of economic and ecological submodels as well as their interactions through waste discharge and the RDA submodel.

The economic submodel was used to simulate the dynamics of total profit as a function of the production rate (level) of four development activities (Appendix 8.1). The RDA submodel simulates the economic (monetary) valuation of coastal water pollution and mangrove degradation caused by four development activities and the population (domestic activities) (Appendix 8.3). These two types of environmental degradation are the output of the ecological submodel (Appendix 8.2). Thus, these economic losses due to ecological damage are a feedback from the ecological submodel to the economic submodel.

8.4.2. STELLA Simulation Approach

The linkage from the economic submodel to the ecological submodel is through the level of production (G-rate) of development activities that is a function of their input (raw materials). While this production process in the economic submodel produces profit (Appendix 8.1), in the ecological submodel such a process (represented by a ghosted input of each development activity) generates waste (R_discharge) and degrades mangroves (Appendix 8.2).

The discharge rate (R_discharge) of four development activities and the population generates their respective coastal water pollution (in the form of waste concentration and affected area) and mangrove degradation (Appendix 8.2). Coastal water pollution and mangrove degradation caused by each development activity and the population were used as an input for the RDA submodel to predict the total economic losses as a function of these two ecological degradations. The total economic losses are used as a feedback from the ecological to economic submodels by subtracting the total economic losses from the total profit to produce social benefits (Appendix 8.3).

The dynamic of economic and ecological submodels as well as their interactions was simulated by using STELLA dynamic simulation model (High Performance Systems, 1990). First of all, the structural diagram (flow chart) of the mental model based upon the system of interest was constructed (i.e. diagrams in Appendix 8.1. to 8.3). This consists of three major stages: (1) laying out the diagram by using structural elements of STELLA which consist of stock, flow, converter, and connector elements; (2) specifying the logic by determining factors (represented by independent converters) that govern flows which are either input or output of stocks within the diagram; and (3) establishing mathematical relationships among stocks, flows, and converters by providing numerical information, mathematical functions, or creating graphs (see Appendix 3.6 for a detailed description about STELLA and its structural elements).

Simulations of the model were then conducted by providing initial values for model variables, selecting integration methods (i.e. Euler, second order Runge-Kutta, or fourth order Runge-Kutta), the time step, the simulation start and end time, and the numerical format for output. Because the model dealt with discrete time steps, the integration method used was Euler's method. The time step for the simulation was one year. The simulation started in year-1 and ended in year-25.

To ensure the consistence and robustness of the model, some reiterating processes were done by checking the model behaviour (output) in the form of graphic and tabular values at a different set of initial values of key model variables. Finally, the model was run under a set of scenarios in which the result will be presented in the following sub-section.

8.4.3. Results and Discussion

As mentioned previously, the main purpose of this simulation model is to provide users (e.g. planners and decision makers) with a set of different alternatives with respect to the level of development activities, so that they may arrive at optimal decisions both socioeconomically and environmentally. Accordingly, the output of the model consists of a set of values for total profit, social benefits, and environmental degradation (coastal water pollution and mangrove degradation) over a 25 year planning period under three different scenarios. Each scenario is defined by creating a set of input graphs (oil, LNG, fertilizer, and Area_tambak) that shows the change in the level of inputs over time (see graphs of Input vs. Time in Appendix 8.1).

Scenario 1: Business as usual

Under a business as usual scenario, the production level of four development activities was set according to their current condition and planning. For example, the production level of LNG, which was reflected by the amount of input, from 1991 (year-0, the start of simulation) to 1999 was 620,880 MMCF, from 2000 to 2010 it was 1000,000 MMCF, and from 2011 to 2014 (year-25, the end of simulation) it was 500,000 MMCF. A detailed list of production (input) level for other three development activities can be seen in Appendix 8.1.

The result of a model simulation under this scenario (Figure 8.5, Tables 8.4, 8.5, and 8.6) indicates that the pattern of production levels of four development activities are proportional to the amount of their input. The production level of fertilizer (represented by curve-1 in Figure 8.5a) is constant until the year-19 (2010), then it declines as the availability of natural gas (its raw material) is expected to be decreasing by that time (Lemhanas, 1988). The production level of LNG increases significantly in the year-9 (2000), because at that time the number of the LNG production trains will be increased from five to eight (Kompas, March 21, 1990). However, as the supply of natural gas in the area decreases, its production level will decline in the year-21 (2012).

From the start of simulation, the production level of oil (represented by curve-3 in Figure 8.5a) decreases and will be terminated in the year-11 (2002). Meanwhile, the production level of tambak (curve-4 of Figure 8.5a) is increasing proportional to the increase in the area of tambak.

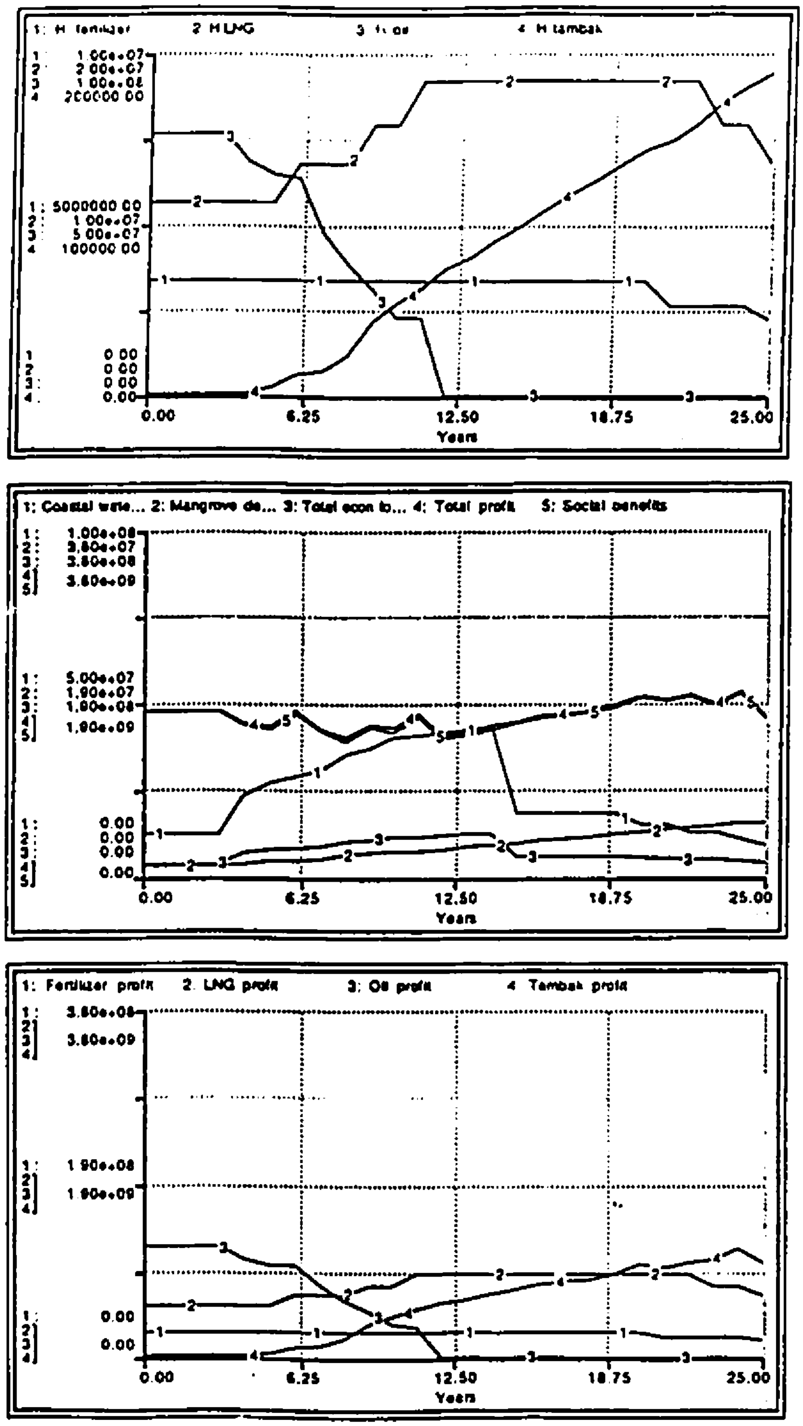
In general, the result of a model simulation under this scenario also shows that the temporal pattern of the concentration of five waste types (Figure 8.5f) and the area affected by these waste types (Figure 8.5e and Table 8.6) over a 25-year period is proportional to the pattern of production levels of four development activities. In terms of the size of the coastal water area affected by waste, the BOD originating from the population has the largest impacts, then followed by the LNG and tambak activities.

In terms of mangrove degradation (Figure 8.5d), the total area of mangrove deteriorated by fertilizer and LNG activities (curve-1 and -2 of Figure 8.5d) is about 800 hectares and remains constant throughout the simulation period. This is because with their existing areal boundaries these two activities will not require additional land openings in the next 25 years (Universitas Mulawarman, 1983; PT. Pupuk Kaltim and UGM, 1986). During the oil production period, the first eleven year of simulation, the total mangrove area degraded by the oil development activity is about 3,000 ha and then drops to about 800 ha (curve-3 of Figure 8.5d) until the end of simulation. The area of mangroves degraded by tambak and population increases over time as the area of tambak and the population size in the region increases.

The most interesting finding under this scenario is that, monetarily, the total profit produced by these four development activities (curve-4 of Figure 8.5b) far exceeds the total economic losses due to ecological damage caused by these activities (curve-3 of Figure 8.5b) (see also Table 8.4). Accordingly, the difference between the value of total profit and social benefits (curve-4 and -5 of Figure 8.5b, and Table 8.4) is very small. It is noteworthy that the monetary value given to the ecological damage (coastal water pollution and mangrove degradation) is 10 (ten) times higher than the current value of coastal water for fisheries purposes (see Appendix 8.3). Even so, the cost of environmental damage in the model may be still underestimated.

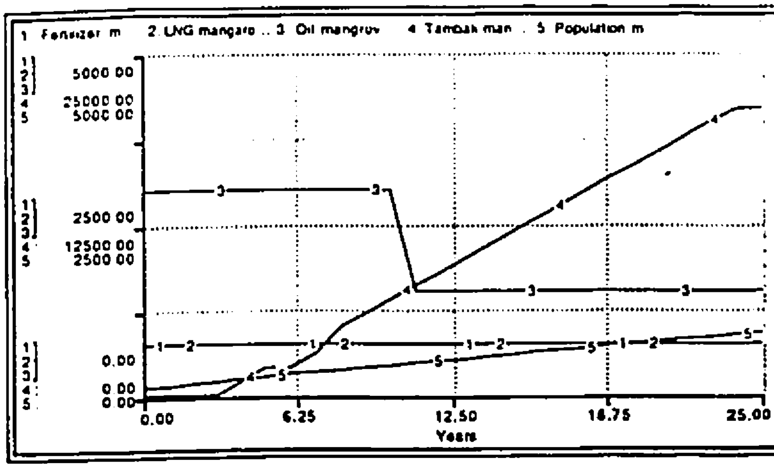
As far as the contribution to the total profit is concerned, the oil is the largest contributor in the first eight years, from year-8 to year-19 the LNG becomes the largest contributor, then in the end tambak production becomes the largest contributor (Figure 8.5c and Table 8.5).

Figure 8.5. The Simulation Results of the Business as Usual Scenario



Legend: In Graph A, 1 = the production of fertilizer (in tonnes); 2 = the production of LNG (tonnes); 3 = the production of oil (barrels); and 4 = the production of shrimp (tonnes). In Graph B, 1 = the cost of coastal water pollution (in US $); 2 = the cost of mangrove degradation (US $); 3 = the total of economic loss as a result of 1 & 2 (US $); 4 = total profit (US $); and 5 = social benefits (US $). In Graph C, 1 = fertilizer profit (US $); 2 = LNG profit (US $); 3 = oil profit (US $); and 4 = tambak profit (US $).

Figure 8.5 (Continued)



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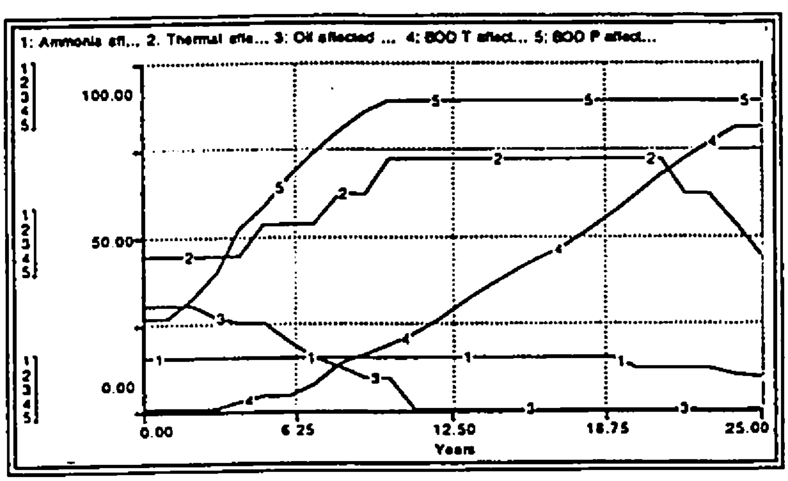
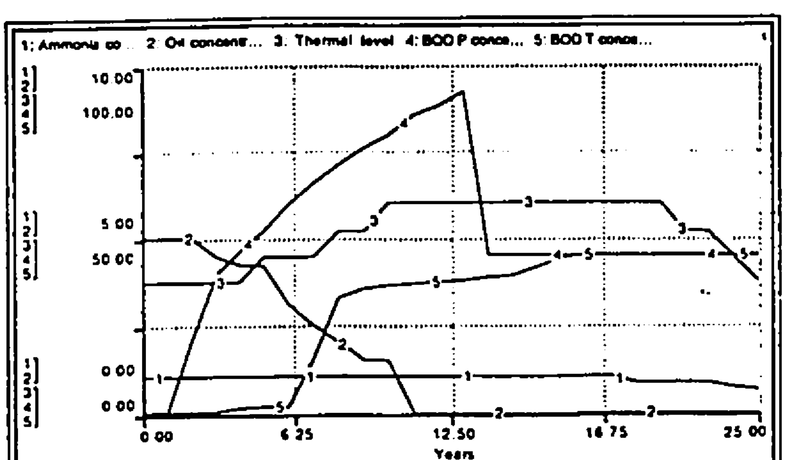


E



F

Legend: In Graph D, 1 = areal mangrove degradation (AMD) by fertilizer activities; 2 = AMD by LNG activities; 3 = AMD by oil; 4 = AMD by tambak; and 5 = AMD by population (units are all in ha.). In Graph E, 1 = the affected area of coastal water (AACW) by ammonia; 2 = AAWC by thermal waste; 3 = AAWC by oil waste; 4 = AAWC by BOD-tambak; and 5 = AAWC by BOD-population (units area all in km^2). In Graph F, 1 = ammonia concentration (ppm), 2 = oil concentration (ppm); 3 temperature (°C); 4 = BOD level caused by population (ppm); and 5 = BOD level; caused by tambak (ppm).

Table 8.4. The Tabular Result of A Model Simulation Under Business as Usual Scenario for Economic Losses due to Coastal Water Pollution, Mangrove Degradation, and Total Economic Losses; Total Profit; and Social Benefits (in US $)

Years	Coastal water pol econ	Mangrove degrad econ l	Total econ loss by ecol d	Total profit	Social benefits
0.00	12136013.546436	1072289.573740	13208303.120176	1815720540.320000	1802512237.199824
1.000000	12136013.546436	1072289.573740	13208303.120176	1815720540.320000	1802512237.199824
2.000000	12136013.546436	1083921.284460	13219934.830896	1815720682.820000	1802500747.989104
3.000000	12136013.546436	1109918.395180	13245931.641616	1815977800.320000	1802731868.378384
4.000000	23169276.025169	1325909.505900	24495185.531069	1673701300.320000	1649206114.788931
5.000000	26696814.556597	1565070.570280	28261885.126877	1633333800.320000	1605071915.193123
6.000000	28477640.593721	1572531.727340	30050172.321061	1811898050.320000	1781847877.998939
7.000000	30565533.064643	1811692.838060	32377225.902703	1612[illegible]28050.320000	1580250824.417297
8.000000	34921777.741705	2282553.948780	37204331.690485	1509655550.320000	1472451218.629515
9.000000	36560130.815983	2521715.059500	39081845.875483	1656936050.320000	1617854204.444617
10.000000	39790387.527784	2760876.170220	42551263.698004	1619399800.320000	1576848536.621996
11.000000	40476290.659760	2655962.780940	43132253.440700	1784618900.320000	1741486646.879300
12.000000	41407066.378141	2895123.891660	44302190.269801	1540058900.320000	1495756710.050199
13.000000	42409788.226265	3134285.002380	45544073.228645	1578518900.320000	1532974827.091355
14.000000	43295765.041386	3373446.113100	46669211.154486	1649693900.320000	1603024689.165514
15.000000	17829209.854373	3612607.223820	21441817.078193	1699118900.320000	1677677083.241807
16.000000	17829209.854373	3851768.334540	21680978.188913	1756718900.320000	1735037922.131087
17.000000	17829209.854373	4090929.445260	21920139.299633	1786193900.320000	1764273761.020367
18.000000	17829209.854373	4330090.555980	22159300.410353	1809818900.320000	1787659599.909647
19.000000	17829209.854373	4569251.666700	22398461.521073	1874843900.320000	1852445438.798927
20.000000	14754209.159881	4808412.777420	19562621.937301	1972718900.320000	1953156278.382699
21.000000	14754209.159881	5047573.888140	19801783.048021	1935960900.000000	1916159116.951979
22.000000	12685388.805076	5286734.998860	17972123.803936	1994480900.000000	1976508776.196064
23.000000	12685[illegible]63.805076	5525896.109580	18211284.914656	1889419300.000000	1871208015.085344
24.000000	10873[illegible]8510	5765057.220300	16638258.048810	2013619300.000000	1996981041.951190
25.000000	906101[illegible]44	5772518.331020	14833531.182964	1749275050.000000	1734441518.817036

Table 8.5. The Tabular Result of A Model Simulation Under Business as Usual Scenario for Fertilizer, LNG, Oil, and Tambak Profits (in US $)

Years	Fertilizer profit	LNG profit	Oil profit	Tambak profit
0.00	26718000.320000	565000800.000000	1224000000.000000	1740.000000
1.000000	26718000.320000	565000800.000000	1224000000.000000	1740.000000
2.000000	26718000.320000	565000800.000000	1224000000.000000	1882.500000
3.000000	26718000.320000	565000800.000000	1224000000.000000	259000.000000
4.000000	26718000.320000	565000800.000000	1080000000.000000	1982500.000000
5.000000	26718000.320000	565000800.000000	1008000000.000000	33615000.000000
6.000000	26718000.320000	678000050.000000	1008000000.000000	99180000.000000
7.000000	26718000.320000	678000050.000000	792000000.000000	115910000.000000
8.000000	26718000.320000	678000050.000000	612000000.000000	192937500.000000
9.000000	26718000.320000	790999300.000000	489600000.000000	349618750.000000
10.000000	26718000.320000	790999300.000000	360000000.000000	441682500.000000
11.000000	26718000.320000	920000900.000000	315000000.000000	522900000.000000
12.000000	26718000.320000	920000900.000000	0.00	593340000.000000
13.000000	26718000.320000	920000900.000000	0.00	631800000.000000
14.000000	26718000.320000	920000900.000000	0.00	702975000.000000
15.000000	26718000.320000	920000900.000000	0.00	752400000.000000
16.000000	26718000.320000	920000900.000000	0.00	810000000.000000
17.000000	26718000.320000	920000900.000000	0.00	839475000.000000
18.000000	26718000.320000	920000900.000000	0.00	863100000.000000
19.000000	26716000.320000	920000900.000000	0.00	928125000.000000
20.000000	26718000.320000	920000900.000000	0.00	1026000000.000000
21.000000	21120000.000000	920000900.000000	0.00	994840000.000000
22.000000	21120000.000000	920000900.000000	0.00	1053360000.000000
23.000000	21120000.000000	790999300.000000	0.00	1077360000.000000
24.000000	21120000.000000	790999300.000000	0.00	1201500000.000000
25.000000	17600000.000000	678000050.000000	0.00	1053675000.000000

Table 8.6. The Tabular Result of A Model Simulation Under Business as Usual Scenario for the Affected Area caused by Ammonia, Thermal, Oil, BOD-Tambak, and BOD-Population (in square km)

Years	Ammonia affected are	Oil affected area	Thermal affected area	BOD P affected area	BOD T affected area
0.00	15.000003	29.999997	44.200063	26.149677	7.128475e-04
1.000000	15.000003	29.999997	44.200063	26.149677	7.128475e-04
2.000000	15.000003	29.999997	44.200063	31.875628	0.035930
3.000000	15.000003	26.470585	44.200063	39.412779	0.192453
4.000000	15.000003	24.705880	44.200063	51.867462	1.953330
5.000000	15.000003	24.70.880	53.040004	58.278496	3.909861
6.000000	15.000003	19.411763	53.040004	66.965452	3.909861
7.000000	15.000003	14.999998	53.040004	73.793969	7.266184
8.000000	15.000003	11.999999	61.879945	80.245872	13.224315
9.000000	15.000003	8.823528	61.879945	85.792175	15.669978
10.000000	15.000003	8.823528	71.971752	88.588927	18.538769
11.000000	15.000003	0.00	71.971752	89.000000	21.473565
12.000000	15.000003	0.00	71.971752	89.000000	26.013934
13.000000	15.000003	0.00	71.971752	89.000000	30.905260
14.000000	15.000003	0.00	71.971752	89.000000	35.227098
15.000000	15.000003	0.00	71.971752	89.000000	39.384726
16.000000	15.000003	0.00	71.971752	89.000000	43.005467
17.000000	15.000003	0.00	71.971752	89.000000	46.429395
18.000000	15.000003	0.00	71.971752	89.000000	50.861891
19.000000	15.000003	0.00	71.971752	89.000000	55.753217
20.000000	11.857177	0.00	71.971752	89.000000	61.273452
21.000000	11.857177	0.00	71.971752	89.000000	67.143043
22.000000	11.857177	0.00	61.879945	89.000000	72.134476
23.000000	11.857177	0.00	61.879945	89.000000	76.536669
24.000000	9.660981	0.00	53.040004	89.000000	81.209847
25.000000	6.692883	0.00	44.200063	89.000000	81.209847

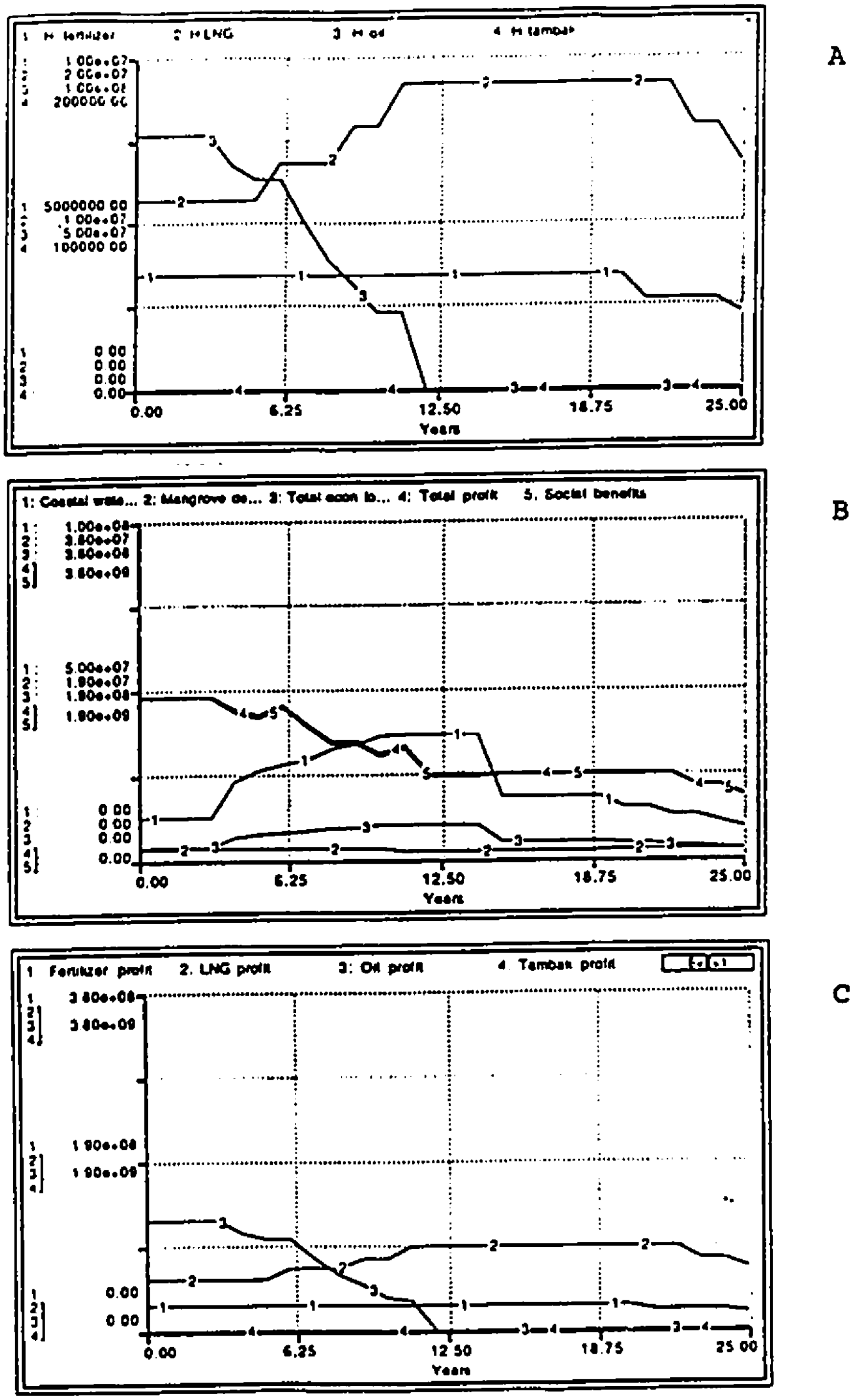
Scenario-2: Zero tambak production

This scenario is the same as the business as usual scenario, except the tambak production was set at zero production (i.e. no tambak development activity). Consequently, there are no shrimps (H-tambak, tambak products) produced under this scenario (curve-4 of Figure 8.6a).

Compared to the previous scenario (see Figure 8.6b and Table 8.7 vis a vis Figure 8.5b and Table 8.4), the total profit and social benefits are almost the same in the first six years under these two scenarios. However, after the year-7, the total profit and social benefits under the second scenario are significantly lower than those in the first scenario. Such a pattern is a logical response of the decline and exhaustion of oil and gas reserves. This implies that as oil and gas reserves decline, the role of tambak development in the region's economy will be more prominent.

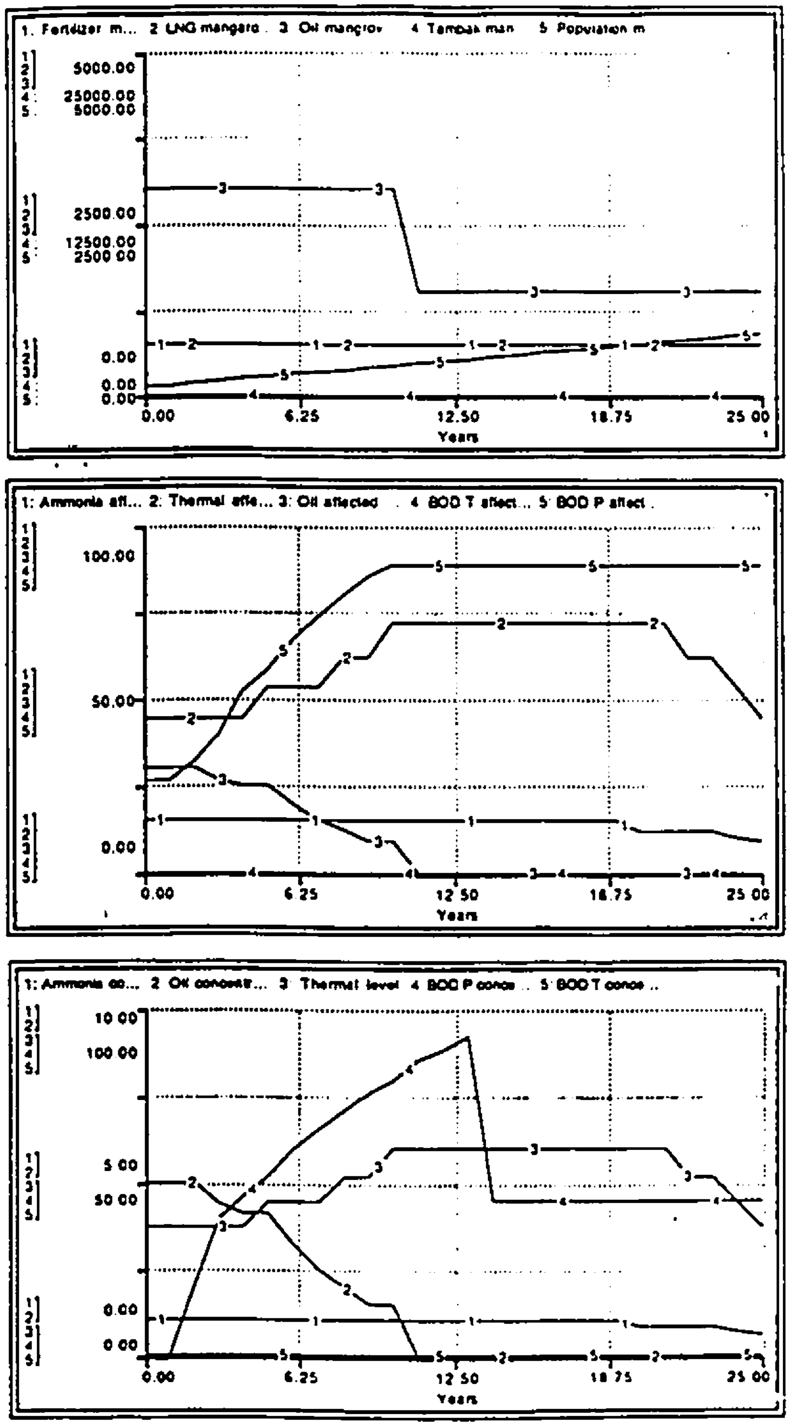
In terms of ecological degradation including the areal mangrove degradation (Figure 8.6d), the coastal water area affected by pollution (Figure 8.6e), and the concentration of five waste types (Figure 8.6f), the magnitude is the same as under the business as usual scenario, minus the contribution of tambak to such ecological degradation.

Figure 8.6. The Simulation Results of the Zero Tambak Production Scenario



Legend: In Graph A, 1 = the production of fertilizer (in tonnes); 2 = the production of LNG (tonnes); 3 = the production of oil (barrels); and 4 = the production of shrimp (tonnes). In Graph B, 1 = the cost of coastal water pollution (in US $); 2 = the cost of mangrove degradation (US $); 3 = the total of economic loss as a result of 1 & 2 (US $); 4 = total profit (US $); and 5 = social benefits (US $). In Graph C, 1 = fertilizer profit (US $); 2 = LNG profit (US $); 3 = oil profit (US $); and 4 = tambak profit (US $).

Figure 8.6 (Continued)



D

E

F

Legend: In Graph D, 1 = areal mangrove degradation (AMD) by fertilizer activities; 2 = AMD by LNG activities; 3 = AMD by oil; 4 = AMD by tambak; and 5 = AMD by population (units are all in ha.). In Graph E, 1 = the affected area of coastal water (AACW) by ammonia; 2 = AAWC by thermal waste; 3 = AAWC by oil waste; 4 = AAWC by BOD-tambak; and 5 = AAWC by BOD-population (units area all in km^2). In Graph F, 1 = ammonia concentration (ppm), 2 = oil concentration (ppm); 3 temperature (^{0}C); 4 = BOD level caused by population (ppm); and 5 = BOD level; caused by tambak (ppm).

Table 8. 7. The Tabular Result of A Model Simulation Under A Scenario of Zero Tambak Production for Economic Losses due to Coastal Water Pollution, Mangrove Degradation, and Total Economic Losses; Total Profit; and Social Benefits (in US $)

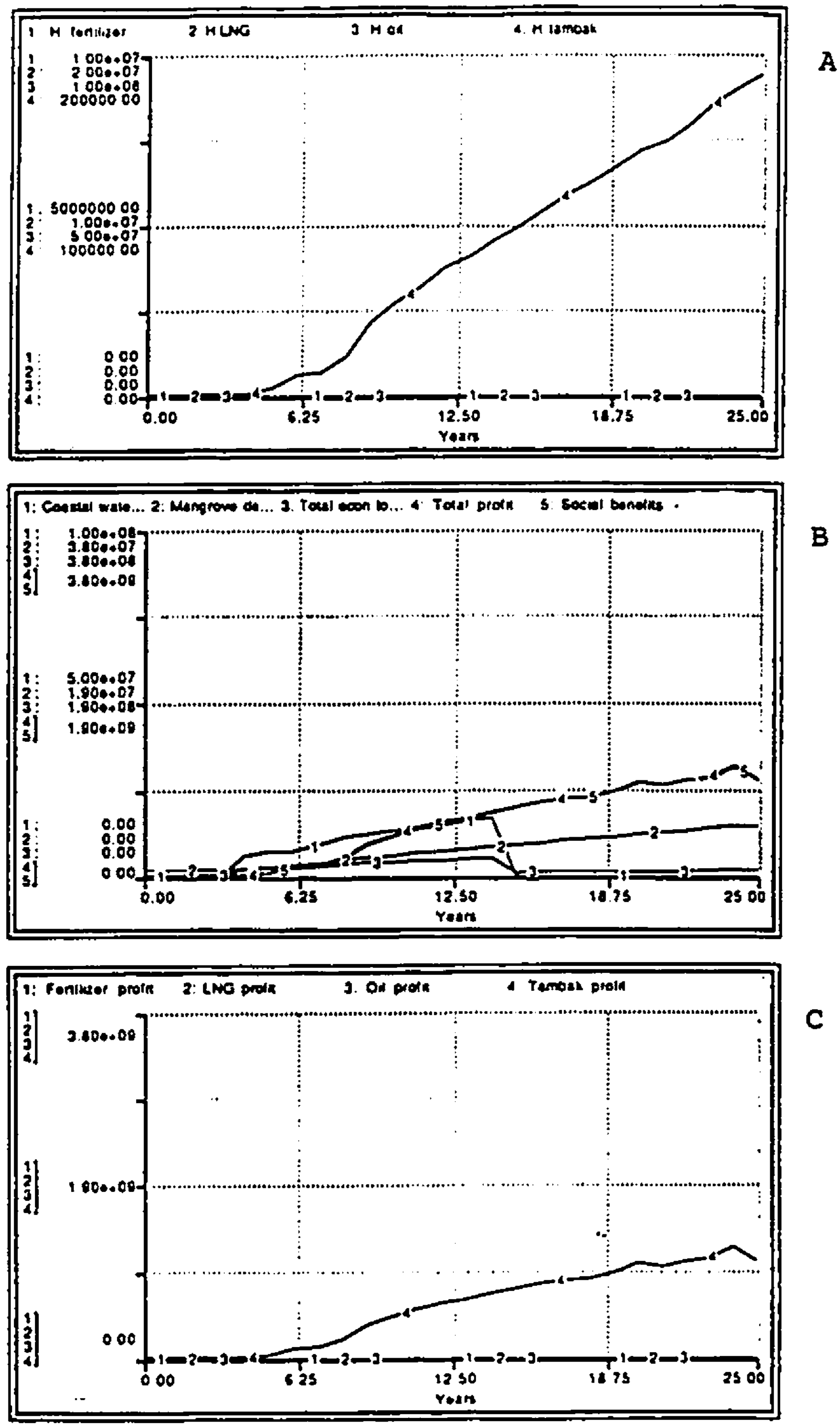
Years	Coastal water pol econ	Mangrove degrad econ l	Total econ loss by ecol d	Total profit	Social benefits
0.00	12136013.546436	1071826.173740	13207839.720176	1815718800.320000	1802510960.599824
1.000000	12136013.546436	1071826.173740	13207839.720176	1815718800.320000	1802510960.599824
2.000000	12136013.546436	1079287.284460	13215300.830896	1815718800.320000	1802503499.489104
3.000000	12136013.546436	1086748.395180	13222761.941616	1815718800.320000	1802496038.378384
4.000000	22768843.329656	1094209.505900	23863052.835556	1671718800.320000	1647855747.484444
5.000000	25895293.121834	1101670.570280	26996963.692114	1599718800.320000	1572721836.627886
6.000000	27676119.158959	1109131.727340	28785250.886299	1712718050.320000	1683932799.433701
7.000000	29075965.260123	1116592.838060	30192558.098183	1496718050.320000	1466525492.221817
8.000000	32210793.176067	1124053.948780	33334847.124847	1316718050.320000	1283383203.195153
9.000000	33347785.326284	1131515.059500	34479300.385784	1307317300.320000	1272837999.934216
10.000000	35989939.831271	1138976.170220	37128916.001491	1177717300.320000	1140588384.318509
11.000000	36074209.854373	802362.780940	36876572.635313	1261718900.320000	1224842327.684687
12.000000	36074209.854373	809823.891660	36884033.746033	946718900.320000	909834866.573967
13.000000	36074209.854373	817285.002380	36891494.856753	946718900.320000	909827405.463247
14.000000	36074209.854373	824746.113100	36898955.967473	946718900.320000	909819944.352527
15.000000	17829209.854373	832207.223820	18661417.078193	946718900.320000	928057483.241807
16.000000	17829209.854373	839668.334540	18668878.188913	946718900.320000	928050022.131087
17.000000	17829209.854373	847129.445260	18676339.299633	946718900.320000	928042561.020367
18.000000	17829209.854373	854590.555980	18683800.410353	946718900.320000	928035099.909647
19.000000	17829209.854373	862051.666700	18691261.521073	946718900.320000	928027638.798927
20.000000	14754209.159881	869512.777420	15623721.937301	946718900.320000	931095178.382699
21.000000	14754209.159881	876973.888140	15631183.048021	941120900.000000	925489716.951979
22.000000	12685388.805076	884434.998860	13569823.803936	941120900.000000	927551076.196064
23.000000	12685388.805076	891896.109580	13577284.914656	812119300.000000	798542015.085344
24.000000	10873200.828510	899357.220300	11772558.048810	812119300.000000	800346741.951190
25.000000	9061012.851944	906818.331020	9967831.182964	695600050.000000	685632218.817036

Scenario-3: With only tambak production

In this scenario, three development activities including oil, LNG, and fertilizer production were set at a zero level. Two assumptions were made in this scenario. First, the mangrove degradation due to population was reduced to a quarter portion from the business as usual condition. This is based on the assumption that without these three activities, the population size of the region will decrease as much as three quarter of the population size in the first scenario. Second, as a corollary of the decrease in the population size, the affected coastal water area by organic pollution (BOD-P) originating from the population is also assumed to decrease as much as 50 %.

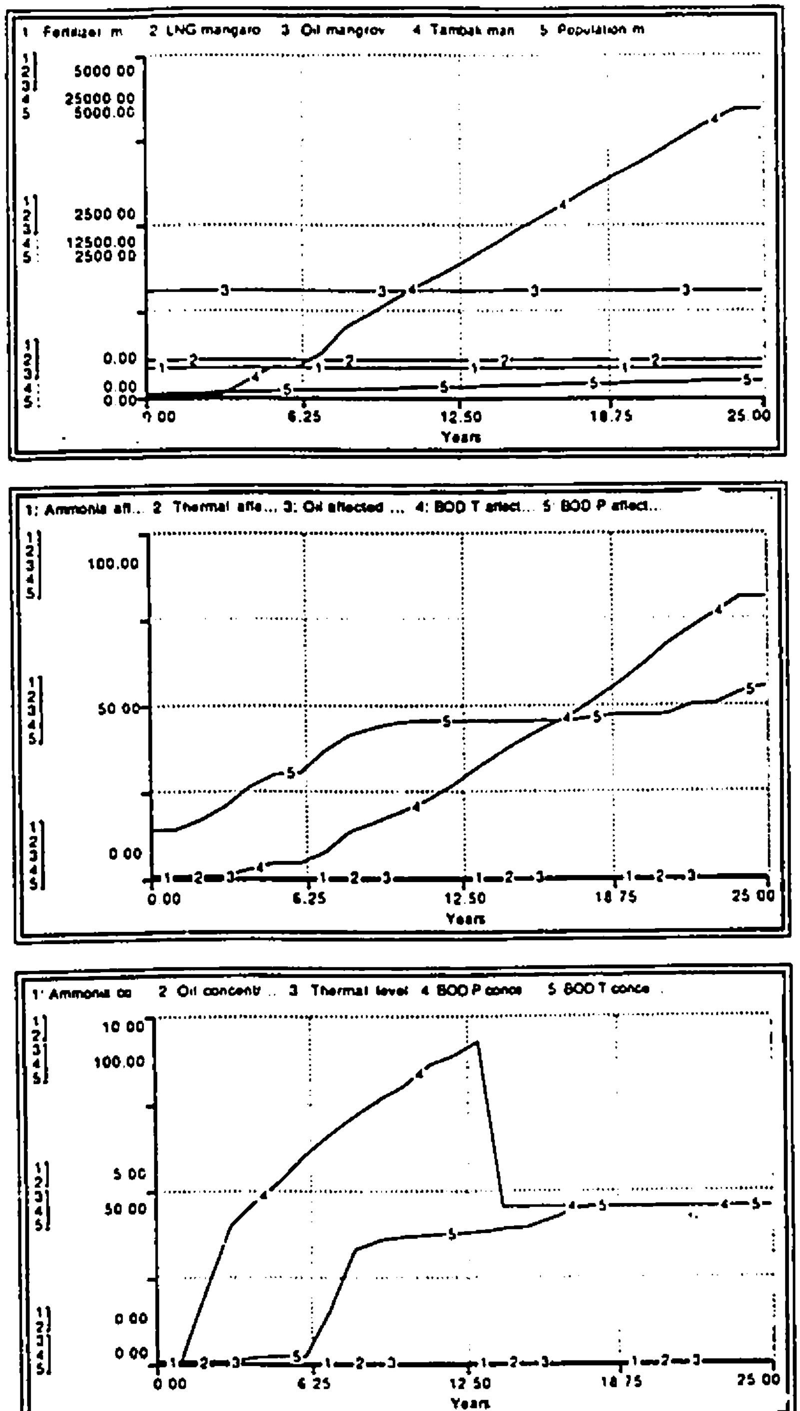
Under this scenario, the total profit in the first five years is lower than the total economic losses due to ecological damage and, thereby, resulting in the negative value of social benefits (Figure 8.7b and Table 8.8). This is partly as a result of mangrove degradation left by oil, LNG, and fertilizer production activities, whereas they do not produce any benefits. In addition, the population and tambak activities have already generated coastal water pollution (manifested in the form of the coastal water affected area) in the first five years. These two conditions make the economic losses due to ecological damage outweigh the total profit which is only produced by tambak production activities.

Figure 8.7. The Simulation Results of the Only Tambak Production Scenario



Legend: In Graph A, 1 = the production of fertilizer (in tonnes); 2 = the production of LNG (tonnes); 3 = the production of oil (barrels); and 4 = the production of shrimp (tonnes). In Graph B, 1 = the cost of coastal water pollution (in US $); 2 = the cost of mangrove degradation (US $); 3 = the total of economic loss as a result of 1 & 2 (US $); 4 = total profit (US $); and 5 = social benefits (US $). In Graph C, 1 = fertilizer profit (US $); 2 = LNG profit (US $); 3 = oil profit (US $); and 4 = tambak profit (US $).

Figure 8.7 (Continued)



Legend: In Graph D, 1 = areal mangrove degradation (AMD) by fertilizer activities; 2 = AMD by LNG activities; 3 = AMD by oil; 4 = AMD by tambak; and 5 = AMD by population (units are all in ha.). In Graph E, 1 = the affected area of coastal water (AACW) by ammonia; 2 = AAWC by thermal waste; 3 = AAWC by oil waste; 4 = AAWC by BOD-tambak; and 5 = AAWC by BOD-population (units area all in km^2). In Graph F, 1 = ammonia concentration (ppm), 2 = oil concentration (ppm); 3 temperature (^{o}C); 4 = BOD level caused by population (ppm); and 5 = BOD level; caused by tambak (ppm).

Table 8.8. The Tabular Result of A Model Simulation Under A Scenario of Only Tambak Production for Economic Losses due to Coastal Water Pollution, Mangrove Degradation, and Total Economic Losses; Total Profit; and Social Benefits (in US $)

Years	Coastal water pol econ	Mangrove degrad econ l	Total econ loss by ecol d	Total profit	Social benefits
0 00	0.00	570209.193435	570209.193435	1740.000000	-568469.193435
1.000000	0.00	570209.193435	570209.193435	1740.000000	-568469.193435
2.000000	0.00	576245.071115	576245.071115	1882.500000	-574362.571115
3.000000	0.00	596646.348795	596646.348795	259000.000000	-337646.348795
4.000000	5686232.051174	807041.626475	6493273.677649	1982500.000000	-4510773.677649
5.000000	6853820.600472	1040606.892570	7894427.493042	33615000.000000	25720572.506958
6.000000	6943254.282024	1042472.181835	7985726.463859	99180000.000000	91194273.536141
7.000000	8938223.378221	1276037.459515	10214260.337736	115910000.000000	105695739.162264
8.000000	11045777.361242	1741302.737195	12787080.098437	192937500.000000	180150419.901563
9.000000	12042474.391879	1974868.014875	14017342.406754	349618750.000000	335601407.593246
10.000000	12904378.399791	2208433.292555	15112811.692346	441682500.000000	426569688.307654
11.000000	13627080.805387	2441998.570235	16069079.375622	522900000.000000	506830920.624378
12.000000	14557856.523768	2675563.847915	17233420.371683	593340000.000000	576106579.628317
13.000000	15560578.371891	2909129.125595	18469707.497486	631800000.000000	613330292.502514
14.000000	16446555.187012	3142694.403275	19589249.590287	702975000.000000	683385750.409713
15.000000	0.00	3376259.680955	3376259.680955	752400000.000000	749023740.319045
16.000000	0.00	3609824.958635	3609824.958635	810000000.000000	806390175.041365
17.000000	0.00	3843390.236315	3843390.236315	839475000.000000	835631609.763685
18.000000	0.00	4076955.513995	4076955.513995	863100000.000000	859023044.486005
19.000000	0.00	4310520.791675	4310520.791675	928125000.000000	923814479.208325
20.000000	0.00	4544086.069355	4544086.069355	1026000000.000000	1021455913.930645
21.000000	0.00	4777651.347035	4777651.347035	994840000.000000	990062348.652965
22.000000	0.00	5011216.624715	5011216.624715	1053360000.000000	1048348783.375285
23.000000	0.00	5244781.902395	5244781.902395	1077300000.000000	1072055218.097605
24.000000	0 00	5478347.180075	5478347.180075	1201500000.000000	1196021652.819925
25 000000	0 00	5480212.457755	5480212.457755	1053675000.000000	1048194787.542245

Among three scenarios, the first scenario (business as usual scenario) produces the largest total profit and social benefits as well as environmental degradation (coastal water pollution and mangrove degradation). Since the total profit produced under the first scenario is much greater than its total economic loss due to ecological damage and by assuming that the resulted environmental degradation will be reversible, then the business as usual scenario seems to be the most optimal one. To ensure sustainable development, the profit generated through the implementation of the business as usual scenario should be partly allocated to enhance sustainable economic bases and restore the degraded environment in the area.

8.5. EVALUATION AND CONCLUSION

On the basis of the analysis of these three scenario, it can be inferred that the holistic model, which integrates economic, ecological and RDA submodels, is able to simulate the system behaviour (in terms of the comparison between the model outputs and inputs) in a reasonable manner. However, further research is needed to improve the robustness of the overall model, especially with respect to ecological and RDA submodels. In addition to some aspects that have been discussed in sub-section 8.3.5, the interaction among pollutants, the accumulative effects of the pollutants, the spatial aspects of pollutants in the coastal water should be included in the further refinement of the model. The target for the improvement in the ecological submodel is to create such a submodel which is able to provide the predictive information regarding the concentration of each pollutant and its associated affected area over time.

Some equations in the RDA submodel need to be improved more precisely and require more reliable data. These include, for instance, the economic valuation of degraded mangroves and polluted coastal water (the affected area). The most comprehensive economic valuation of environmental degradation is based upon the marginal opportunity coast (MOC) approach (Pearce and Markandya, 1990). Marginal opportunity cost refers to the best alternative use to which particular resources could be put if they were not being used for the purpose being costed.

The MOC consists of three components: direct, external, and user costs. The marginal direct cost (value) of a resource is the value of such a resource for the current use, such as fish landing of a given area of coastal water, firewood and chips from a mangrove forest, and tourist income from a mangrove reserve. The marginal external value of a resource is the total loss of other resources as a result of the degradation of the former resource. For instance, the removal of mangroves may cause the decline of fisheries production of the adjacent coastal water, and the increase in coastal erosion.

The marginal user cost stems from intergenerational considerations. In the case of non-renewable resources, any positive rate of exploitation will imply eventual exhaustion.

This means that using one unit of the resource now implies that it will be unavailable in the future. This places a scarcity premium on the resource, the amount of which will depend on how large the stock is relative to the rate of exploitation, how strong future demand is relative to the present demand, what substitutes are likely to be available in the future and at what cost, and what the discount factor is (Munasinghe and Schramm, 1983; Pearce and Markandya, 1990). For renewable resources, if its present and future use is likely to take place on a sustainable basis, then any of the resource that is utilized now will be exactly replaced through natural or managed regeneration. In that case, there will be no scarcity premium to be added to the present direct and external costs (Pearce and Markandya, 1990).

Prior to any application, the model should be validated, for example, by a way of a historical run to tract historical data. It is obvious that the model by no means has a good predictive capability. Nonetheless, it is useful as a framework for analyzing the trade-offs between economic profit and environmental degradation generated by a multiple coastal resource uses (development activities). For example, the model indicates that in terms of mangrove degradation, tambak production activities exert the largest impact. In terms of coastal water area affected, the population creates the largest impact.

The model also provides a systematic framework, namely through the integration of economic, ecological, and RDA submodels, as a means to arrive at optimal decisions for sustainable coastal development. Thus, if one really wants to derive optimal decisions quantitatively, one has to make all the relationships and data that make up three submodels as reliable as possible.

IX. A MANAGEMENT FRAMEWORK FOR SUSTAINABLE DEVELOPMENT OF COASTAL RESOURCES

Based upon the analysis of problems and issues (Chapters III and VI), the biophysical and socioeconomic conditions (Chapters IV and V), the results of spatial planning analysis and simulation modelling (Chapters VII and VIII), and sustainable development principles for CRM (Chapter II), this final Chapter of the dissertation offers some critical policies and directions for the management of sustainable coastal resources utilization in the region.

The information and data required for coastal resource management and planning will be described in the subsequent section, which also provides a means of developing and managing such a database. To carry out the proposed CRM policies and programs effectively, appropriate institutional arrangements are presented in the last section. Although this management framework is applied in the context of East Kalimantan, it is hoped, as stated in Chapter I, that the underlying principles of the framework can also be applicable for other coastal areas not only in Indonesia but in other countries as well.

9.1. MANAGEMENT AND DEVELOPMENT POLICIES

An integrated and holistic plan is needed to manage sustainable development of coastal resources. This plan encompasses a goal or a set of goals, objectives, policies and, to some extent, programs. As mentioned in Chapter I, the goal of any CRM effort in the region is to utilize coastal resources on a sustainable basis for the benefit of all people. This goal is in harmony with the long-term goal for the development of marine and coastal resources of the country: to increase the effectiveness of marine and coastal resources utilization and to improve the management of related activities so as to contribute to sustainable development at both regional and national levels (GBHN, Basic Guidelines of State Policies).

The goal can be achieved if the direction and patterns of local and regional development policies as well as activities, which influence the coastal ecosystem, are aligned to the ecological capacity of the coastal zone. Accordingly, all CRM efforts in the region should focus on five major objectives: (1) increasing the use of coastal ecosystems and their renewable resources within sustainable limits; (2) optimizing the use of non-renewable coastal resources to enhance regional and national sustainable development; (3) mitigating pressures (environmental degradation) on the coastal ecosystem resulting from both within coastal zone and adjacent systems (i.e. upland areas and the open seas); (4) managing and enhancing the sustainable capacity of coastal resource bases for development options of future generations; and (5) determining an optimal spatial planning that maintain the balanced proportion between developed, cultivated, and natural zones.

Because of the heavy reliance of the regional economy on the oil and gas sector, it is prudent to design management and development policies and programs in two stages, namely the oil and gas period and the post-oil and gas period. Policy during the oil and gas period should focus on promoting the optimal multiple-use strategies of coastal ecosystems and their resources. In the post-oil and gas period, the policy will focus on sustainable utilization of renewable resources, manufacturing (home industry), eco-tourism based on biodiversity rich areas, and service sector. The socioeconomic dimension of sustainable development (Chapter II) requires the assurance of sustainable livelihood for the local people. Therefore, throughout the course of development, target group-oriented development should be the basic policy. Finally, these policies should be supported by two other policies i.e. strengthening local and provincial capabilities, and public education and participation.

9.1.1. Policies and Programs during the Oil and Gas Period

In order for sustainable development of coastal resources in the region to occur, the development policy during this period (the present until the exhaustion of oil and gas reserves in the area, which is predicted by the year 2020) should focus on promoting multiple-resource uses. There are, at least, four basic reasons why a multiple-use strategy is to lead to sustainable development in the area.

First, the coastal ecosystem itself provides a mix of resources (see Chapter V), which naturally suggest ways to use it on a sustainable, multiple-use basis. Second, the human community in every region (including the study area) is composed of people who have different kinds of expertise and aptitudes (preference for work). In the study area, there is a variety of professions, such as fishermen, fish farmers, farmers, industrial (oil, gas, coal, timber) workers, crafts men and women, and government officials. It is extremely difficult to change one's profession, such as from fisherman to oil man. Third, a multiple-use strategy is far less susceptible to unanticipated fluctuations in price than a mono-use strategy. The drastic decline in the world's oil price in the early 1980's, which put Indonesia's economy in shaky position, should be enough leverage to avoid a heavy reliance on one sector of any region's economy.

Lastly, no single sector of the economy can be given "absolute control" over an area and at the same time manage its activities in an environmentally responsible way. It is not the nature of the neo-classical economy (capitalism) to be benevolent towards the environment. Unless it has to be. By maintaining and supporting multiple-resource uses, potentially dominating sectors like oil and gas are forced to act with considerations for others. To ensure that a multiple-use strategy can lead to sustainable development of coastal resources, the following four major programs should also be implemented.

(1) Expanding sustainable economic basis

As described in Chapters III and IV, the present economic structure of the region is highly dominated by the high-technology sectors i.e. oil, gas, coal, and timber. The traditional small industrial sectors (e.g. agriculture and home industry), the basic livelihood of the majority of the population in the region, have been left behind without any significant improvement. Even more sombre is the fact that most benefits of this high-technology sectoral development do not accrue to the local people who are, in essence, still in a needy condition. This type of pattern has occurred also in the arena of the oil and gas development in other areas, such as Arun in Aceh province (Mubyarto, 1986) and in Riau Province (Ahmad, 1990).

If this development pattern persists, the outcome of the currently lucrative high-technology development for the region can only be the creation of "dead areas", with degraded environmental conditions and poverty (e.g. Sanga-Sanga, Semboja, and, to some extent, Tarakan). Therefore, high-technology development should be used to nourish other economic bases, which can employ as many local people as possible, so as to provide a foundation for sustained economic development after the oil and gas period.

There are numerous options for a combination of multiple-use strategies in the study area. Chapter VII (spatial planning) reveals that, at least, fourteen types of development activities can be carried out in the region.

Furthermore, GTZ/TAD-PPS (1990b) identified some 30 areas of development potential in the agriculture sector alone that could be harnessed in the area (Table 9.1).

Table 9.1 Agricultural Development Potentials in Coastal Kutai and Samarinda Area.

	Category	Type of production activities
1	Food and crop Horticulture	Cassava production for processing, small-scale rice cultivation, small-scale intensive vegetable production near urban centers, fruit production and processing.
2	Industrial and estate crops	cloves, cacao, coconuts, coffee, oil palm, pepper, rubber, and sugar cane.
3	Agroforestry	fuel wood production, rattan growing and processing, fodder tress, palm sugar production, essential medicinal/aromatic oils production, and raw material for herbal drugs.
4	Animal husbandry	Cattle breeding, rearing and fattening; buffalo rearing; sheep in combination with tree crops; goat keeping; day old chicks; duck breeding; and animal feed production.
5	Fisheries	Shrimp and milkfish culture, shrimp cracker production, seaweed production (harvesting or aquaculture), and tuna and shark fishing

Source: Collected from GTZ/TAD-PPS (1990 b).

This can be done through two main approaches. First, when technically, socioeconomically and environmentally feasible, the coexistence of high-technology development projects (e.g. oil and gas) and more traditional resource-use activities (e.g. aquaculture and agriculture) should be encouraged. There is ample evidence of such positive coexistence ('symbiotic mutualism') between two or more development activities in this area (see Chapters V and VI), and others. Examples include oil rigs and artisanal fisheries along the North Coast of Java, rice fields and a fertilizer plant at Cikampek in West Java, and the LNG plant and tambaks in Arun.

There are, however, several prerequisites for such coexistence. New development activities must be carefully chosen so as to minimize additional management problems. Cross-sectoral impacts (e.g. pollution and physical habitat degradation) of each development activity should be minimized. Rules and regulations for all development activities involved should be clearly defined and strictly enforced. Finally, the attitude of respect and care for the sustainability of activities other than one's own business should be nurtured.

Second, the trickle-down effects of this high-technology sectoral development should be maximized. This process can be stepped up in a variety of ways. For example, the big business of catering services in the oil-and gas-related industries is still handled by companies from Jakarta. And, sadly, even raw materials (e.g. vegetables, fruits, meats, and fish) are mostly imported from Java, while the products of horticultural farms of local people in Bontang are difficult to sell. Giving up such business to local people (e.g. village cooperatives, either the government-sponsored or the community-based ones) will not only strengthen economic capabilities (purchasing power) of the local community but also enhance other economic bases, the seeds for sustainable development. The business in transportation services of these high-technology industries, which are presently still in the hands of Jakarta or Balikpapan companies, should also be gradually given to the local people.

(2) Environmental Restoration and Adjustments

Simultaneously with the enhancement of economic bases, the current environmental degradation should be restored, and development policies and programs which brought about such environmental degradation have to be adjusted. This encompasses the following programs:

Conservation of coral reef ecosystems

Law enforcement on fishing practices and the banning of coral mining must be strengthened. This, however, should be combined with a serious effort to provide alternative livelihoods for the poor coral miners. In addition, the trade of coral materials must be forbidden. Coral dredging, which has been conducted by existing industrial activities, should be avoided in the future. The protection effort for coral ecosystem offshore from Kutai National Park should be safeguarded not only by the Kutai National Park Management, but also by the Fisheries District Agency, and District Police.

Conservation of Mangrove Ecosystems

Replanting of mangrove lands abandoned as a result of oil and gas related activities, coal mining, and others should be carried out. Within the whole study area, mangroves may be allocated into three broad categories: conversion, conservation, and preservation zones. The conversion zone has high economic and environmental feasibility for other uses. The conservation zone is a mangrove that can be harvested on a sustainable basis. The preservation zone has high ecological (e.g. biodiversity and nutrient flows) and physical (e.g. land stabilization and storm reduction) functions without whose existence, the whole study area would lose its ecological integrity.

At this stage of the study, the exact quantitative allocation of mangroves into these three categories is impossible. Some broad guidelines can, however, be offered. The preservation zone should include the entire mangrove ecosystem of Kutai National Park and the Mahakam Delta. The existing tambak activities in these two mangrove areas may be tolerated, but without any further opening (land clearing) and a strict control should be implemented. It is socioeconomically and politically very difficult, if not impossible, to relocate the existing fish farmers and their settlement.

Within the conversion zone, development activities should be located behind the 'green-belt zone', and the execution of this development should be carried out with great environmental care. The conversion zone may include the suitable mangrove areas for the proposed development activity between the Mahakam Delta and Kutai National Park, and between the Sangatta River and Sangkulirang. Sustainable harvest from the mangrove conservation zone may be carried out through the

Indonesian selective cutting system, with replanting after the harvest. The sites for the conservation zone include mangroves between the Sangatta river and the Mangkalihat Peninsula.

Tambak development

The extent, distribution, and types of tambak development should be arranged according to the proposed spatial planning. In addition, its impact on coastal water quality should be considered according to the assimilative capacity of the coastal waters. The decline in water quality of the North Coast of Java, which has caused bacterial outbreak on tambak production systems, has resulted in the decrease of their productivity. It has been argued that one of many factors that have brought about the deterioration of this coastal water quality is the high and continuous discharge of organic waste from tambaks themselves (personal communications with farmers in Cirebon, West Java, 1990). So, the Java's experience should be a good lesson for tambak's development in the study area.

Industrial development

The waste discharge from existing industrial activities should be strictly monitored, making sure that the discharges do not exceed the environmental standard. Future industries should be located on sites that have minimal negative impacts on critical ecosystems, such as mangroves and coral reefs.

Industrial development must have a plan that incorporates zonation for industries, standards for environmental quality maintenance, as well as transportation facilities and ports.

Integrated watershed management

The level of pollution and sediment loads in many rivers within the study area, particularly the Mahakam and Sangatta river, is increasing. This, sooner or later, will affect the integrity of critical coastal ecosystems, such as coral reefs, sea-grass beds, demersal ecosystems, and mangroves. The sedimentation occurring around the Mahakam river mouth, which requires the dredging cost of some 2 billion rupiahs annually, is strongly believed to be the result of poor upland management, especially within the forestry sector. The increased sedimentation of the Sangatta river is caused mainly by surface coal mining as well as deforestation. In the meantime, pollution of the Mahakam river is brought about by industrial and domestic activities.

Therefore, an integrated watershed management plan that incorporates water quality requirements for coastal waters with existing effluent standards and the forestry management practices should be established. The Governor's Decree No.339/1988 concerning environmental standards for the Province of East Kalimantan should be strictly enforced. Industries and sectors that affect river water quality should be closely monitored. The technical and financial needs for the establishment of integrated watershed management may be obtained from the recent River Clean-up Program (Prokasih = Program Kali Bersih), which is a national program intended to reverse the decline in water quality of 25 polluted rivers in eleven provinces, including East Kalimantan.

Improving coastal water quality

Although the decline in coastal water quality may be caused by upland activities, major contributors of pollutants to coastal water are currently human activities within the coastal zone, particularly oil and gas-related activities (Chapter IV and VI).

Accordingly, sampling and monitoring of waste discharge from these industries should be intensified, and environmental regulations (e.g. Governor Decree No.339/1988) must be more seriously enforced.

In addition, with the rapidly growing population in Samarinda, Muara Badak, and Bontang areas, domestic sewage could be a serious problem for the coastal environment in the near future. Hence, the treatment and management of domestic sewage should also be planned.

Sustainable utilization of fisheries and forest resources

Although the exploitation level of most fisheries stocks in the study area is still below the MSY level (Chapter V), the utilization of fisheries resources must be based on sound development principles to ensure its sustainability. This may be achieved through management schemes which determine fish stocks and sustainable yields and the maximum number of fishermen, set levels of effort, and specify appropriate fishing gear.

Lowland tropical forests in the study area are mostly already overexploited (Chapters V, VI, and VII). To reverse this condition to a more sustainable pattern, reafforestation and the Indonesian selective cutting programs must be strengthened within the production forest area. Forest concessionaires which violate such programs should be closely monitored and, to a certain degree, their permits should be suspended.

Co-development and management

Environmental restoration and adjustment programs will require a considerable amount of budget. It would be discouraging for the regional government, with the existing limited budget, to bear responsibility for all expenditures to carry out these programs. One of many alternatives to deal with this issue is to involve the participation of high-technology industrial sectors (timber, coal, and oil and gas) to alleviate such an issue.

There has been a good example about the co-development and management between the regional government and industries in conserving environmental endowments. The successful management of preserving underground water sources (aquifers) beneath the Bontang protected forest carried out jointly by the Management of Kutai National Park, PT. Badak NGL., Co., and PT. Pupuk Kaltim is one of such an example.

There are still many areas of environmental restoration and adjustment that can be done through such a co-management. For instance, replanting lowland dipterocarp forest between Samarinda and Kutai National Park will not only be restoring forest but also be safeguarding future life and prosperity of East Kalimantan's people.

(3) Spatial planning

Spatial planning can potentially be a powerful tool to avoid conflicts arising from multiple-use strategies of a given coastal ecosystem. Prior to the implementation of development projects, planners and project's executors (e.g. farmers, fishermen, forester, and oil companies) could cooperatively discuss and plan the best location for each project based upon spatial planning concepts. This can minimize unnecessary physical habitat degradation, as well as ensure the technical viability of the respective project.

At the regional planning level, spatial planning that is presented in Chapter VII can be used as basic guidelines (e.g. pinpointing potential areas for certain types of development at a larger scale) for the spatial allocation of multiple-use strategies of the coastal zone. At the project implementation phase, a more detailed level of spatial planning is required. All involved development activities (including settlements, industrial zones, and recreational areas) should be mapped.

In addition, the scale should be large enough (up to village or city level if possible) to accommodate the detail needed to permit spatial planning.

Spatial planning of the coastal zone must also incorporate marine components. These include, at least, such basic information as (1) the extent, types, distribution and condition of marine resource systems (e.g. coral reefs, sea-sea-grass beds, fishing grounds, nursery and spawning grounds); (2) biodiversity aspects of onshore areas (e.g. wetland and waterfowl sites); (3) hydrometeorology (e.g. the direction and speed of current and winds, tidal patterns, waves, and the density pattern); and (4) geomorphology (e.g. slope, bathymetry, shoreline conditions, and bottom topography of the coastal water). More detailed information requirements for spatial planning can be seen in Table 7.6. This information allows the spatial planning to be comprehensive and integrated in dealing with land and sea water interactions.

(4) Optimizing multiple-resource uses

In spite of its soundness as a means of applying sustainable development principles in resource utilization, the application of a multiple-use strategy deserves careful and keen considerations at all stages of the project cycle, from planning to implementation. It is not just a matter of minimizing the cross-sectoral negative impacts of each activity. The most challenging task for the planner and decision-maker is how to choose the optimal combination from available development options.

The optimality question in sustainable development is very different from conventional economic (financial) analyses, where optimal condition means either profit maximization or cost minimization. In sustainable development, as elaborated in Chapter VIII, an optimality means that each development activity must not only be beneficial socioeconomically, but also environmentally safe. The latter consideration has been proved to be more intricate to deal with than the former. This is because one should understand how the receiving environment (ecosystem) functions and reacts to any perturbation caused by both human activities and natural forces. Meanwhile, our knowledge of ecosystem's functions and performances to perturbations (pollution and physical degradation) is barely adequate.

However, coastal planners and users are very frequently forced to make decisions regarding optimal choices of multiple-resource uses with little background data. In this case, a simulation modelling analysis based on incomplete information, such as the one in Chapter VIII, is still very useful in helping coastal decision-makers and planners to make rational decisions. It provides planners and decision-makers with a set of relationships between the economic and the ecological components of the modelled system. This type of information allows them to identify which activity is exerting negative impacts ("impact maker") and which activity is "impact taker". In addition, it provides them with a set of variables and functional relationships of the modelled system that need more detailed research, if the results of the model (e.g. its predictive capability) is expected to be more accurate.

After all, the result of any quantitative analysis (e.g. spatial planning and simulation modelling) is only one of many inputs to planning and decision-making processes of the CRM. The most appropriate management decision for coastal resources development is usually the one that combines such a quantitative basis with the scientifically intuitive judgement of a decision-maker, which is based upon her/his working experience with both the human and ecological systems under consideration.

9.1.2. Policies of the Post Oil and Gas Period

If development policies and programs during the oil and gas period are carried out based upon sustainable development principles (as prescribed in sub-section 9.1.1), the economy of the region in this post oil and gas period will be based on a stronger and more diversified economic base, particularly on the renewable resources. This scenario is expected to result in sustainable development of the region.

(1) Renewable Resource Development

Renewable resources which will be the main thrust for the future economic development in the region are agriculture, forests, fisheries, and animal husbandry (see also Table 9.1). The development of this primary-based sector includes not only the extractive, cultivation (rearing) and breeding activities, as commonly perceived, but also their down-stream activities, such as processing, marketing, and other agribusiness-related activities. Potential down-stream processing in the forestry sector include, for instance, high quality rattan furniture for export; activated charcoal; laminated, polyester and paper overlay plywood; wood veneer; and laminated board. This is important to ensure that added values, which can be generated through this primary-based sector, stay in the region.

It is noteworthy that sustainable principles should be applied throughout the process. Sustainable harvest and yields are required in the extraction of forests as well as fisheries resources. Environmental standards are essential to protect the environment from severe pollution.

(2) Industry and Manufacturing

Non-renewable resources which will be a basis for manufacturing and industrial activities in the area during this period are non-mineral resources, ranging from coal to quartz sands (see Chapter V). With an estimated coal reserve of some 3.6 billion tonnes and the current production rate of 800,000 tonnes (Chapter V), coal reserves in the area will last for approximately 4,500 years.

Processing and manufacturing industries from non-oil minerals include coal-based chemicals, cement, phosphate fertilizer, limestone meal for fertilizer, limestone for construction, ornamental stonework, ceramics, glass, tiles, and briquettes from coal.

9.1.3. Target Group-Oriented Development

It is timely to focus economic development in the region on people, not merely on foreign income generation. Development policies, which are currently dominated by a production and export orientation, should be balanced with a fairer distribution of income. Alternative livelihood programs for local people, who have been displaced by the current industrial development, are needed to prevent further encroachment on ecologically sensitive or critical habitats.

Development priority should be given first to the poor local people by providing technologically and economically accessible development projects, such as agriculture, aquaculture, and home industry. This must be supported by the development of their forward and backward linkages which include distributive services for farms inputs and consumer goods, financial (credit) services, marketing services, and extension services.

More local people, particularly the younger ones, should be employed in industrial development. This may be achieved by providing the necessary training and education. The capability and function of the regional Agency for Work Training (BLKK = Balai Latihan Keterampilan Kerja) should be strengthened to meet the demand for training.

9.1.4. Strengthening Provincial and Local Capabilities

The unique nature of coastal ecosystems, combined with the complexity of CRM, makes national objectives and approaches difficult to implement at the regional or local level. Therefore, a more decentralized approach to coastal resource planning and management, based on actual issues and local needs, is needed for sustainable coastal resource development. This approach, however, requires that provincial and local capabilities be improved.

In this context, provincial and local capabilities mean the managerial and budgetary capability of all development actors (governmental agencies, private businesses, non-governmental agencies, and educational institutions) in the region. The personnel of agencies and institutions involved in the development and management of coastal resources should be trained so that they can analyze management issues and develop plans as well as programs. Practical training courses in coastal resource management, and integrated planning and management are needed for planners, decision makers, and other development actors involved in CRM.

9.1.5. Public Education and Participation

As in other areas of resource management, CRM is essentially a management of people and their relationships (e.g. extraction, living space, and waste disposal) to coastal resources (Lemay and Hale, 1989). Consequently, public education should be promoted to provide a means of communicating CRM issues and programs to people and motivating them to change their attitudes in ways that are more compatible with sustainable development of coastal resources. Public education regarding CRM issues can be conducted through both formal systems (e.g. schools and universities) and informal systems (e.g. mass media, traditional shows, and "pesantren").

Furthermore, the public (local people) should also be involved in the formulation, implementation, and monitoring of CRM policies and programs. This is essential to nurture a sense of belonging in the public. The sense of belonging is probably the most fundamental element in creating a successful and lasting CRM. Since the majority of people in the coastal area have a very low education level, only their informal leaders and non-governmental agencies may represent them in such a public participation.

Public participation in development planning can be carried out, for instance, through the annual bottom-up planning process that enables project proposals to be made by Village Development Committee (LKMD), through sub-district meetings (Temu Karya Kecamatan), on to district level appraisal forum (Rakorbang Tk II), which select projects to be funded by the district development budget (APBD Tk II), or to be passed on to the Provincial Forum (Rakorbang Tk I), for feasible insertion in the Provincial Budget (APBD Tk I), or for possible consideration at national level consultations

(Konsultasi Nasional) for funding from the national budget (APBN).

9.2. ENVIRONMENTAL AND RESOURCE INFORMATION

Planning and management decisions for sustainable development of coastal resources can not be done merely by an intuitive approach (guesswork). Adequate and reliable information is required for developing such planning and management decisions. However, data gathering, processing, analysis, and dissemination can be extremely expensive, particularly for developing countries like Indonesia.

The management of environmental and resource information is, therefore, crucial in supporting sustainable coastal development. This section offers a strategy for managing such information which includes: (1) the identification of types and amount of data that are required for CRM; (2) database organization and analysis; and (3) methods for data gathering. The strategy is intended to develop an information system which is useful to the users and cost effective.

9.2.1. Types and Quantity of Data required for CRM

To identify the types and amount of data required for CRM correctly, one has to know what is the task of CRM. In this context, the task is to make planning and decisions with regard to the utilization of coastal resources on a sustainable basis (Chapter I and III). As described in Chapter II, at the core of sustainable development is the need to balance demand and supply of ecological endowments of a regional unit (e.g. coastal zone) under consideration. Thus, proper planning and decisions (policies and programs) for sustainable development require information on both supply and demand for ecological endowments, as well as their dynamic interactions.

The supply of ecological endowments is the capacity of a regional unit (coastal ecosystem) to provide space, natural resources (raw materials), waste reception, and life-support systems for the life and progress of a human community. Demand for ecological endowments is determined by population size and its characteristics (e.g. age structure, educational composition, and spatial distribution), and the standard of living. Technology is also important for sustainable development of coastal resources. This is because technology can enhance the capacity of natural ecosystem to supply ecological endowments through, among others, habitat reconstruction and rehabilitation (e.g. "Prokasih" and replanting programs), conservation, and preservation. On the demand side, technology, such as recycling and waste treatment plants, can reduce the human demand for ecological endowments.

Although not exhaustive, Table 9.2 combined with Table 7.6 (see Chapter VII) provides an example of the types and quantity of data required for planning and decision-making processes of sustainable coastal resource development in the study area. Another example of data and information requirements for the management of sustainable coastal resource development is the one that has been proposed for the FMG project (Figure 9.1).

The identification of data required for CRM can also be gained through "a user-survey approach". This means that the CRM database is created based upon the data requirements of each party (user) involved in the CRM. To be realistic, each party should identify its data requirement based on the real world condition which, in this case, constitutes: (1) coastal resource bases; (2) human community (users); (3) the interactions between these two systems; (4) problems and issues; and (5) the goal and objectives. A framework for the creation of an information system for the CRM is presented in Figure 9.2.

A valuable coastal information system is one that provides users with the necessary data appropriately organized so that they can make optimal decisions about the real world of CRM. The success of such an information system is determined by four major factors: the data set, the decision model, the decision criteria, and database organization (Aronoff, 1989).

Ideally, a comprehensive coastal database should constitute the real world of CRM. Almost all coastal databases, therefore, represent a model which is an abstraction of reality. So, the best coastal database is the one that has all the necessary information needed by users as determined by decision criteria; the minimum data quality requirement; and personnel, budget, and time constraints.

Figure 9.1. Information Content of the FMG System (Ricketts, McIver and Butler, 1989 quoted from Ricketts, 1991)

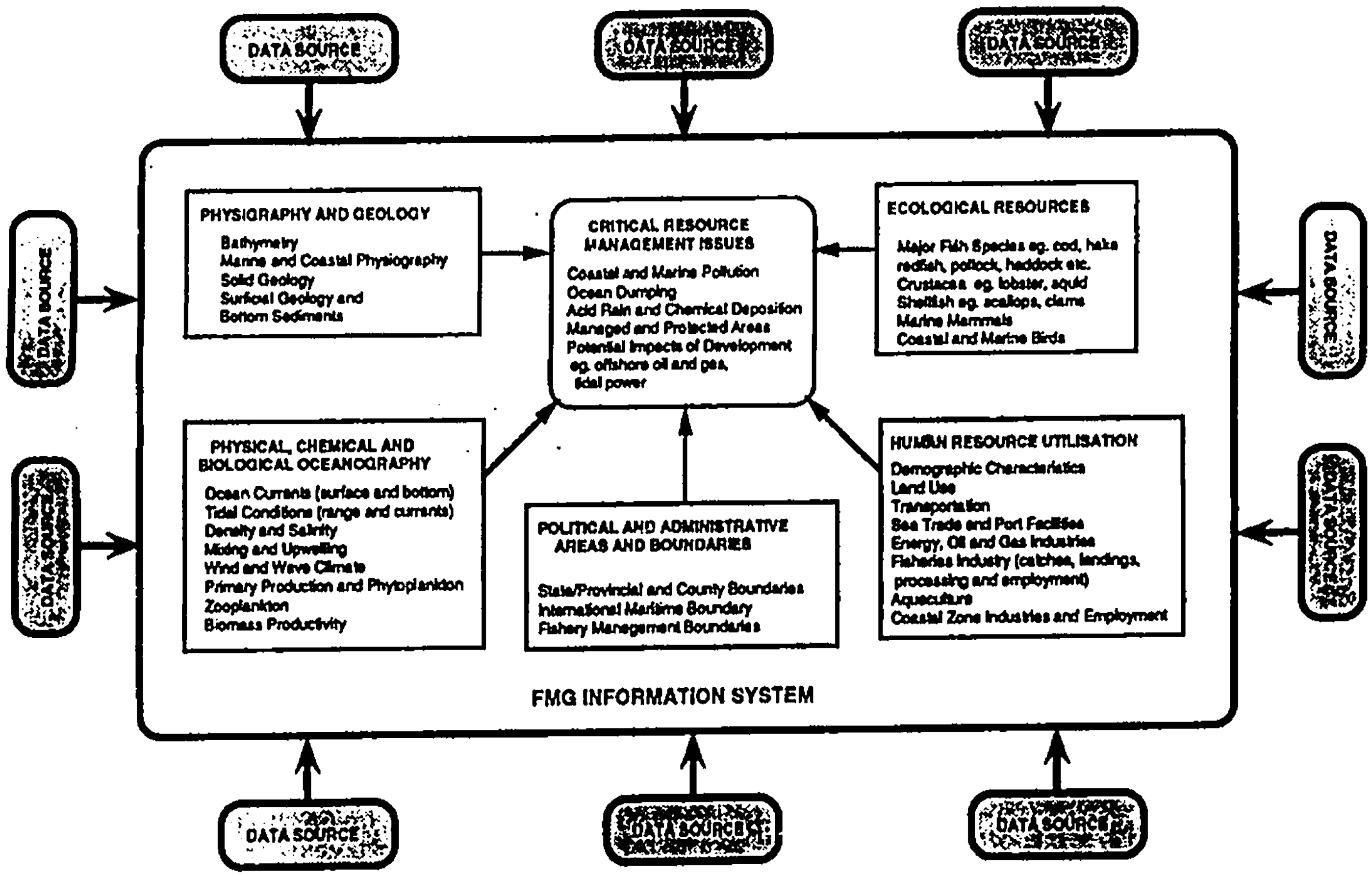


Table 9.2 An example of data and information required for planning and management of sustainable coastal resource development

Category (1)	Types of data and information (2)
A. Supply of ecological endowments	
1. Natural resources	- Types, potential, distribution, and condition. - The sustainable capacity: MSY, TAC, etc.
2. Waste reception	- Oceanographic and hydrometrological data that determine the assimilative capacity of coastal environment: transport paths of contaminants (advective and diffusive processes in solution or particulate states, gaseous transport and exchanges at interfaces, and biological transport and transfer); and biological and health effects. - Natural purification by coastal vegetation. - Distribution and concentration of contaminants in the coastal environment.
3. Spatial provision	- Spatial suitability and availability of the coastal zone (land and water) for various human uses (development activities) and natural functions (preservation and conservation zones).
4. Life support systems	- Conservation values: biodiversity and natural processes. - Geological, geomorphological, climatological, and hydrological characteristics. - Recreational values (amenities). - Natural hazards.
B. Demand for ecological endowments	
1. Demand for coastal land	- The present and future condition (extent and distribution) of development activities.
2. Demand for natural resources	- The existing and future utilization rate of coastal resources: types and number of development activities.
3. Rate of waste disposal	- Types and amount of waste discharges from all human (development) activities.
C. Human community	
1. Population	- The number and its spatial distribution. - Age structure, sex composition, education composition and the growth rate.
2. Aspiration for ecological endowments	- The standard of living, land and resource ownerships.
3. Infrastructures	- Transport networks, urban centers, marketing facilities, financial and extension services.

Table 9.2 (Continued)

Category (1)	Types of data and information (2)
D. Process-response systems	
1. Interregional linkages	- The relationships between poor upland management (e.g. deforestation) and coastal sedimentation and productivity, between river flows and the productivity of coastal waters, and between mangrove extent and the productivity of coastal fisheries.
2. Cross-sectoral impacts and externalities	- Impacts of development activities on coastal ecosystems. - Impacts of one development activity on another - Economic valuation of natural resource systems

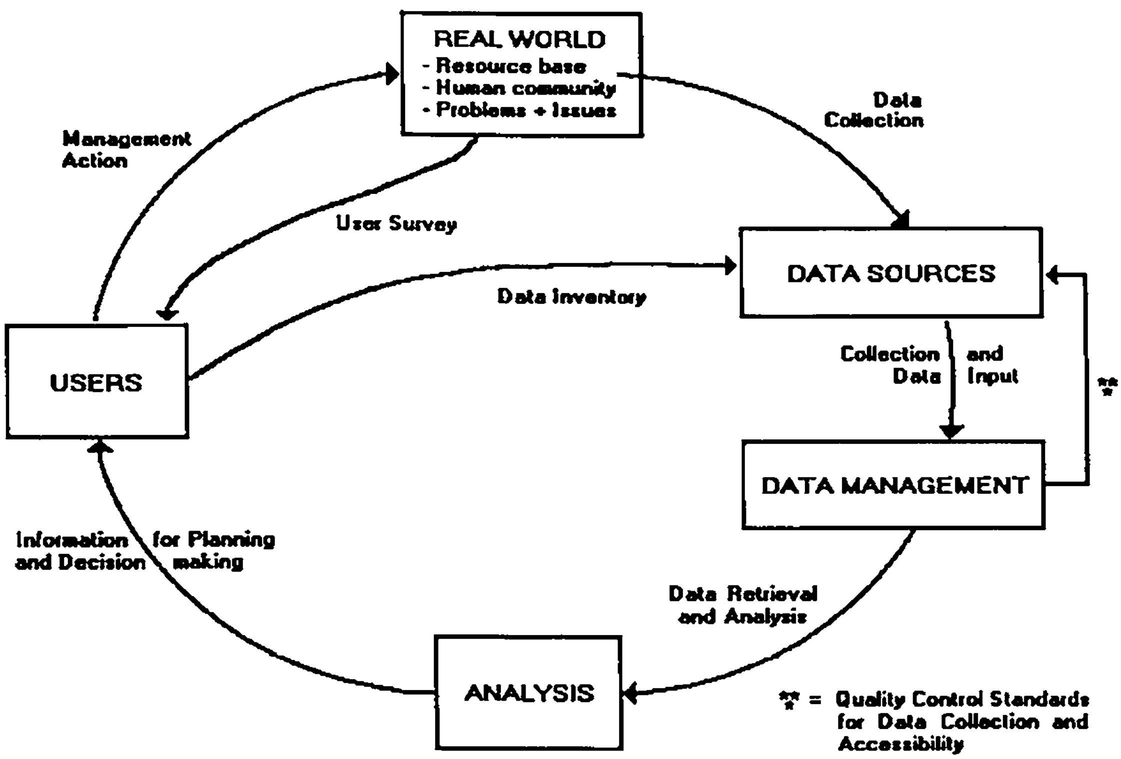


Figure 9.2. A Framework of Creating Information Systems for Coastal Resource Management (Modified from Aronoff, 1989))

Decision criteria in CRM are derived from its objectives. For example, if the objective of a certain CRM is just how to generate maximum profit, then data that should be collected will include only the capacity of coastal ecosystem to provide space and natural resources as well as their demand side, without any consideration of data on waste assimilative capacity and life-support systems. Accordingly, the decision model that is used to analyze the database, i.e. to test different results from several scenarios (based on the aforementioned criteria) can be represented, for instance, only by the overlay modelling (Chapter VII) and the economic sub-model of Chapter VIII.

However, if the objective of the CRM is to develop coastal resources on a sustainable basis, then the data that should be gathered are like those presented in Table 9.2. The decision models for such database include, for instance, both spatial overlay modelling (Chapter VII) and the entire ecologic and economic modelling of Chapter VIII. It is noteworthy that a good decision criterion is one that not only satisfies the decision-makers who establish the criteria, but also meets the needs and aspiration of people who will be affected by such a decision.

Quality of data is crucial for the success of planning and decision-making processes in CRM. The optimal data quality is the minimum level of quality that is required for appropriate decision-making. Five important aspects that determine data quality are accuracy, precision, timeliness, currency, and completeness (Aronoff, 1989). Accuracy measures how often, by how much, and how predictably the data will be correct. Precision measures the fitness of the scale used to describe the data. Time indicates at what point or over what period of time the data were collected. Currency measures how recently the data were collected. Completeness refers to the portion of the area of interest for which data are available.

The desire to collect the type and amount of data required for CRM is frequently constrained by budget, time, and personnel in the CRM organization. To overcome these constraints, an integrated information management approach is needed. Such an approach requires that all information users should be involved from the beginning of database development (i.e. the identification of types and amount of data needed by each user) to data analysis. This will cut costs by avoiding redundancy and overlapping in data collection, equipment purchased, and staff employed.

9.2.2. Database Organization and Analysis

Data that were collected will be meaningless if they can not be accessed by the users in the right place at the right time. For data to be useful, they have to be organized so that their inputting, storage, and retrieval processes can easily be carried out. Furthermore, to make data become valuable information for the users, they need to be analyzed according to user needs. The entire cycle of data processing (i.e. input, storage, retrieval, and presentation of output) and analysis constitutes an information system.

Because most data in the CRM context are related to spatial attributes (geographic location), it will be much more efficient if the organization and management of coastal data is handled by a geographic information system (GIS). For East Kalimantan Province, the data organization and management may be properly handled by the provincial Bappeda (Provincial Level Development Planning Board). This is simply because Bappeda is, so far , the only governmental agency that has GIS facilities. In addition, one of the major functions of Bappeda is to coordinate and plan all development activities taking place in the province.

Data retrieval and analysis will be much easier, if they are arranged under agreed and consistent subject headings. Detailed analyses for CRM requires data to be segregated into the smallest administrative unit possible, such as the village level. Data have also to be classified into consistent geographic (spatial) units. In terms of classification, major categories presented in Table 9.2 can be a good example for CRM purposes.

For the information management system to be more useful for sustainable coastal resource development, it should be equipped with an additional analytical capability that is able to combine the what if scenario question in both spatial and temporal dimensions. Such an analytical capability requires the combination of conventional GIS with the possibility of calling up mathematical models of various types and degree of complexities (i.e. statistical procedures, optimization algorithms, and simulation programs). This may be done through the interfacing between GIS and expert systems (Roberts and Ricketts, 1990).

9.2.3. Data Collection

The proposed information management system for CRM needs data input. In the context of East Kalimantan Province, data are not collected by Bappeda, which is in charge of managing the information system. Rather, they are gathered from technical departments at provincial to village levels, universities and research institutions, and from the private sector (e.g. oil and gas, coal, and timber companies).

There are three major weaknesses in the current data gathering system conducted by Bappeda. First, only a small fraction of the data (reports) from field research (ground surveys and remote sensing) carried out by private sectors and agencies from Java is submitted to the Bappeda. For example, almost all reports of EIA studies conducted by oil and gas-related companies, and coal companies are not submitted to Bappeda.

Second, most data collected by various agencies are without georeferences. This makes any type of spatial analysis and time-series analysis, which are essential for CRM, prohibitively difficult. In this context, georeferenced data are resource data that pertain to location on the earth's surface (e.g. longitude and latitude). With the availability and relatively inexpensive nature of the GPS (Geographic Positioning Satellite) tool, all field research should be encouraged to make georeferences for all data collected.

Third, Bappeda only collects and receives data from departmental agencies, universities, private companies, and others without having procedures to evaluate the quality of data. This is dangerous as the quality of data determine the quality of decisions produced.

9.3. INSTITUTIONAL ARRANGEMENTS

Institutional arrangements are needed to implement planning, policies, and programs of any CRM. Institutional arrangements refer to the composite of laws, customs, and organizations established by society to allocate scarce resources and competing values for a social goal, such as to govern a nation or to manage a nation's coastal environment and its resources (Sorensen et al., 1984). Currently, management of the coastal ecosystem and its resources in the region uses a sectoral approach. At least 14 governmental agencies are involved in CRM of East Kalimantan Province (Table 9.3).

Each sectoral agency has its own functions, and quite often disregards its cross-sectoral impacts and the relationships of various components of coastal ecosystems. This has caused overlapping of mandates and conflicts of interests among agencies. The situation becomes more complicated where there are vertical conflicts between governmental agencies of different administrative levels, i.e. central government, provincial government, and district-level government.

To resolve this problem, a more integrated and interdisciplinary institutional arrangement is needed to manage coastal resource utilization in the region. A coordination agency should be established to orchestrate and coordinate the

Table 9.3 Agencies and their Management Functions in CRM of East Kalimantan Province

Agencies	Policy and Plan making	Fund and/or construct projects and program	Regulation s (letting permit)	Levy Charge s	Acquire, manage and sell property	Taxatio n	Generate and Disseminat e Informatio n
1. Bappeda	*						*
2. Fisheries	*	*	*	*			*
3. Agriculture	*	*	*				*
4. Public Works	*	*			*		*
5. Forestry	*	*	*	*			*
6. Mines and Energy	*	*	*				
7. Communication and Transportation	*	*	*	*	*	*	
8. Industry	*	*	*	*			*
9. Transmigration	*	*			*		*
10. Governor Office	*	*	*	*	*	*	
11. Village Development (Bangda)	*	*					*
12. BKLH							*
13. Universities	*						*
14. BKPMD			*				
15. Trade			*				
16. DPRD	*		*				
17. NGO's	*	*					*

management functions of all agencies involved in the CRM listed in Table 9.3. Such a role can be played by the Bappeda of East Kalimantan Province by strengthening its authority and capability. This implies that all agencies involved in CRM, from central government to district levels, should consult and coordinate with Bappeda prior to the execution of any management function described in Table 9.3.

As far as laws and regulations for CRM are concerned, there have been enough of them. The problem is that there have been inadequate actions to target and enforce these regulations. For example, the violation of Governor Decree No.339/1988 concerning environmental standards by most industries along the Mahakam river, illegal mangrove cutting within Kutai National Park, and massive ammonia discharge by P.T. Pupuk Kaltim have not been penalized yet. There is an urgent need, therefore, to evaluate the justification of existing laws and regulations in terms of benefits and costs, as well as to streamline laws and regulations whenever appropriate.

It is understood that the above management framework for sustainable development of coastal resources can not entirely be implemented by the existing provincial and local capabilities at the present time. However, such a management framework can be used as a guide to the sustainable development of coastal resources. Indeed, the sustainable development of coastal resources can be achieved through an adaptive and incremental (step-by-step) approach of the proposed framework.

9.4. CONCLUSION

The application of sustainable development concept in practical planning and decision-making processes of coastal resource development requires the recognition of the supply capacity of the environment in providing ecological endowments and the assessment of human demand for them. To achieve sustainable coastal development, demand and supply for ecological endowments of the coastal zone should be in a balance. A systems approach used in this study, including GIS, simulation modelling, and policy analysis, has been very useful for systematically defining an integrated management framework for sustainable coastal resource development.

As the number of land systems suitable and available as large areas (more than 15,000 ha) is limited, except for sugarcane and oil palm, the successful food and estate crops as well as tambak production will rely on small-scale holders. The threat on the sustainable capacity of coastal ecosystems, in the form of physical degradation and water pollution, originates from both intensive high-technology development and poverty. Accordingly, policies and programs to enhance sustainable economic bases and to restore the degraded environment should simultaneously be undertaken. The budget for implementing these programs may be derived from the profit generated by the high technology development sector.

The implementation of a sustainable development concept in the management of coastal resource utilization requires a more decentralized approach to planning and decision-making processes by using smaller units, which involve local government and consider local potentials, needs and aspirations so that community is not lost. This could be carried out while maintaining the national and regional perspectives of the planning framework.

The management of sustainable coastal resource development should be based on the cyclical nature of resource management so that research (information collection)-planning -implementation-monitoring is built into an ongoing process. This principle underscores the need to begin implementation as soon as possible so that a feedback loop is created to improve the plan and better define the upcoming research needs. Understanding the process of this cycle, and incorporating, all the institutional and individual actors are important in its overall success.

APPENDICES

Notes:

Appendices are numbered based upon the chapter and the number of appendices within each associated chapter. For example, Appendix 3.1 means Appendix number one of Chapter I and Appendix 7.12 means Appendix number twelve of Chapter VII.

Appendix 3.1. A Brief Description of ARC/INFO GIS

ARC/INFO is a geographic information system (GIS), a set of computer programs, used to automate, manipulate, analyze, and display geographic data in digital form. It is characterized by: its model, the GIS functions it performs, its modular design, its ability to integrate many types of data, its utility for developing application-specific user interfaces with screen menus, its fourth generation macro language (AML), its open architecture which allows for the integration of numerous relational database management systems, and its ability to operate on many types of computers with a variety of graphic hardware.

ARC/INFO is designed so that logical groups of functions are organized within individual modules (subsystems). Thus, ARC/INFO contains a number of subsystems or programs, each having its own set of commands and logical functions. Five subsystems were used to accomplish the spatial planning analysis of this study: ARC, INFO, ARCEDIT, ARCPLOT, and ADS.

* ARC

ARC is the main program environment in ARC/INFO. It consists of commands which start each of the other subsystems and also has extensive capabilities like:

- Map coverage digitizing and editing
- Error discovery and verification commands used for map data automation
- Workspace and file management operations to list, rename, copy, delete, and describe map data files
- Coordinate projection and transformation functions useful for merging adjacent map sheets and for overlay functions
- Analytical operations including feature buffering, map overlay, nearest neighbour analysis, and reporting of summary statistics.

* INFO

INFO is a complete relational database manager for the tabular data associated with geographic features in map coverages. ARC/INFO keeps track of and updates map feature attribute tables which are stored as INFO data files. ARC/INFO maintains the relationships between each map feature and a corresponding tabular record. INFO can be used to manipulate and update each feature's attributes by performing logical and arithmetic operations on the rows and columns of the table. ARC/INFO is used to create data for map features and then INFO is applied to perform tabular and statistical analyses.

Many data types can be stored and manipulated as map feature attributes including integer numbers, decimal numbers, alphanumeric characters, and dates.

* ARCEDIT

ARCEDIT is a unique graphics and database editor that combines the capabilities of CAD functions with the power of a geographic database. It combines all of the facilities for digitizing map coverages, with a more comprehensive set of editing commands.

ARCEDIT can be used to edit feature attributes, add high quality text annotation, use other database layers as a background display, easily diagnose and correct digitizing errors, and perform rubbersheeting and map sheet edgematching.

ARCEDIT takes advantage of feature-based editing. It can be used to move, copy, add, delete, reshape, and update points, lines, areas, and map annotation. ARCEDIT can only be run by using graphic monitor or add a mouse and digitizer to digitize and enter map locations.

* ARCPLOT

ARCPLOT is the interactive cartographic and mapping subsystem of ARC/INFO. It can be used to perform all ARC/INFO mapping tasks to produce a great variety of map graphics from simple screen display to high quality cartographic plots for reports and presentations. Features from any number of map coverages can be selected for display and drawn with different symbols according to their geographic attributes.

ARCPLOT supports a variety of display devices. It can be used to create map graphic on the screen, as well as large format maps which can be plotted on pen plotters, electrostatic plotters, or graphic printers that are available on the host computer.

* ADS

The ADS (ARC Digitizing System) is a simple system used to digitize and perform edits on line, area, and point features. ADS provides full digitizing capabilities with an easy-to-learn menu interface so that anyone can quickly learn to use ADS.

In ADS, a series of menus will appear on the graphic screen. To select the menu option, just press digitizer buttons. Then the user may begin digitizing. For detailed editing, the user can define a window and zoom in for a closer look. For more sophisticated editing and for adding cartographic enhancements, ARCEDIT is used.

Appendix 3.2. Biophysical Requirements for Wetland Rice
(FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)		30 - 32	33 - 35	> 35
Annual Mean Temperature (C)	25 - 29	22 - 24	18 - 21	< 18
Water Availability (W)				
1. Dry month (<75 mm)	0 - 3	3.1 - 9	9.1 - 9.5	> 9.5
2. Mean Annual Rainfall (mm)	> 1500	1200 - 1500	800 - 1200	< 800
Rooting Conditions (r)				
1. Soil drainage class	4, 5	6, 7	3	1, 2
2. Soil texture	3, 4	2, 5	1, 5	1
3. Rooting depth (cm)	> 50	41 - 50	20 - 40	< 20
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 3	2	1	
2. Ph (surface soil)	5.5 - 7.0	7.1 - 8.0	8.1 - 8.5	> 8.5
		4.5 - 5.4	4.0 - 4.6	< 4.0
Nutrient availability (n)				
1. Available P2O5	5	4	3 - 2	1
2. Available K2O	=> 3	2	1	
Toxity (x)				
Salinity (mmhos/cm)	< 3	3.1 - 5.0	5.1 - 8.0	> 8.0
Terrain (S)				
1. Slope (%)	0 - 3	3 - 5	5.1 - 8.0	> 8.0
2. Rock outcrops (%)	0		> 2	

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirement for Upland (Dryland) Rice (FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)		27 - 30	31 -32	> 32
Annual Mean Temperature (C)	20 - 26	18 -19	16 17	< 16
Water Availability (W)		8.1 - 8.5	8.6 - 9	> 9
1. Dry month (<75 mm)	5 - 8	< 5		
2. Mean Annual Rainfall (mm)	> 1500	1500 - 1000	1000 - 750	< 750
Rooting Conditions (r)				
1. Soil drainage class	3, 4	5, 6	7, 2	1
2. Soil texture	3, 4	2, 3, 5	1, 5	1, 6
3. Rooting depth (cm)	> 60	40 - 59	20 - 39	< 20
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=>3	2	1	
2. Ph (surface soil)	5.0 - 6.0	6.1 - 7.0	7.1 - 8.5	> 8.5
		4.5 - 4.9	4.0 - 4.5	< 4.0
Nutrient availability (n)				
1. Available P2O5	=> 4	3	2	1
2. Available K2O	=> 2	1		
Toxity (x)				
Salinity (mmhos/cm)	< 3	3 - 5	5 - 8	> 8
Terrain (S)				
1. Slope (%)	0 - 5	5 - 15	15 - 24	> 24
2. Rock outcrops (%)	0		1	=> 2

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Maize
(FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)			31 - 32	> 32
Annual Mean Temperature (C)	20 - 26	27 - 30	18 - 20	< 18
Water Availability (W)				
1. Dry month (<75 mm)	1 - 7	7.1 - 8.0	8.1 - 9.0	> 9.0
2. Mean Annual Rainfall (mm)	> 1200	1200 - 900	900 - 600	< 600
Rooting Conditions (r)				
1. Soil drainage class	3, 4	5	6, 2	7, 1
2. Soil texture	3, 4	2, 5	1, 5	1, 6
3. Rooting depth (cm)	> 60	40 - 59	20 - 39	< 20
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 3	2	1	
2. Ph (surface soil)	6.0 - 7.0	7.1 - 7.5	7.6 - 8.5	> 8.5
		5.9 - 5.5	5.4 - 5.0	< 5.0
Nutrient availability (n)				
1. Available P2O5	5	4	3 - 2	1
2. Available K2O	=> 3	2	1	
Toxity (x)				
Salinity (mmhos/cm)	< 2	2 - 4	5 - 8	> 8
Terrain (S)				
1. Slope (%)	0 - 5	5 - 15	15 - 20	> 20
2. Rock outcrops (%)	0		1	=> 2

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Soybean
(FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)		29 - 30	31 - 32	> 32
Annual Mean Temperature (C)	23 - 28	20 - 22	18 - 19	< 18
Water Availability (W)		< 3		
1. Dry month (<75 mm)	3.0 - 7.5	7.6 - 8.5	8.6 - 9.5	> 9.5
2. Mean Annual Rainfall (mm)	1000 - 1500	1500 - 2500	2500 - 3500	> 3500
		700 - 1000	500 - 700	< 500
Rooting Conditions (r)				
1. Soil drainage class	3, 4	2	5, 6	1, 7
2. Soil texture	3, 4	2, 5	1, 5, 6	1, 6
3. Rooting depth (cm)	> 50	30 - 49	15 - 29	< 15
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 3	2	1	
2. Ph (surface soil)	6.0 - 7.0	7.1- 7.5	7.6 - 8.5	> 8.5
		5.5 - 5.9	5.0 - 5.4	< 5.0
Nutrient availability (n)				
1. Available P2O5	=> 4	3	2 - 1	
2. Available K2O	=> 1			
Toxity (x)				
Salinity (mmhos/cm)	< 2.5	2.5 - 4.0	4.0 - 8.0	> 8.0
Terrain (S)				
1. Slope (%)	0 - 5	5 - 15	15 - 20	> 20
2. Rock outcrops (%)	0		1	=> 2

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Cocoa
(FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)		29 - 32	33 - 35	> 35
Annual Mean Temperature (C)	25 - 28	20 - 24		< 20
Water Availability (W)				
1. Dry month (<75 mm)	0		1 - 2	> 2
2. Mean Annual Rainfall (mm)	1500 - 2500	> 2500		
		1200 - 1500	1000 - 1200	< 1000
Rooting Conditions (r)				
1. Soil drainage class	3	5, 4	2	7, 6, 1
2. Soil texture	2, 3, 4	1, 5	5, 6	1
3. Rooting depth (cm)	> 150	100 - 149	60 - 99	< 60
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 4	3	2	1
2. Ph (surface soil)	5.0 - 6.5	6.6 - 7.5	7.6 - 8.5	> 8.5
		4.5 - 4.9	< 4.5	
Nutrient availability (n)				
1. Available P2O5	=> 3	2	1	
2. Available K2O	=> 2	1		
Toxity (x)				
Salinity (mmhos/cm)	< 1	1 - 3	3 - 6	> 6
Terrain (S)				
1. Slope (%)	0 - 8	8 - 15	15 - 50	> 50
2. Rock outcrops (%)	0	1	2	=> 3

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Rubber
(FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)		31 - 34		> 34
Annual Mean Temperature (C)	26 - 30	24 - 25	22 - 23	< 22
Water Availability (W)				
1. Dry month (<75 mm)	0	1	2	> 2
2. Mean Annual Rainfall (mm)	2500 - 4000	4000		
		2000 - 2500	1500 - 2000	< 1500
Rooting Conditions (r)				
1. Soil drainage class	3	4, 2	5	7, 6, 1
2. Soil texture	2, 3, 4	1, 5	5, 6	1, 6
3. Rooting depth (cm)	> 200	130 - 199	80 - 129	< 80
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 3	2	1	
2. Ph (surface soil)	4.0 - 7.0	7.1 - 7.5	7.6 - 8.5	> 8.5
		3.0 - 3.9	< 3.0	
Nutrient availability (n)				
1. Available P2O5	=> 4	3	2	1
2. Available K2O	=> 2	1		
Toxity (x)				
Salinity (mmhos/cm)	< 1	1 - 3	3 - 6	> 6
Terrain (S)				
1. Slope (%)	0 - 8	8 - 15	15 - 50	> 50
2. Rock outcrops (%)	0	1	2	=> 3

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Oil Palm
(FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings S1	S2	S3	N
Temperature Regime (t)	24 - 28	29 - 32	33 - 34	> 34
Annual Mean Temperature (C)		22 - 23	20 - 21	< 20
Water Availability (W)				
1. Dry month (<75 mm)	0 - 1	1.1 - 2	2.1 - 3	> 3
2. Mean Annual Rainfall (mm)	2000 - 3000	3000 - 4000	4000 - 6000	> 6000
		1750 - 2000	1500 - 1750	< 1500
Rooting Conditions (r)				
1. Soil drainage class	4, 3	6, 5	2	7, 1
2. Soil texture	2, 3, 4	1, 5	5, 6	1
3. Rooting depth (cm)	> 100	70 - 99	45 - 69	< 45
Nutriont Retention (f)				
1. CEC (me/100 gr soil)	=> 3	2	1	
2. Ph (surface soil)	5.0 - 6.0	6.1 - 7.0	7.1 - 8.5	> 8.5
		4.5 - 4.9	< 4.5	
Nutrient availability (n)				
1. Available P2O5	=> 3		2	1
2. Available K2O	=> 2		1	
Toxity (x)				
Salinity (mmhos/cm)	< 2	2 - 3	3 - 6	> 6
Terrain (S)				
1. Slope (%)	0 - 8	8 - 15	15 - 50	> 50
2. Rock outcrops (%)	0	1	2	=> 3

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Banana (FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)				
Annual Mean Temperature (C)	25 - 27	28 - 29 23 - 24	30 - 32 19 - 22	>32 < 19
Water Availability (W)				
1. Dry month (<75 mm)	0 - 1	1.1 - 2.0	2.2 - 3.0	> 3
2. Mean Annual Rainfall (mm)	2000 - 4000	4000 - 5000 1500 - 2000	1000 - 1500	> 5000 < 1000
Rooting Conditions (r)				
1. Soil drainage class	4, 3	2	6, 5	7, 1
2. Soil texture	2, 3, 4	1, 5	5, 6	1
3. Rooting depth (cm)	> 100	70 - 99	45 - 69	< 45
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 3	2	1	
2. Ph (surface soil)	6.0 - 7.0	7.1 - 7.5 5.0 - 5.9	7.6 - 8.5 < 5.0	> 8.5
Nutrient availability (n)				
1. Available P2O5	=> 3	2	1	
2. Available K2O	=> 4		3	2 - 1
Toxity (x)				
Salinity (mmhos/cm)	< 2	2 - 3	3 - 6	> 6
Terrain (S)				
1. Slope (%)	0 - 8	8 - 15	15 - 50	> 50
2. Rock outcrops (%)	0	1	2	=> 3

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Coconut
(FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)	25 - 28	29 - 32	33 - 34	> 34
Annual Mean Temperature (C)		23 - 24	21 - 22	< 21
Water Availability (W)				
1. Dry month (<75 mm)	0 - 1	1.1 - 2.0	2.1 - 4.0	> 4.0
2. Mean Annual Rainfall (mm)	2000 - 3000	3000 - 5000	> 5000	
		1300 - 1200	1000 - 1300	< 1000
Rooting Conditions (r)				
1. Soil drainage class	3	4, 2	5, 1	7, 6
2. Soil texture	1, 2, 3, 4	5	1, 5, 6	1
3. Rooting depth (cm)	> 150	90 - 149	40 - 89	< 40
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 4	3	2	1
2. Ph (surface soil)	5.5 - 7.0	7.1 - 7.5	7.6 - 8.5	> 8.5
		5.0 - 5.4	4.0 - 4.9	< 4.0
Nutrient availability (n)				
1. Available P2O5	=> 3	2	1	
2. Available K2O	=> 3	2	1	
Toxity (x)				
Salinity (mmhos/cm)	<2	2 - 4	4 - 8	> 8
Terrain (S)				
1. Slope (%)	0 - 8	8 - 15	15 - 50	> 50
2. Rock outcrops (%)	0	1	2	=> 3

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Sugarcane
(FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)		31 - 32	33 - 34	> 34
Annual Mean Temperature (C)	25 - 30	23 - 24	21 - 22	< 21
Water Availability (W)				
1. Dry month (<75 mm)	1 - 3	< 1	3.1 - 5.0	> 5.0
2. Mean Annual Rainfall (mm)	1500 - 4000	1200 - 1500	< 4000	
			1000 - 1200	< 1000
Rooting Conditions (r)				
1. Soil drainage class	3, 4	5	6, 2	7, 1
2. Soil texture	2, 3, 4	1, 5	5, 6	1
3. Rooting depth (cm)	> 75	55 - 74	30 - 54	< 30
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 4	3	2	1
2. Ph (surface soil)	5.5 - 7.0	7.1 - 7.5	7.6 - 8.5	> 8.5
		4.5 - 5. 4	4.0 - 4.4	< 4.0
Nutrient availability (n)				
1. Available P2O5	5	4	3 - 2	1
2. Available K2O	=> 3	2	1	
Toxity (x)				
Salinity (mmhos/cm)	< 3.5	3.5 - 5.5	5.5 - 12	> 12
Terrain (S)				
1. Slope (%)	0 - 8	8 - 15	15 - 20	> 20
2. Rock outcrops (%)	0		1	=> 2

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for
Leucaena Leucochepala/
Agroforestry (FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)		31 - 34	> 34	-
Annual Mean Temperature (C)	21 - 30	19 - 20	< 19	-
Water Availability (W)		< 3		
1. Dry month (<75 mm)	3 - 4	4.1 - 6.0		> 6.0
2. Mean Annual Rainfall (mm)	750 - 1000	1000 - 2000	> 2000	-
		750 - 600	< 600	
Rooting Conditions (r)				
1. Soil drainage class	4, 3, 2	5, 1	7, 6	-
2. Soil texture	3, 4, 5	1, 2, 5	5	
3. Rooting depth (cm)	> 50	< 50	-	-
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	-	-	-	-
2. Ph (surface soil)	7.8 - 8.0	8.1 - 8.5		> 8.5
		6.0 - 6.9	5.0 - 5.9	< 5.0
Nutrient availability (n)				
1. Available P2O5	-	-	-	-
2. Available K2O	-	-	-	-
Toxity (x)				
Salinity (mmhos/cm)	< 4	4 - 8	-	> 8
Terrain (S)				
1. Slope (%)	0 - 15	15 - 30	30 - 50	> 50
2. Rock outcrops (%)	0	1	2 - 3	=> 4

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.2 (cont.) Biophysical Requirements for Pasture/Livestock (FAO/CSR, 1983)

Land Characteristics Group by Land Qualities	Land Suitability Ratings			
	S1	S2	S3	N
Temperature Regime (t)				
Annual Mean Temperature (C)	20 - 30	31 - 35 18 - 19	36- 40 12 - 17	> 40 < 12
Water Availability (W)				
1. Dry month (<75 mm)	0	0 - 2	2.1 - 6.0	> 6.0
2. Mean Annual Rainfall (mm)	1500 - 4000	4000 - 6000 1000 - 1500	400 -1000	> 6000 < 400
Rooting Conditions (r)				
1. Soil drainage class	5, 4, 3	6, 2	7, 1	-
2. Soil texture	2, 3, 4, 5	1, 5	1, 6	1
3. Rooting depth (cm)	=> 30	20 - 29	15 - 19	< 15
Nutrient Retention (f)				
1. CEC (me/100 gr soil)	=> 3	2	1	-
2. Ph (surface soil)	5.0 - 6.5	6.6 - 7.0 4.5 - 4.9	7.1 - 8.5 < 4.5	> 8.5
Nutrient availability (n)				
1. Available P2O5	=> 4	3	2 - 1	-
2. Available K2O	=> 2	1	-	-
Toxity (x)				
Salinity (mmhos/cm)	< 3	3 - 5	5 - 10	> 10
Terrain (S)				
1. Slope (%)	0 - 8	8 - 15	15 - 30	> 30
2. Rock outcrops (%)	0	1	2 - 3	=> 4

Notes:
S1 = highly suitable
S2 = moderately suitable
S3 = poorly suitable
N = not suitable

Appendix 3.3 Biophysical Requirements for Tambak (Brackishwater Fish/Shrimp Pond)

Criteria parameter	Criteria range
1. TOPOGRAPHY	
Slope (%)	0 - 2
Relief	Flat - undulating
Elevation (cm above mean sea level)	0 - 150
2. SOIL	
Texture	Sandy clay to clay loam
Organic (%)	<= 10 - 20
Depth of potential cat clay (cm)	> 150 - 100
pH	4.0 - 7.0
3. TIDAL CHARACTERISTICS	
Tidal range (m)	0.5 - 3.5
Amplitude	
- Daily fluctuation (m)	0.5 - 2.0
- Maximum annual fluctuation (m)	3.0
4. CLIMATIC CONDITION	
Av annual rainfall (mm)	1000 - 3600
Dry months (mean <100 mm)	1 - 5
Rainfall (day/year)	100 - 170
5. WATER	
Temperature (°C)	25 - 32
Suspended matter (g m^3)	<500 - 10000
pH	5.5 - 9.5
Salinity (ppt)	5 - 45
Dissolved oxygen (ppm)	3.0 - 5.0
Alkalinity (meq/l)	1.0 - >2.0
Free CO_2 (ppm)	0 - 40000
Total hardness (meq/l eq to $CaCO_3$ ppm)	10 - >20-
Amonia (ppm)	0 - 0.5

Sources: Direktorat Bina Program Perikanan; D K Hussain et.al. (1984); van Hengel et.al. (1986), quoted from LRDC/ Bina Program (1987).

Appenxix 3.4. Biophysical Characteristics of a Land System (MPT)
based on LRDC/Bina Program (1987)

LAND SYSTEM: MAPUT(MPT) AREA: 26,336km^2 : REF NO KTS 27 :
PROVINCES: 19=5,233km^2, 21=23,892km^2, 20=2,444km^2, :
LAND TYPE: sedimentary hills, non-orientated :
LAND REGION: sed,other sed,hills DESAUNETTES CODES DOM:H33 INC: H32, :
SATELLITE SCENES: / / ,of / / ; / / ,of / / :
AERIAL PHOTOS: 23F/Y7 /002, / / , / / , / / , / / :
RADAR: Star 1 1718-1 :

LITHOLOGY: sedimentary INDURATION: hard
GRADE: mixed MINERALOGY: felsic
ROCK TYPE: sandstone, shale, mudstone, marl ROCK OUTCROP 5%:
WATER GROUNDWATER: none DOMESTIC SOURCE: rain, perennial river :
FISHERIES: river RIVERS FLOOD RISK: none INUNDATION: none
CLIMATE MEAN ANNUAL RAIN: 1600-4400mm WET MTHS: 0-12 DRY MTHS: 0-3 GROWING
PERIOD ARABLE: 210-365d TREE CROPS: 150-365d MEAN TEMP:min 15-23oC max 22-31oC:
VEGETATION/LAND USE: moist primary lowland forest, submontane forest, shifting
cultivation. AREA USED: %:
ACCELERATED EROSION EXTENT: local EVIDENCE: gulley :
SOIL GT GPS DOMINANT>60%: Tropudults ASSOCIATED 20-60%: Dystropepts
TEXTURE TOP/SUB SOIL DOM: mod.fine/mod.fine
ASSOCIATED 20-60%: mod.fine/fine :
SOIL CHARACTERISTICS OF DOMINANT SOIL GREAT GROUP
DEPTH PEAT: 0-10cm MINERAL SOIL: 26-50cm DRAINAGE: well drained
EXCH K TOP: low SUB: v.low TOTAL K TOP: low SUB: v.low
AVAIL P TOP: low SUB: v.low TOTAL P TOP: low SUB: v.low
CEC pH7 TOP: low SUB: v.low pH(H20) TOP: 4.6-5.0 SUB: 4.6-5.0
Al SATN TOP: SUB: EXCH Al TOP: n SUB: n
ACID SULPHATE HAZARD AT:. cm SALINITY: mmhos/cm EC at 25oC:

ALTITUDE MIN: 0m MAX: 1500m RANGE 0-1500m: PLAN/PROF DOM: 4 INC: 4P, :
DRAINAGE PATTERN: dendritic DENSITY: >4.0k/k2 VAR: low :
SLOPE STEEPNESS: 41-60% VAR: med LENGTH: 101-200m VAR: med CURVATURE: straight:
SLOPE DISTBN VALLEYS(0-3%) 5% INTERFLUVES(0-8%) 5% (9-25%) 10% (26-40%) 30%:
RELIEF AMPLITUDE: 51-300m VAR: med : TERRAIN: hilly :
CRESTS SHAPE: irregular LENGTH: 1001-5000m VAR: med WIDTH: <50m VAR: low :
SPURS PROMINENCE: clear STEEPNESS: >40%:
VALLEY FLOOR WIDTH: 25-200m VAR: med :
FACETS 1 slope 95% area 2 floodplain 5% area 3 % area:
FRAGMENTATION VALLEYS: small blocks INTERFLUVES: small blocks:

RELIABILITY GROUNDWATER QUALITY:#, WATER SOURCE:2, FLOODING/INUNDATION:3,
CLIMATE:2, SOIL GROUP:2, SOIL TEXTURE:2, SOIL DEPTH:2, SOIL DRAINAGE:2,
SOIL NUTRIENTS:2, ELEVATION:2, SLOPE:3, FACETS:3, FRAGMENTATION:3.

Appendix 3.5. Thirteen Biophysical Characteristics of Land Systems in the Study Area

No	Land system	Annual mean temperature	Dry month	Mean annual rainfall	Soil drainage class	Soil texture	Rooting depth	CEC	pH	Available P2O5	Available K2O	Salinity	Slope (%)	Rock outcrop (%)
1	PTG	23 - 31	0 - 3	1600 - 3200	1	2, 5	> 150	*	*	*	*	> 4.0	< 2	0
2	KJP	23 - 31	0 - 3	1600 - 3900	7	5	> 150	*	6.1 - 6.5	*	*	> 4.0	< 2	0
3	KHY	23 - 31	0 - 3	1600 - 3900	6	5	> 150	*	*	*	*	< 4.0	< 2	0
4	TNJ	23 - 31	0 - 3	1700 - 3300	5	5	101 - 150	3	4.6 - 5.0	3	3	< 4.0	< 2	0
5	GBT	23 - 31	0 - 3	1700 - 3900	7	6	> 200	5	4.6 - 5.0	3	1	< 4.0	< 2	0
6	BLI	23 - 31	0 - 3	1700 - 3500	7	5	> 150	3	5.1 - 5.5	3	2	< 4.0	< 2	0
7	BKN	22 - 30	0 - 3	1800 - 3300	6	4	> 150	3	5.1 - 5.5	3	2	< 4.0	< 2	0
8	MGH	23 - 31	0 - 1	1800 - 2200	6	4	101 - 150	3	5.1 - 5.5	3	2	< 4.0	2 - 8	0
9	BRH	23 - 31	0 - 1	1900 - 3000	7	1	76 - 100	*	*	*	*	< 4.0	< 2	0
10	LWW	22 - 28 30 - 31	0 - 6	1600 - 4400	3	4	101 - 150	2	4.0 - 4.5	2	2	< 4.0	2 - 8	0
11	KPR	23 - 31	0 - 1	1600 - 2700	3	4	26 - 50	4	6.6 - 7.3	2	4	< 4.0	2 - 8	10
12	TWH	22 - 23 20 - 31	0 - 6	1600 - 4400	3	4	101 - 150	2	4.0 - 4.5	2	2	< 4.0	16 - 25	0
13	TWB	21 - 23 29 - 31	0 - 1	1800 - 4400	3	2, 4	101 - 150	2	4.0 - 4.5	2	2	< 4.0	16 - 40	0
14	MPT	15 - 23 22 - 31	0 - 2	1600 - 4400	3	4	26 - 50	2	4.6 - 5.0	2	2	< 4.0	41 - 60	5
15	GBJ	23 - 31	0 - 1	1600 - 2100	3	4, 5	0 - 10	3	6.6 - 7.3	3	3	< 4.0	16 - 25	60
16	MTL	20 - 23 28 - 31	0 - 6	1800 - 4400	3	2	101 - 150	2	4.6 - 5.0	2	2	< 4.0	41 - 60	5
17	LH	18 - 23 25 - 31	0 - 1	1800 - 4200	3	4	26 - 50	2	4.6 - 5.0	2	2	< 4.0	> 60	5
18	PDH	12 - 23 19 - 30	0 - 3	1800 - 4400	3	2, 4	26 - 50	*	*	*	*	< 4.0	41 - 60	5
19	OKI	20 - 23 28 - 31	0 - 3	1600 - 4200	*	4, 1	0 - 10	5	6.6 - 7.3	3	3	< 4.0	> 60	90

Appendix 3.5 (Continued)

Note:

* Soil drainage class:

1 = excessively drained
2 = somewhat excessively drained
3 = well drained
4 = moderately well drained
5 = somewhat poorly drained
6 = poorly drained
7 = very poorly drained

* Soil texture:

1 = coarse texture (loamy sand, sand)
2 = moderately coarse texture (sandy loam)
3 = medium texture (loam, silt loam, silt)
4 = moderately fine texture (clay loam, silty clay loam, sandy clay loam)
5 = fine texture (heavy clay, clay, sandy clay, silty clay)
6 = massive, or organic soil

* CEC = Cation Exchange Capacity (in milliequivalent per 100 grams of soil as measured by the NH_4OA_c, pH 7 method):

1 = very low (less than 5)
2 = low (5 - 16)
3 = medium (17 - 24)
4 = high (25 - 40)
5 = very high (greater than 40)

* Available P_2O_5 (in ppm):

1 = very low (less than 10)
2 = low (10 - 15)
3 = medium (16 - 25)
4 = high (26 - 35)
5 = very high (greater than 35)

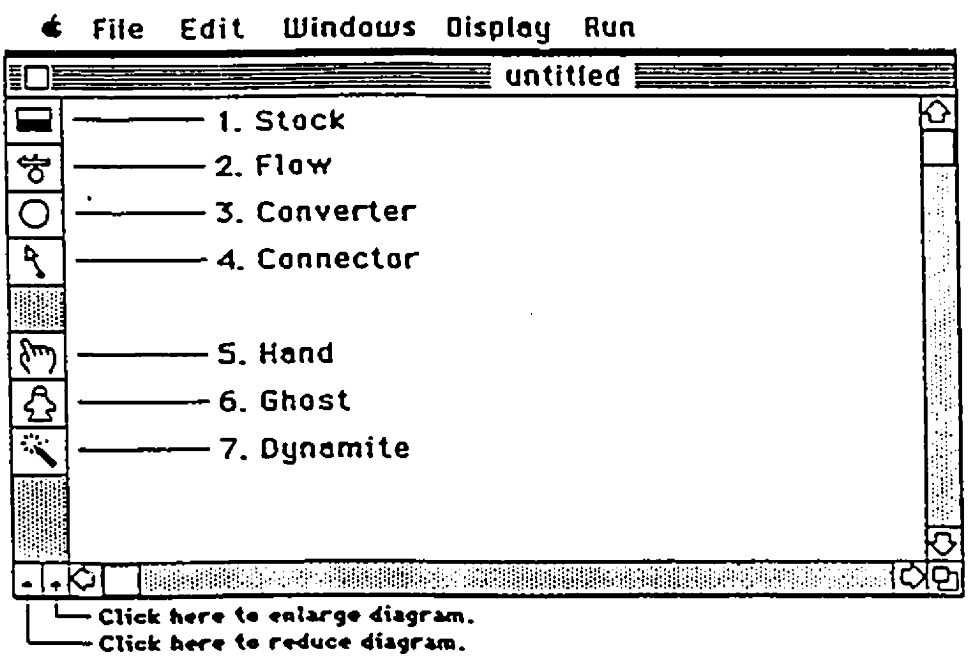
* Available K_2O (in ppm):

1 = very low (less than 10)
2 = low (10 - 20)
3 = medium (21 - 40)
4 = high (41 - 60)
5 = very hidh (greater than 60)

Appendix 3.6. A Brief Description of STELLA

STELLA, which is an acronym for Systems Thinking, Experiential Learning Laboratory with Animation, is designed to enable people to build an intuition for the dynamics generated by systems involving interdependent relationships. This simulation software can only be run within the Macintosh. STELLA takes advant ge of the Macintosh graphic user interface by using symbols, windows, and menus to design and run simulations.

STELLA uses symbols that are based on a set designed by Jay Forrester of the Massachusetts Institute of Technology. In STELLA, this graphic language, known as systems dynamics, consists of four structural elements: (1) stock, (2) flow, (3) converter, and (4) connector (see the following diagram window). These four elements are the only building blocks that the user needs to construct diagrams to dynamically model and simulate any system of interest. Below the structural elements is a "tool kit" containing three tools (hand, ghost, and dynamite) which enable the user to position, define, replicate and detonate the elements in the diagram.



Stocks (the box symbol) are the generic symbol for anything that accumulates. For instance, water accumulates in a bathtub, pollutants may accumulate in a body of waters, and money accumulates in people's bank accounts. Determining how the stocks (state variables) of the system change over time is conceptually very simple: the rate of change of a state variable is equal to what comes in minus what goes out during a given time period.

In STELLA, the flow symbol specifies inflow and outflow. One uses the mouse to grab the flow symbol and drag it into a stock to define an inflow or away from the stock to define an outflow. The flow icon consists of a hollow pipe with an arrow on one end and a "cloud" on the other. The pipes are conduits for carrying flows of things into and out of stocks. Flows are regulated by the little spigots attached to the top of each pipe. The equations that govern the rate of flow are indicated by the circles below the flow lines. The circle is called a "converter" because it takes inputs and "converts" them into outputs. The "cloud" is the symbol that STELLA uses to indicate that the user does not care about where whatever is flowing comes from, or where it goes. If the user does care, the cloud could be replaced by a stock. Then, an inflow to one stock would be an outflow from another. And conversely, an outflow from one stock would be an inflow to another. Clouds thus define the boundary of the model.

The fourth structural element, the connector, is used to connect a converter to another converter or to a stock. This is to represent inputs, not inflows, from one converter to another or to a stock. The connector can not be used to link a stock to another stock or to a converter.

The dynamite symbol is used to eliminate any structural elements in a model diagram. The ghost symbol is used to put symbols in the background to reduce clutter on the screen. STELLA's ghost tool enables the user to replicate another stock, flow or converter which already exists in the model. The "ghosted" entity takes on all of characteristics of its "living" counterpart. The diagram can extend over several pages and can be expanded or contracted. To display parts of a large diagram, the user can scroll horizontally or vertically.

In addition to the diagram and graph windows, STELLA has a table window for displaying numerical output, and an equation window for displaying the mathematical relationships of variables in the model in the current system diagram.

The advantage of STELLA is the ease with which the user can change the model and see effects of those changes on the system's behaviour (performances). Adding other variables to the model is also easy. The user can create complex models in stages, checking the results at each stage.

Appendix 7.1. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Wetland Rice Based on Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overal rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	3	3	3	0	1	3	*	*	*	*	1	3	3	r2	0
2	KJP (kajapah)	3	3	3	2	1	3	*	3	*	*	1	3	3	r2 x	1
3	KHY (Kahayan)	3	3	3	2	1	3	*	*	*	*	2	3	3	r2	1
4	TNJ (Tanjung)	3	3	3	2	1	3	3	2	1	3	2	3	3	r2 n2	1
5	GBT (Gambut)	3	3	3	2	1	3	3	2	1	1	2	3	3	r2 n2 n3	1
6	BLI (Belti)	3	3	3	2	1	3	3	2	1	2	2	3	3	r2 n2	1
7	BKN (Bakunan)	3	3	3	2	3	3	3	2	1	2	2	3	3	n2	1
8	MGH (Mangkaho)	3	3	3	2	3	3	3	2	1	2	2	1	3	n2 s1	1
9	BRH (Barah)	3	3	3	2	0	3	*	*	*	*	2	3	3	f2 n2	0
10	LWW (Lawanguwang)	2	2	3	1	3	3	2	1	1	2	2	2	3	r: f2 n2	1
11	KPR (Kapor)	3	3	3	1	3	2	3	2	1	3	2	1	0	s3	0
12	TWH (Teweh)	2	2	3	1	3	3	2	1	1	2	2	0	3	s1	0
13	TWB (Tewai Baru)	2	3	3	1	2	3	2	1	1	2	2	0	3	s1	0
14	GBJ (Gunung Baju)	3	3	3	1	1	0	3	3	1	2	2	0	0	r3 s1 s3	0
15	MPT (Maput)	2	3	3	1	2	1	2	2	1	2	2	0	0	s1 s3	0
16	MTL (Mantalat)	2	2	3	1	2	3	2	1	1	2	2	0	0	s1 s3	0
17	LHI (Lahai)	2	3	3	1	3	1	2	1	1	2	2	0	0	s1 s3	0
18	PDH (Pendreh)	0	3	3	1	2	1	*	*	*	*	2	0	0	l s1 s3	0
19	OKI (Oki)	2	3	3	*	0	0	3	2	1	3	2	0	0	r1 r2 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable

S2 = 2 = moderately suitable

S3 = 1 = marginally suitable

N = 0 = not suitable

* = data not available

Appendix 7.2. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Dryland Rice Based on Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	2	2	3	0	2	3	*	*	*	*	0	3	3	r1 x	0
2	KJP (kajapah)	2	2	3	1	1	3	*	2	*	*	0	3	3	x	0
3	KHY (Kahayan)	2	2	3	2	1	3	*	*	*	*	2	3	3	r2	1
4	TNJ (Tanjung)	2	2	3	2	1	3	3	2	2	3	2	3	3	r2	1
5	GBT (Gambut)	2	2	3	1	0	3	3	2	2	2	2	3	3	r2	0
6	BLI (Beliti)	2	2	3	1	1	3	3	3	2	3	2	3	3	r1 r2	1
7	BKN (Bakunan)	2	2	3	2	3	3	3	3	2	3	2	3	3	t w1 r1 n2 x	2
8	MGH (Mangkaho)	2	2	3	2	3	3	3	3	2	3	2	2	3	t w1 r1 n2 x s1	2
9	BRH (Barah)	2	2	3	1	0	3	*	*	*	*	2	3	3	r3	0
10	LWW (Lawanguwang)	3	2	3	3	3	3	2	1	1	2	2	1	3	f2 n2 s1	1
11	KPR (Kapor)	2	2	3	3	3	1	3	2	1	3	2	2	0	s3	0
12	TWH (Teweh)	2	2	3	3	3	3	2	1	1	3	2	1	3	f2 n2 s1	1
13	TWB (Tewai Baru)	3	2	3	3	2	3	2	1	1	3	2	0	3	s1	0
14	GBJ (Gunung Baju)	2	2	3	3	3	1	3	2	2	3	2	1	0	r3 s3	0
15	MPT (Maput)	3	2	3	3	3	1	2	1	1	3	2	0	0	s1 s3	0
16	MTL (Mantalat)	3	2	3	3	2	3	2	1	1	3	2	0	0	s1 s3	0
17	LHI (Lahai)	2	2	3	3	3	1	2	1	1	3	2	0	0	s1 s3	0
18	PDH (Pendreh)	3	2	3	3	2	1	*	*	*	*	2	0	0	s1 s3	0
19	OKI (Okki)	3	2	3	*	0	0	3	2	2	3	2	0	0	r1 r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable

S2 = 2 = moderately suitable

S3 = 1 = marginally suitable

N = 0 = not suitable

* = data not available

Appendix 7.3. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Maize Based on Biophysical Criteria
(FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	2	3	3	0	2	3	*	*	*	*	0	3	3	r1 x	0
2	KJP (Kajapah)	2	3	3	0	1	3	*	3	*	*	0	3	3	r1 x	0
3	KHY (Kahayan)	2	3	3	1	1	3	*	*	*	*	2	3	3	r1 r2	1
4	TNJ (Tanjung)	2	3	3	1	1	3	3	0	1	3	2	3	3	f2	0
5	GBT (Gambut)	2	3	3	0	0	3	3	0	1	1	2	3	3	r1 r2 f2	0
6	BLI (Befiti)	2	3	3	0	1	3	3	1	1	2	2	3	3	r1	0
7	BKN (Bakunan)	3	3	3	1	3	3	3	1	1	2	2	3	3	r1 f2 n2	1
8	MGH (Mangkaho)	2	3	3	1	3	3	3	1	1	2	2	1	3	r1 f2 n2 s1	1
9	BRH (Barah)	2	3	3	0	0	3	*	*	*	*	2	3	3	r1 r2	0
10	LWW (Lawanguwang)	3	3	3	3	3	3	2	0	1	1	2	1	3	f2	0
11	KPR (Kapor)	2	3	3	3	3	1	3	3	1	3	2	1	0	s3	0
12	TWH (Teweh)	2	3	3	3	3	3	2	0	1	2	2	0	3	f2 s1	0
13	TWB (Tewai Baru)	2	3	3	3	2	3	2	0	1	2	2	0	3	f2 s1	0
14	GBJ (Gunung Baju)	2	3	3	3	3	0	3	3	1	3	2	0	0	s1 s3	0
15	MPT (Maput)	3	3	3	3	3	1	2	0	1	2	2	0	0	f2 s1 s3	0
16	MTL (Mantalat)	3	3	3	3	2	3	2	0	1	2	2	0	0	f2 f1 f3	0
17	LHI (Lahai)	1	3	3	3	3	1	2	0	1	2	2	0	0	f2 s1 s3	0
18	PDH (Pendreh)	0	3	3	3	2	1	*	*	*	*	2	0	0	[illegible] s1 s3	0
19	OKI (Okai)	3	3	3	*	0	0	3	3	1	3	2	0	0	r2 r3 s1 s3	0

Suitability ratings :
S1 = 3 = highly suitable
S2 = 2 = moderately suitable
S3 = 1 = marginally suitable
N = 0 = not suitable
* = data not available

Appendix 7.4. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for
Soybean Based on Biophysical Criteria
(FAO/CSR, 1983)

No	Land systems	t	w1	w2	r1	r4	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	3	2	2	0	2	3	*	*	*	*	0	3	3	r1 x	0
2	KJP (Kajapah)	3	2	1	0	1	3	*	3	*	*	0	3	3	r1 x	0
3	KHY (Kahayan)	3	2	1	1	1	3	*	*	*	*	2	3	3	w2 r1 r2	1
4	TNJ (Tanjung)	3	2	1	1	1	3	3	0	2	3	2	3	3	f2	0
5	GBT (Gambut)	3	2	1	0	0	3	3	0	2	3	2	3	3	r1 r2 f2	0
6	BLI (Beliti)	3	2	1	0	1	3	3	1	2	3	2	3	3	r1	0
7	BKN (Bakunan)	3	2	1	1	3	3	3	1	2	3	2	3	3	w2 r1 f2	1
8	MGH (Mangkaho)	3	2	2	1	3	3	3	1	2	3	2	1	3	r1 f2 s1	1
9	BRH (Barah)	3	2	2	0	0	3	*	*	*	*	2	3	3	r1 r2	0
10	LWW (Lawanguwang)	3	2	1	3	3	3	2	0	1	3	2	1	3	f2	0
11	KPR (Kapor)	3	2	2	3	3	2	3	3	1	3	2	1	0	s3	0
12	TWH (Teweh)	2	2	1	3	3	3	2	0	1	3	2	0	3	f2 s1	0
13	TWB (Tewai Baru)	2	2	1	3	2	3	2	0	1	3	2	0	3	f2 s1	0
14	GBJ (Gunung Baju)	3	2	2	3	3	1	3	3	2	3	2	0	0	s1 s3	0
15	MPT (Maput)	0	2	1	3	3	1	2	0	1	3	2	0	0	t f2 s1 s3	0
16	MTL (Mantalat)	2	2	1	3	2	3	2	0	1	3	2	0	0	f2 s1 s3	0
17	LHI (Lohai)	2	2	1	3	3	1	2	0	1	3	2	0	0	f2 s1 s3	0
18	PDH (Pendreh)	0	2	1	3	2	1	*	*	*	*	2	0	0	t s1 s3	0
19	OKI (Oki)	2	2	1	*	0	0	3	1	2	3	2	0	0	r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable
S2 = 2 = moderately suitable
S3 = 1 = marginally suitable
N = 0 = not suitable
* = data not available

Appendix 7.5. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Cocoa Based on Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	3	1	3	0	1	3	*	*	*	*	0	3	3	r1	0
2	KJP (kajapah)	3	1	2	0	2	3	*	3	*	*	0	3	3	r1 x	0
3	KHY (Kahayan)	3	1	2	0	2	3	*	*	*	*	2	3	3	r1	0
4	TNJ (Tanjung)	3	1	2	0	2	2	2	2	3	3	2	3	3	r1	0
5	GBT (Gambut)	3	1	2	0	1	3	3	2	3	2	2	3	3	r1	0
6	BLI (Beliti)	3	1	2	0	1	3	2	3	3	3	2	3	3	r1	0
7	BKN (Bakunan)	2	1	2	0	3	3	2	3	3	3	2	3	3	r1	0
8	MGH (Mangkaho)	3	1	3	0	3	2	2	3	3	3	2	3	3	r1	0
9	BRH (Barah)	3	1	3	0	0	1	*	*	*	*	2	3	3	r1 r2	0
10	LWW (Lawanguwang)	2	0	2	3	3	2	1	1	2	2	2	3	3	w1	0
11	KPR (Kapor)	3	1	3	3	3	0	3	2		3	2	3	3	r3	0
12	TWH (Teweh)	2	0	2	3	3	2	1	1	2	3	2	1	3	w1	0
13	TWB (Tewai Baru)	2	1	2	3	3	2	1	1	2	3	2	1	3	w1 f1 f2 s1	1
14	GBJ (Gunung Baju)	3	1	3	3	3	0	2	2	3	3	2	1	0	r3 s3	0
15	MPT (Maput)	2	1	2	3	3	0	1	2	2	3	2	0	0	r3 s1 s3	0
16	MTL (Mantalat)	2	0	2	3	3	2	1	2	2	3	2	0	0	w1 s1 s3	0
17	LHI (Lohai)	2	1	2	3	3	0	1	2	2	3	2	0	0	r3 s1 s3	0
18	PDH (Pendreh)	0	1	2	3	3	0	*	*	*	*	2	0	.	t r3 s1 s3	0
19	OKI (Okki)	2	1	2	*	0	0	3	2	3	3	2	0	0	r2 r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable

S2 = 2 = moderately suitable

S3 = 1 = marginally suitable

N = 0 = not suitable

* = data not available

Appendix 7.6. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Rubber Based on Biophisycal Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	3	0	3	0	1	2	•	•	•	•	1	3	3	w1 r1	0
2	KJP (kajapah)	3	0	3	0	1	2	•	3	•	•	1	3	3	w1 r1	0
3	KHY (Kahayan)	3	0	3	0	1	2	•	•	•	•	2	3	3	w1 r1	0
4	TNJ (Tanjung)	3	0	3	0	0	3	3	3	2	2	2	3	3	w1 r1 r2	0
5	GBT (Gambut)	3	0	3	0	1	2	3	3	2	3	2	3	3	w1 r1	0
6	BLI (Beliti)	3	0	3	0	1	2	3	3	2	3	2	3	3	w1 r1	0
7	BKN (Bakunan)	3	0	3	0	3	2	3	3	2	3	2	3	3	w1 r1	0
8	MGH (Mangkaho)	3	2	1	0	3	1	3	3	2	•	2	3	3	r1	0
9	BRH (Barah)	3	2	2	0	0	1	•	•	•	•	2	3	3	r1 r2	0
10	LWW (Lawanguwang)	1	0	3	3	3	1	2	3	1	2	2	3	3	w1	0
11	KPR (Kapor)	3	2	1	3	3	0	3	3	1	3	2	3	3	r3	0
12	TWH (Teweh)	1	0	3	3	3	1	2	3	1	3	2	1	3	w1	0
13	TWB (Tewai Baru)	1	2	3	3	3	1	2	3	1	3	2	1	3	t r3 r2 s1	1
14	GBJ (Gunung Baju)	3	2	1	3	3	0	3	3	2	3	2	1	0	r3 s3	0
15	MPT (Maput)	2	0	3	3	3	0	2	3	3	3	2	0	0	w1 r3 s1 s3	0
16	MTL (Mantalai)	3	0	3	3	3	1	2	3	1	3	2	0	0	w1 s1 s3	0
17	LHI (Lahai)	3	2	3	3	3	0	2	3	1	3	2	0	0	r3 s1 s3	0
18	PDH (Pendreh)	0	0	3	3	3	0	•	•	•	•	2	0	0	t w1 r3 s1 s3	0
19	OKI (Okai)	1	0	3	•	0	0	3	3	2	3	2	0	0	w1 r2 r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable

S2 = 2 = moderately suitable

S3 = 1 = marginally suitable

N = 0 = not suitable

• = data not available

Appendix 7.7. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Oil Palm Based on Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	3	3	3	0	1	3	*	*	*	*	1	3	3	r1	C
2	KJP (kajapah)	3	3	2	0	1	3	*	2	*	*	1	3	3	r1	0
3	KHY (Kahayan)	3	3	2	2	1	3	*	*	*	*	1	3	3	r2 x	1
4	TNJ (Tanjung)	3	3	3	2	1	3	3	2	3	3	2	3	3	r2	1
5	GBT (Gamuut)	3	3	2	0	1	3	3	2	3	1	2	3	3	r1	0
6	BU (Belli)	3	3	3	0	1	3	3	3	3	3	2	3	3	r1	0
7	BKN (Bakunan)	3	3	3	2	3	3	3	3	3	3	2	3	3	r1 x	2
8	MGH (Mangkaho)	3	3	2	2	3	3	3	3	3	3	2	3	3	w2 r1 x	2
9	BRH (Barah)	3	3	3	0	0	2	*	*	*	*	2	3	3	r1 r2	0
10	LWW (Lawanguwang)	2	0	2	3	3	3	2	1	1	1	2	3	3	w1	0
11	KPR (Kapar)	3	3	3	3	3	0	3	2	1	3	2	3	0	r3 s3	0
12	TWH (Teweh)	2	0	2	3	3	3	2	1	1	3	2	1	3	w1	0
13	TWB (Tewai Baru)	2	3	2	3	3	3	2	1	1	3	2	1	3	f2 n2 s1	1
14	GBJ (Gunung Baju)	3	3	2	3	3	0	3	2	3	3	2	1	0	r3 s3	0
15	MPT (Maput)	2	3	2	3	3	0	2	?	1	3	2	0	0	r3 s1 s3	0
16	MTL (Mantalal)	2	0	2	3	3	3	2	2	1	3	2	0	0	w1 s1 s3	0
17	LHI (Lohai)	2	3	2	3	3	0	2	2	1	3	2	0	0	r3 s1 s3	0
18	PDH (Pendreh)	0	3	2	3	3	0	*	*	*	*	2	0	0	t r3 s1 s3	0
19	OKI (Okki)	2	3	2	*	0	0	3	2	3	3	2	0	0	r2 r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable
S2 = 2 = moderately suitable
S3 = 1 = marginally suitable
N = 0 = not suitable
* = data not available

Appendix 7.8. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Banana Based or Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	2	3	3	0	1	3	*	*	*	*	1	3	3	r1	0
2	KJP (kajapah)	2	3	3	0	1	3	*	3	*	*	1	3	3	r1	0
3	KHY (Kahayan)	2	3	3	1	1	3	*	*	*	*	2	3	3	r1 r2	1
4	TNJ (Tanjung)	2	3	3	1	1	3	3	1	3	1	2	3	3	r1 r2 f2 n3	1
5	GBT (Gambut)	2	3	3	0	1	3	3	1	3	0	2	3	3	r1 n3	0
6	BLI (Befiti)	2	3	3	0	1	3	3	2	3	0	2	3	3	r1 n3	0
7	BKN (Bakunan)	2	3	3	1	3	3	3	2	3	0	2	3	3	n3	0
8	MGH (Mangkaho)	2	3	2	1	3	3	3	2	3	0	2	3	3	n3	0
9	BRH (Baroh)	2	3	3	0	0	2	*	*	*	*	2	3	3	r1 r2	0
10	LWW (Lawanguwang)	2	0	3	3	3	3	2	1	2	0	2	3	3	w1 n3	0
11	KPR (Kapor)	2	3	3	3	3	0	3	3	2	1	2	3	0	r3 s3	0
12	TWH (Teweh)	2	0	3	3	3	3	2	1	2	0	2	1	3	w1 n3	0
13	TWB (Tewai Baru)	2	3	2	3	3	3	2	1	2	0	2	1	3	n3	0
14	GBJ (Gunung Baju)	2	3	2	3	3	0	3	3	3	1	2	1	0	r3 s3	0
15	MPT (Maput)	1	3	3	3	3	0	2	1	2	0	2	0	0	r3 n3 s1 s3	0
16	MTL (Mantalat)	2	0	3	3	3	3	2	1	2	0	2	0	0	w1 n3 s1 s3	0
17	LHI (Lohai)	2	3	3	3	3	0	2	1	2	0	2	0	0	r3 n3 s1 s3	0
18	PDH (Pendreh)	0	3	3	3	3	0	*	*	*	*	2	0	0	t r3 s1 s3	0
19	OKI (Okki)	2	3	3	*	0	0	3	2	3	1	2	0	0	r2 r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable

S2 = 2 = moderately suitable

S3 = 1 = marginally suitable

N = 0 = not suitable

* = data not available

Appendix 7.9. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Coconut Based on Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	2	1	3	1	1	3	*	*	*	*	1	3	3	w1 r1 r2 x	1
2	KJP (kajapah)	2	1	2	0	1	3	*	3	*	*	1	3	3	r1	C
3	KHY (Kahayan)	2	1	2	0	1	3	*	*	*	*	2	3	3	r1	0
4	TNJ (Tanjung)	2	1	3	0	1	2	2	1	3	3	2	3	3	r1	0
5	GBT (Gambut)	2	1	2	0	1	3	3	1	3	1	2	3	3	r1	0
6	BLI (Befiti)	2	1	2	0	1	3	2	2	3	2	2	3	3	r1	0
7	BKN (Bakunan)	2	1	3	0	3	3	2	2	3	2	2	3	3	r1	0
8	MGH (Mangkaho)	2	3	2	0	3	2	2	2	3	2	2	3	3	r1	0
9	BRH (Barah)	2	3	3	0	0	1	*	*	*	*	2	3	3	r1 r2	0
10	LWW (Lawanguwang)	2	0	2	3	3	2	1	1	2	1	2	3	3	w1	0
11	KPR (Kapar)	2	3	3	3	3	0	3	3	2	3	2	3	0	r3 s3	0
12	TWH (Teweh)	2	0	2	3	3	2	1	1	2	2	2	1	3	w1	0
13	TWB (Tewai Baru)	2	3	2	3	3	2	1	1	2	2	2	1	3	f1 f2 s1	1
14	GBJ (Gunung Baju)	2	3	2	3	3	0	2	1	3	3	2	1	0	r3 s3	C
15	MPT (Maput)	2	1	3	3	3	0	1	1	2	2	2	0	0	r3 s1 s3	0
16	MTL (Mantalat)	2	0	2	3	3	2	1	1	2	2	2	0	0	w1 s1 s3	0
17	LHI (Lohai)	2	3	2	3	3	0	1	1	2	2	2	0	0	r3 s1 s3	0
18	PDH (Pendreh)	0	1	2	3	3	0	*	*	*	*	2	0	0	t r3 s1 s3	0
19	OKI (Okki)	2	1	2	*	0	0	3	3	3	3	2	0	0	r2 r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable

S2 = 2 = moderately suitable

S3 = 1 = marginally suitable

N = 0 = not suitable

* = data not available

Appendix 7.10. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Sugarcane Based on Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	3	3	3	0	1	3	*	*	*	*	1	3	3	r1	0
2	KJP (Kajnpah)	3	3	3	0	1	3	*	3	*	*	1	3	3	r1	0
3	KHY (Kahayan)	3	3	3	1	1	3	*	*	*	*	3	3	3	r1 r2	1
4	TNJ (Tanjung)	3	3	3	1	1	3	2	2	1	3	3	3	3	r1 r2 n2	1
5	GBT (Gambut)	3	3	3	0	1	3	3	2	1	1	3	3	3	r1	0
6	BLI (Beliti)	3	3	3	0	1	3	2	2	1	2	3	3	3	r1	0
7	BKN (Bakunan)	3	3	3	1	3	3	2	2	1	2	3	3	3	r1 n2	1
8	MGH (Mangkaho)	3	2	3	1	3	3	2	2	1	2	3	3	3	r1 n2	1
9	BRH (Barah)	3	2	3	0	0	3	*	*	*	*	3	3	3	r1 r2	0
10	LWW (Lawangwang)	2	3	3	3	3	3	1	1	1	1	3	3	3	f1 f2 n2 n3	1
11	KPR (Kapor)	3	2	3	3	3	1	3	3	1	3	3	3	0	s3	0
12	TWH (Teweh)	2	3	3	3	3	3	1	1	1	2	3	0	3	s1	0
13	TWB (Tewai Baru)	2	2	3	3	3	3	1	1	1	2	3	0	3	s1	0
14	GBJ (Gunung Baju)	3	3	3	3	3	1	2	3	2	3	3	0	0	s1 s3	0
15	MPT (Maput)	2	2	3	3	3	1	1	2	1	2	3	0	0	s1 s3	0
16	MTL (Mantalat)	2	3	3	3	3	3	1	2	1	2	3	0	0	s1 s3	0
17	LHI (Lohai)	0	2	3	3	3	1	1	2	1	2	3	0	0	t s1 s3	0
18	PDH (Pendreh)	0	3	3	3	3	1	*	*	*	*	3	0	0	t s1 s3	0
19	OKI (Okki)	2	3	3	*	0	0	3	3	1	3	3	0	0	r2 r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable

S2 = 2 = moderately suitable

S3 = 1 = marginally suitable

N = 0 = not suitable

* = data not available

Appendix 7.11. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Agro Forestry Based on Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	3	2	1	2	1	3	+/-	+/-	+/-	+/-	2	3	3	w2 r2	1
2	KJP (kajapah)	3	2	1	1	1	3	+/-	2	+/-	+/-	2	3	3	w2 r1 r2	1
3	KHY (Kahayan)	3	2	1	1	1	3	+/-	+	+/-	+/-	2	3	3	w2 r1 r2	1
4	TNJ (Tanjung)	3	2	1	1	1	3	-	0	-	-	3	3	3	f2	0
5	GBT (Gambut)	3	2	1	1	1	3	-	0	-	-	3	3	3	f2	0
6	BLI (Beliti)	3	2	1	1	1	3	-	1	-	+/-	3	3	3	w2 r1 r2 f2	1
7	BKN (Bakunan)	3	2	1	1	3	3	-	1	-	+/-	3	3	3	w2 r1 f2	1
8	MGH (Mangkaho)	3	2	2	1	3	3	-	1	-	+/-	3	3	3	r1 f2	1
9	BRH (Barah)	3	2	1	1	2	3	+/-	+	+/-	+/-	3	3	3	w2 r1	1
10	LWW (Lawanguwang)	3	2	1	3	3	3	-	0	-	-	3	3	3	f2	0
11	KPR (Kapor)	3	2	1	3	3	2	-	2	-	-	3	3	0	s3	0
12	TWH (Teweh)	3	2	1	3	3	3	-	0	-	-	3	2	3	f2	0
13	TWB (Tewai Baru)	3	2	1	3	2	3	-	0	-	+/-	3	1	3	f2	0
14	GBJ (Gunung Baju)	3	2	1	3	3	2	-	2	-	-	3	2	0	s3	0
15	MPT (Maput)	3	2	2	3	3	2	-	0	-	-	3	0	0	f2 s1 s3	0
16	MTL (Mantalat)	3	2	1	3	2	3	-	0	-	-	3	0	0	f2 s1 s3	0
17	LHI (Lahai)	3	2	1	3	3	2	-	0	-	-	3	0	0	f2 s1 s3	0
18	PDH (Pendreh)	3	2	1	3	2	2/-	+/-	+	+/-	+/-	3	0	0	s1 s3	0
19	OKI (Okki)	3	2	1	+	2	2	-	2	-	-	3	0	0	s1 s3	0

<u>Suitability ratings :</u>

S1 = 3 = highly suitable

S2 = 2 = moderately suitable   + = 9

S3 = 1 = marginally suitable   - = 8

N = 0 = not suitable   +/- = 7

+ = data not available

- = no criteria available

Appendix 7.12. The Suitability Ratings of Landsystems in East Kalimantan Coastal Zone for Pasture Based on Biophysical Criteria (FAO/CSR, 1988)

No	Land systems	t	w1	w2	r1	r2	r3	f1	f2	n2	n3	x	s1	s3	Limiting factors	Overall rating
		Average annual temp	Dry month	Average annual rainf.	Soil drain class	Soil texture	Rooting depth	CEC	pH	Avail P205	Avail K20	Salinity	Slope	Rock outcrop		
1	PTG (Puting)	3	2	3	1	3	3	*	*	*	*	1	3	3	r1 x	1
2	KJP (kajapah)	3	2	3	1	2	3	*	3	*	*	1	3	3	r1 x	1
3	KHY (Kahayan)	3	2	3	2	2	3	*	*	*	*	3	3	3	w1 r1	2
4	TNJ (Tanjung)	3	2	3	2	2	3	3	2	2	3	3	3	3	w1 r1 r2 f2 n2 n3	2
5	GBT (Gambut)	3	2	3	1	1	3	3	2	2	2	3	3	3	r1 r2	1
6	BLI (Belti)	3	2	3	1	2	3	3	3	2	3	3	3	3	r1	1
7	BKN (Bakunan)	3	2	3	2	3	3	3	3	2	3	3	3	3	w1 r1 n2	2
8	MGH (Mangkaho)	3	2	3	2	3	3	3	3	2	3	3	3	3	w1 r1 r2	2
9	BRH (Barah)	3	2	3	1	0	3	*	*	*	*	3	3	3	r2	0
10	LWW (Lawanguwang)	3	1	3	3	3	3	2	1	1	2	3	3	3	w1 n2 f2	1
11	KPR (Kapar)	3	2	3	3	3	3	3	2	1	3	3	3	0	s3	0
12	TWH (Teweh)	3	1	3	3	3	3	2	1	1	3	3	1	3	w1 f2 n2 s1	1
13	TWB (Tewai Baru)	3	2	3	3	3	3	2	1	1	3	3	0	3	s1	0
14	GBJ (Gunung Baju)	3	2	3	3	3	0	3	2	2	3	3	1	0	r3 s3	0
15	MPT (Maput)	3	2	3	3	3	3	2	2	1	3	3	0	0	s1 s3	0
16	MTL (Mantalat)	3	1	3	3	3	3	2	2	1	3	3	0	0	s1 s3	0
17	LHI (Lohai)	3	2	3	3	3	3	2	2	1	3	3	0	0	s1 s3	0
18	PDH (Pendreh)	3	2	3	3	3	3	*	*	*	*	3	0	0	s1 s3	0
19	OKI (Okki)	3	2	3	*	2	0	3	2	2	3	3	0	0	r3 s1 s3	0

Suitability ratings :

S1 = 3 = highly suitable

S2 = 2 = moderately suitable

S3 = 1 = marginally suitable

N = 0 = not suitable

* = data not available

Appendix 7.13. The Suitability Rating of Land Systems for Tambak and Quarrying (LRDC/Bina Program, 1987).

Land systems	Tambak	Quarrying
PTG	N	N
KJP	S	N
KHY	S	N
TNJ	N	N
GBT	N	S
BLI	N	N
BKN	N	N
MGH	N	N
BRH	N	S
LWW	N	S
KPR	N	S
TWH	N	S
TWB	N	S
GBJ	N	S
MPT	N	S
MTL	N	S
LHI	N	S
PDH	N	S
OKI	N	S

Notes:

- N = not suitable
- S = suitable

Appendix 7.14. The Area of Land Systems by Suitability Classes for Fourteen Development Activities in Muara Jawa, Anggana and Samarinda Sub-region (in km^2)

NO.	DEVELOPMENT ACTIVITIES	S2												
		BKN	BLI	KHY	KJP	LHI	LWW	MGH	MPT	MTL	PTG	TWB	TWH	TOTAL
1	Wetland Rice													
2	Dryland Rice	3.1558						27.4624						30.6182
3	Maize													
4	Soybean													
5	Cocoa													
6	Rubber													
7	Oil Palm	3.1558						27.4624						30.6182
8	Banana													
9	Coconut													
10	Sugar Cane													
11	Agro Forestry													
12	Pasture	3.1558		170.733				27.4624						201.3513
13	Tambak													
14	Swamping													

NO.	DEVELOPMENT ACTIVITIES	S3												
		BKN	BLI	KHY	KJP	LHI	LWW	MGH	MPT	MTL	PTG	TWB	TWH	TOTAL
1	Wetland Rice	3.1558	68.7293	170.733	1112.4922		29.5274	27.4624						1,412.1002
2	Dryland Rice		68.7293	170.733			29.5274						432.3403	701.3301
3	Maize	3.1558		170.733				27.4624						201.3513
4	Soybean	3.1558		170.733				27.4624						201.3513
5	Cocoa											163.9124		163.9124
6	Rubber											163.9124		163.9124
7	Oil Palm			170.733								163.9124		334.6455
8	Banana			170.733										170.7331
9	Coconut										12.4955	163.9124		176.4079
10	Sugar Cane	3.1558		170.733			29.5274	27.4624						230.8787
11	Agro Forestry	3.1558	68.7293	170.733	1112.4922			27.4624			12.4955			1395.0683
12	Pasture		68.7293		1112.4922		29.5274				12.4955		432.3403	1655.5847
13	Tambak			170.733	1112.4922									1283.2253
14	Swamping					64.9754	29.5274		199.5601	155.2011		163.9124	432.3403	1045.5247

NO.	DEVELOPMENT ACTIVITIES	N												
		BKN	BLI	KHY	KJP	LHI	LWW	MGH	MPT	MTL	PTG	TWB	TWH	TOTAL
1	Wetland Rice					64.9754			199.5601	155.2011	12.4955	163.9124	432.3403	1,028.4928
2	Dryland Rice				1112.4922	64.9754			199.5601	155.2011	12.4955	163.9124		1,708.6367
3	Maize		68.7293		1112.4922	64.9754	29.5274		199.5601	155.2011	12.4955	163.9124	432.3403	2,239.2417
4	Soybean		68.7293		1112.4922	64.9754	29.5274		199.5601	155.2011	12.4955	163.9124	432.3403	2,239.2417
5	Cocoa	3.1558	68.7293	170.733	1112.4922	64.9754	29.5274	27.4624	199.5601	155.2011	12.4955		432.3403	2,276.6806
6	Rubber	3.1558	68.7293	170.733	1112.4922	64.9754	29.5274	27.4624	199.5601	155.2011	12.4955		432.3403	2,276.6806
7	Oil Palm		68.7293		1112.4922	64.9754	29.5274		199.5601	155.2011	12.4955		432.3403	2,075.3213
8	Banana	3.1558	68.7293		1112.4922	64.9754	29.5274	27.4624	199.5601	155.2011	12.4955	163.9124	432.3403	2,269.8599
9	Coconut	3.1558	68.7293	170.733	1112.4922	64.9754	29.5274	27.4624	199.5601	155.2011			432.3403	2,264.1851
10	Sugar Cane		68.7293		1112.4922	64.9754			199.5601	155.2011	12.4955	163.9124	432.3403	2,289.7143
11	Agro Forestry				1	64.9754	29.5274		199.5601	155.2011		163.9124	432.3403	1,045.5247
12	Pasture					64.9754			199.5601	155.2011		163.9124		583.6490
13	Tambak	3.1558	68.7293			64.9754	29.5274	27.4624	199.5601	155.2011	12.4955	163.9124	432.3403	1,157.3677
14	Swamping	3.1558	68.7293	170.733	1112.4922			27.4624			12.4955			1,395.0683

NO.	LAND SYSTEM	AREA (km2)	NO OF POLYGON
1	BKN	3.1558	
2	BLI	68.7293	
3	KHY	170.7331	
4	KJP	1112.4922	
5	LHI	64.9754	
6	LWW	29.5274	
7	MGH	27.4624	
8	MPT	199.5601	
9	MTL	155.2011	
10	PTG	12.4955	
11	TWB	163.9124	
12	TWH	432.3403	
TOTAL		2,440.5930	

Appendix 7.15. The Area of Land Systems by Suitability Classes for Fourteen Development Activities in Samarinda, Muara Badak, and Bontang Sub-region (in km^2)

NO	DEVELOPMENT ACTIVITIES	S2																	
		BKN	BLJ	BRH	GBJ	GBT	KHY	KJP	KPR	LHI	LWW	MPT	MTL	PDH	PTG	TNJ	TWB	TWH	TOTAL
1	Wetland Rice																		
2	Dryland Rice	28.3171																	28.3171
3	Maize																		
4	Soybean																		
5	Cocoa																		
6	Rubber																		
7	Oil Palm	28.3171																	28.3171
8	Banana																		
9	Coconut																		
10	Sugar Cane																		
11	Agro Forestry																		
12	Pasture	28.3171					262.6140									72.8592			363.7911
13	Tambak																		
14	Quarrying																		

NO.	DEVELOPMENT ACTIVITIES	S3																	
		BKN	BLJ	BRH	GBJ	GBT	KHY	KJP	KPR	LHI	LWW	MPT	MTL	PDH	PTG	TNJ	TWB	TWH	TOTAL
1	Wetland Rice	28.3171	22.8255			37.0963	262.6140	167.6120			689.0900					72.8592			1,280.4157
2	Dryland Rice		22.8255				262.6140				689.0900					72.8592		587.1060	1,634.5771
3	Maize	28.3171					262.6140												290.9319
4	Soybean	28.3171					262.6140												290.9319
5	Cocoa																265.9933		265.9933
6	Rubber																265.9933		265.9933
7	Oil Palm						262.6140									72.8592	265.9933		601.4673
8	Banana						262.6140									72.8592			335.4740
9	Coconut														16.7271		265.9933		282.7204
10	Sugar Cane	28.3171					262.6140				689.0900					72.8592			1,052.8819
11	Agro Forestry	28.3171	22.8255	90.6642			262.6140	167.6120							16.7271				588.7607
12	Pasture		22.8255			37.0963		167.6120			689.0900				16.7271			587.1060	1,520.5305
13	Tambak						262.6140	167.6120											430.2260
14	Quarrying			90.6642	2.1079	37.0963			46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690			265.9933	587.1060	3,702.5703

NO.	DEVELOPMENT ACTIVITIES	N																	
		BKN	BLJ	BRH	GBJ	GBT	KHY	KJP	KPR	LHI	LWW	MPT	MTL	PDH	PTG	TNJ	TWB	TWH	TOTAL
1	Wetland Rice			90.6642	2.1079				46.6733	91.2725		623.3014	1,232.4420	36.6690	16.7271		265.9933	587.1060	2,993.1103
2	Dryland Rice			90.6642	2.1079	37.0963		167.6120	46.6733	91.2725		623.3014	1,232.4420	36.6690	16.7271		265.9933		2,610.6390
3	Maize		22.8255	90.6642	2.1079	37.0963		167.6120	46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690	16.7271	72.8592	265.9933	587.1060	3,982.6021
4	Soybean		22.8255	90.6642	2.1079	37.0963		167.6120	46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690	16.7271	72.8592	265.9933	587.1060	3,982.6021
5	Cocoa	28.3171	22.8255	90.6642	2.1079	37.0963	262.6140	167.6120	46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690	16.7271	72.8592		587.1060	4,007.5407
6	Rubber		22.8255	90.6642	2.1079	37.0963	262.6140	167.6120	46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690	16.7271	72.8592		587.1060	3,979.2236
7	Oil Palm		22.8255	90.6642	2.1079	37.0963		167.6120	46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690	16.7271			587.1060	3,643.7496
8	Banana	28.3171	22.8255	90.6642	2.1079	37.0963		167.6120	46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690	16.7271		265.9933	587.1060	3,930.8609
9	Coconut		22.8255	90.6642	2.1079	37.0963	262.6140	167.6120	46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690		72.8592		587.1060	3,982.4956
10	Sugar Cane		22.8255	90.6642	2.1079	37.0963		167.6120	46.6733	91.2725		623.3014	1,232.4420	36.6690	16.7271		265.9933	587.1060	3,220.6521
11	Agro Forestry				2.1079	37.0963			46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690		72.8592	265.9933	587.1060	3,604.7733
12	Pasture			90.6642	2.1079				46.6733	91.2725		623.3014	1,232.4420	36.6690			265.9933		2,388.2044
13	Tambak	28.3171	22.8255	90.6642	2.1079	37.0963			46.6733	91.2725	689.0900	623.3014	1,232.4420	36.6690	16.7271	72.8592	265.9933	587.1060	3,843.3072
14	Quarrying	28.3171	22.8255				262.6140	167.6120							16.7271	72.8592			570.9557

NO	LAND SYSTEM	AREA (km^2)	NO. OF POLYGON
1	BKN	28.3171	
2	BLJ	22.8255	
3	BRH	90.6642	
4	GBJ	2.1079	
5	GBT	37.0963	
6	KHY	262.6140	
7	KJP	167.6120	
8	KPR	46.6733	
9	LHI	91.2725	
10	LWW	689.0900	
11	MPT	623.3014	
12	MTL	1,232.4420	
13	PDH	36.6690	
14	PTG	16.7271	
15	TNJ	72.8592	
16	TWB	265.9933	
17	TWH	587.1060	
TOTAL		4,273.5340	

Appendix 7.16. The Area of Land Systems by Suitability Classes for Fourteen Development Activities in Kutai National Park (in km^2)

NO	DEVELOPMENT ACTIVITIES	S2										
		BRH	KHY	KJP	LHI	LWW	MPT	MTL	POH	TWB	TWH	TOTAL
1	Wetland Rice											
2	Dryland Rice											0.0000
3	Maize											
4	Soybean											
5	Cocoa											
6	Rubber											
7	Oil Palm											
8	Banana											
9	Coconut											
10	Sugar Cane											
11	Agro Forestry											
12	Pasture		0.6207									0.6207
13	Tambak											
14	Quarrying											

NO	LAND SYSTEM	AREA (km2)	NO OF POLYGON
1	BRH	5.6919	
2	KHY	0.6207	
3	KJP	38.8882	
4	LHI	92.5697	
5	LWW	292.6684	
6	MPT	747.6041	
7	MTL	815.0830	
8	POH	73.3176	
9	TWB	72.7239	
10	TWH	25.5400	
TOTAL		2164.7075	

NO	DEVELOPMENT ACTIVITIES	S3										
		BRH	KHY	KJP	LHI	LWW	MPT	MTL	POH	TWB	TWH	TOTAL
1	Wetland Rice		0.6207	38.8882		292.6684						332.1773
2	Dryland Rice		0.6207			292.6684					25.5400	318.8291
3	Maize		0.6207									0.6207
4	Soybean		0.6207									0.6207
5	Cocoa									72.7239		72.7239
6	Rubber									72.7239		72.7239
7	Oil Palm		0.6207							72.7239		73.3446
8	Banana		0.6207									0.6207
9	Coconut									72.7239		72.7239
10	Sugar Cane		0.6207			292.6684						293.2891
11	Agro Forestry	5.6919	0.6207	38.8882								45.2008
12	Pasture			38.8882		292.6684					25.5400	357.0966
13	Tambak		0.6207	38.8882								39.5089
14	Quarrying	5.6919			92.5697	292.6684	747.6041	815.0830	73.3176	72.7239	25.5400	2,125.1986

NO.	DEVELOPMENT ACTIVITIES	N										
		BRH	KHY	KJP	LHI	LWW	MPT	MTL	POH	TWB	TWH	TOTAL
1	Wetland Rice	5.6919			92.5697		747.6041	815.0830	73.3176	72.7239	25.5400	1,832.5307
2	Dryland Rice	5.6919		38.8882	92.5697		747.6041	815.0830	73.3176	72.7239		1,845.8784
3	Maize	5.6919		38.8882	92.5697	292.6684	747.6041	815.0830	73.3176	72.7239	25.5400	2,164.0868
4	Soybean	5.6919		38.8882	92.5697	292.6684	747.6041	815.0830	73.3176	72.7239	25.5400	2,164.0868
5	Cocoa	5.6919	0.6207	38.8882	92.5697	292.6684	747.6041	815.0830	73.3176		25.5400	2,091.9836
6	Rubber	5.6919	0.6207	38.8882	92.5697	292.6684	747.6041	815.0830	73.3176		25.5400	2,091.9836
7	Oil Palm	5.6919		38.8882	92.5697	292.6684	747.6041	815.0830	73.3176		25.5400	2,091.3629
8	Banana	5.6919		38.8882	92.5697	292.6684	747.6041	815.0830	73.3176	72.7239	25.5400	2,164.0868
9	Coconut	5.6919	0.6207	38.8882	92.5697	292.6684	747.6041	815.0830	73.3176		25.5400	2,091.9836
10	Sugar Cane	5.6919		38.8882	92.5697		747.6041	815.0830	73.3176	72.7239	25.5400	1,871.4184
11	Agro Forestry				92.5697	292.6684	747.6041	815.0830	73.3176	72.7239	25.5400	2,119.5067
12	Pasture	5.6919			92.5697		747.6041	815.0830	73.3176	72.7239		1,806.9907
13	Tambak	5.6919			92.5697	292.6684	747.6041	815.0830	73.3176	72.7239	25.5400	2,125.1986
14	Quarrying		0.6207	38.8882								39.5089

Appendix 7.17. The Area of Land Systems by Suitability Classes for Fourteen Development Activities in Sangkulirang Sub-region (in km ^{2})

NO	DEVELOPMENT ACTIVITIES	S2												
		GBJ	KHY	KJP	KPR	LHI	LWW	MPT	MTL	OKI	PDH	TWB	TWH	TOTAL
1	Wetland Rice													
2	Dryland Rice													
3	Maize													
4	Soybean													
5	Cocoa													
6	Rubber													
7	Oil Palm													
8	Banana													
9	Coconut													
10	Sugar Cane													
11	Agro Forestry													
12	Pasture		100.9912											100.9912
13	Tambak													
14	Quarrying													

NO.	DEVELOPMENT ACTIVITIES	S3												
		GBJ	KHY	KJP	KPR	LHI	LWW	MPT	MTL	OKI	PDH	TWB	TWH	TOTAL
1	Wetland Rice		100.9912	6.5110			193.4277							300.9299
2	Dryland Rice		100.9912				193.4277						592.1007	974.5996
3	Maize		100.9912											100.9912
4	Soybean		100.9912											100.9912
5	Cocoa		100.9912									340.4555		637.4467
6	Rubber											340.4555		340.4555
7	Oil Palm		100.9912									340.4555		537.4467
8	Banana		100.9912											100.9912
9	Coconut											340.4555		340.4555
10	Sugar Cane		100.9912				193.4277							302.4189
11	Agro Forestry		100.9912	6.5110										195.5022
12	Pasture			6.5110			193.4277						592.1007	792.1194
13	Tambak		100.9912	6.5110										195.5022
14	Quarrying	299.5735			16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093	340.4555	592.1007	3,300.2033

NO.	DEVELOPMENT ACTIVITIES	N												
		GBJ	KHY	KJP	KPR	LHI	LWW	MPT	MTL	OKI	PDH	TWB	TWH	TOTAL
1	Wetland Rice	299.5735			16.0000	30.3630		1,231.0530	144.4094	58.9424	385.7093	340.4555	592.1007	3,106.8556
2	Dryland Rice	299.5735		6.5110	16.0000	30.3630		1,231.0530	144.4094	58.9424	385.7093	340.4555		2,521.1059
3	Maize	299.5735		6.5110	16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093	340.4555	592.1007	3,306.7943
4	Soybean	299.5735		6.5110	16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093	340.4555	592.1007	3,306.7943
5	Cocoa	299.5735	100.9912	6.5110	16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093		592.1007	3,147.3300
6	Rubber	299.5735	100.9912	6.5110	16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093		592.1007	3,147.3300
7	Oil Palm	299.5735		6.5110	16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093		592.1007	2,958.3388
8	Banana	299.5735		6.5110	16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093	340.4555	592.1007	3,306.7943
9	Coconut	299.5735	100.9912	6.5110	16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093		592.1007	3,147.3300
10	Sugar Cane	299.5735		6.5110	16.0000	30.3630		1,231.0530	144.4094	58.9424	385.7093	340.4555	592.1007	3,113.3666
11	Agro Forestry	299.5735			16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093	340.4555	592.1007	3,300.2033
12	Pasture	299.5735			16.0000	30.3630		1,231.0530	144.4094	58.9424	385.7093	340.4555		2,614.6749
13	Tambak	299.5735			16.0000	30.3630	193.4277	1,231.0530	144.4094	58.9424	385.7093	340.4555	592.1007	3,300.2033
14	Quarrying		100.9912	6.5110										195.5022

NO.	LAND SYSTEM	AREA (km2)	NO POLYGON
1	GBJ	299.5735	
2	KHY	100.9912	
3	KJP	6.5110	
4	KPR	16.0000	
5	LHI	30.3630	
6	LWW	193.4277	
7	MPT	1,231.0530	
8	MTL	144.4094	
9	OKI	58.9424	
10	PDH	385.7093	
11	TWB	340.4555	
12	TWH	592.1007	
	TOTAL	3495.7855	

Appendix 7.18. The Area of Land Systems by Suitability Classes for Fourteen Development activities in Labuhan Bini Sub-region (in km^2)

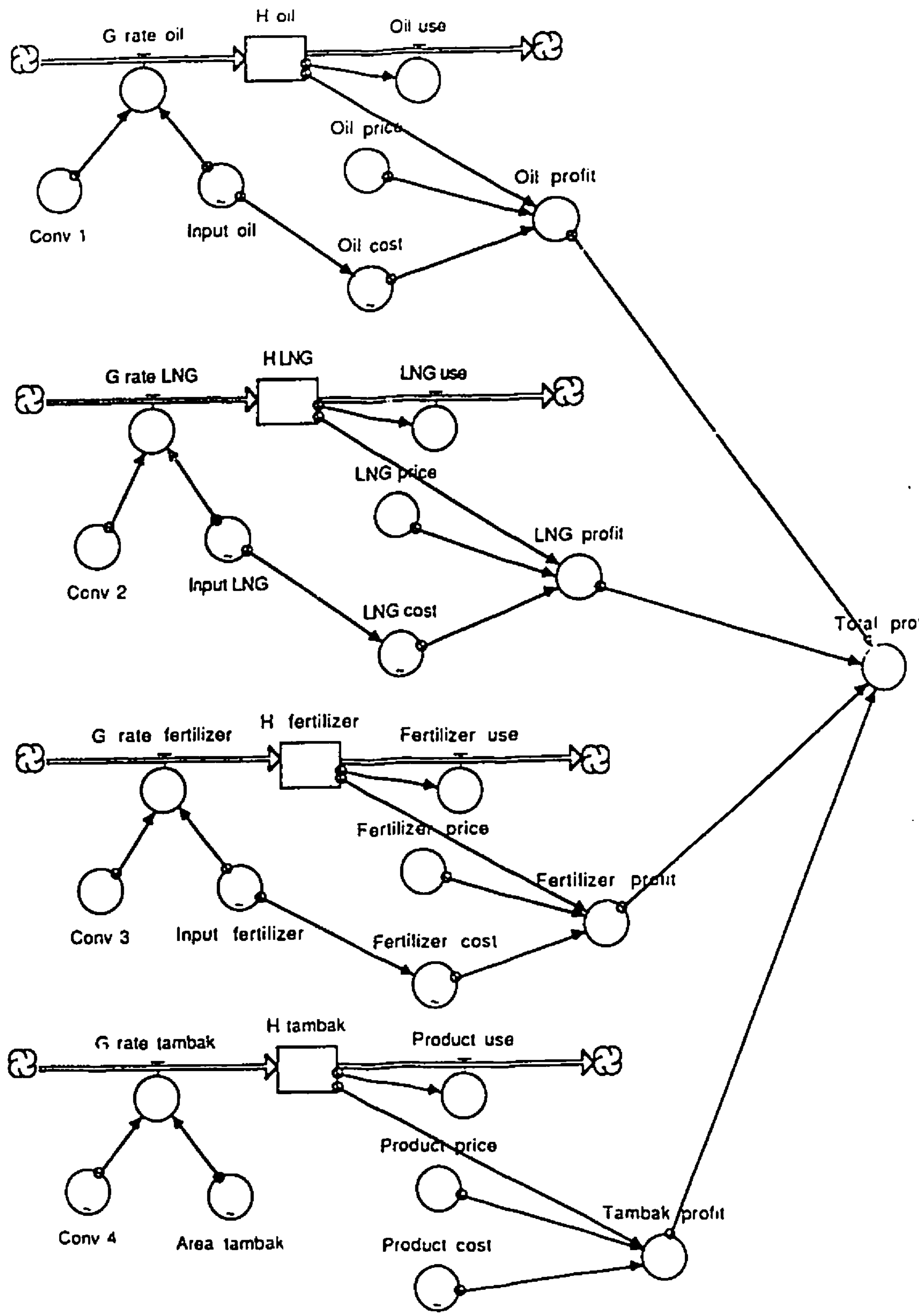
NO.	DEVELOPMENT ACTIVITIES	S2							
		GBJ	KJP	KPR	LWW	MPT	OKI	TWH	TOTAL
1	Wetland Rice								
2	Dryland Rice								
3	Maize								
4	Soybean								
5	Cocoa								
6	Rubber								
7	Oil Palm								
8	Banana								
9	Coconut								
10	Sugar Cane								
11	Agro Forestry								
12	Pasture								
13	Tambak								
14	Quarrying								

NO	LAND SYSTEM	AREA (km2)	NO. OF POLYGON
1	GBJ	460.3366	
2	KJP	50.3293	
3	KPR	150.2935	
4	LWW	227.429	
5	MPT	274.9567	
6	OKI	195.6309	
7	TWH	605.4065	
TOTAL		1964.3025	

NO.	DEVELOPMENT ACTIVITIES	S3							
		GBJ	KJP	KPR	LWW	MPT	OKI	TWH	TOTAL
1	Wetland Rice		50.3293		227.429				277.7583
2	Dryland Rice				227.429			605.4065	832.8355
3	Maize								0
4	Soybean								0
5	Cocoa								0
6	Rubber								0
7	Oil Palm								0
8	Banana								0
9	Coconut								0
10	Sugar Cane				227.429				227.429
11	Agro Forestry		50.3293						50.3293
12	Pasture		50.3293		227.429			605.4065	883.1648
13	Tambak		50.3293						50.3293
14	Quarrying	460.337		150.294	227.429	274.9567	195.6309	605.4065	1914.0532

NO.	DEVELOPMENT ACTIVITIES	N							
		GBJ	KJP	KPR	LWW	MPT	OKI	TWH	TOTAL
1	Wetland Rice	460.337		150.294		274.9567	195.6309	605.4065	1686.6242
2	Dryland Rice	460.337	50.3293	150.294		274.9567	195.6309		1131.547
3	Maize	460.337	50.3293	150.294	227.429	274.9567	195.6309	605.4065	1964.3025
4	Soybean	460.337	50.3293	150.294	227.429	274.9567	195.6309	605.4065	1964.3025
5	Cocoa	460.337	50.3293	150.294	227.429	274.9567	195.6309	605.4065	1964.3025
6	Rubber	460.337	50.3293	150.294	227.429	274.9567	195.6309	605.4065	1964.3025
7	Oil Palm	460.337	50.3293	150.294	227.429	274.9567	195.6309	605.4065	1964.3025
8	Banana	460.337	50.3293	150.294	227.429	274.9567	195.6309	605.4065	1964.3025
9	Coconut	460.337	50.3293	150.294	227.429	274.9567	195.6309	605.4065	1964.3025
10	Sugar Cane	460.337	50.3293	150.294		274.9567	195.6309	605.4065	1736.9535
11	Agro Forestry	460.337		150.294	227.429	274.9567	195.6309	605.4065	1914.0532
12	Pasture	460.337		150.294		274.9567	195.6309		1081.2177
13	Tambak	460.337		150.294	227.429	274.9567	195.6309	605.4065	1914.0532
14	Quarrying		50.3293						50.3293

Appendix 8.1. The Diagram of the Economic Submodel



H_fertilizer(t) = H_fertilizer(t - dt) + (G_rate_fertilizer - Fertilizer_use) * dt
INIT H_fertilizer = G_rate_fertilizer
DOCUMENT: H_fertilizer (t) is the total fertilizer (Urea and Ammonia) produced in year_t (in tonnes).

The differential equation means that the amount of fertilizer in year_t is equal to the amount of fertilizer in year_(t-dt), plus the amount of fertilizer flowed in (G_rate_fertilizer), the amount of fertilizer flowed out (Fertilizer_use), over time dt.

INFLOWS:

G_rate_fertilizer = Conv_3*Input_fertilizer
DOCUMENT: The G-rate-fertilizer is the production rate of fertilizer (in tonnes per year). It is defined as Conv_3 (the conversion factor from Input_fertilizer to H_fertilizer) times Input_fertilizer (the raw material of fertilizer, which is the natural gas).

OUTFLOWS:

Fertilizer_use = H_fertilizer
DOCUMENT: The Fertilizer_use can be for either domestic or export markets. However, the model is not concerned with this aspect. Accordingly, the Fertilizer_use is represented by a cloud symbol.

H_LNG(t) = H_LNG(t - dt) + (G_rate_LNG - LNG_use) * dt
INIT H_LNG = G_rate_LNG
DOCUMENT: H_LNG (t) is the total LNG produced in year_t (in ton).

The differential equation means that the amount of LNG in year_t is equal to the amount of LNG in year_(t-dt), plus the amount of LNG flowed in (G_rate_LNG), minus the amount of LNG flowed out (LNG_use), over time dt.

INFLOWS:

G_rate_LNG = Conv_2*Input_LNG
DOCUMENT: The G_rate_LNG is the production rate of LNG (in ton per year). It is defined as Conv_2 (the conversion factor from the Input_LNG to the H_LNG) times the Input_LNG (the raw material of LNG, which is natural gas).

OUTFLOWS:

LNG_use = H_LNG
DOCUMENT: LNG-use can be for either domestic or export markets. However, the model does not consider this aspect. Accordingly, the outflow of LNG_use is represented by a cloud symbol.

H_oil(t) = H_oil(t - dt) + (G_rate_oil - Oil_use) * dt
INIT H_oil = G_rate_oil
DOCUMENT: H_oil (t) is the total oil produced in year_t (in barrels).

The equation is essentially a generic differential equation which means that the amount of oil in year-t is equal to the amount of oil in year -(t - dt) or the previous year, plus the amount of oil flowed in (G-rate_oil), minus the amount of oil flowed out (Oil use), over time of dt.

INFLOWS:
G_rate_oil = Conv_1*Input_oil
DOCUMENT: G_rate_oil is the production rate of oil (in barrels per year). It is defined as Conv_1 (the conversion factor of input-oil to H-oil) times Input_oil (the raw material of H_oil).

OUTFLOWS:
Oil_use = H_oil
DOCUMENT: Oil use can be either for domestic or for export markets. However, the model does not care of this aspect. Hence, the outflow of oil use is represented by a cloud symbol.

H_tambak(t) = H_tambak(t - dt) + (G_rate_tambak - Product_use) * dt
INIT H_tambak = G_rate_tambak
DOCUMENT: H_tambak (t) is the total shrimp produced in year_t (in tonnes).

The differential equation means that the amount of shrimp in year_t is equal to the amount of shrimp in year_(t-dt), plus the amount of shrimp flowed in (G-rate-tambak), minus the amount of shrimp flowed out (Product-use), over time dt.

INFLOWS:
G_rate_tambak = Conv_4*Area_tambak
DOCUMENT: The G-rate-tambak is the production rate of shrimp (in tonnes per year). It is defined as the Conv_4 (the productivity of tambak in ton/ha/year) times the Area_tambak (the total area of tambak in the study area being cultivated).

OUTFLOWS:
Product_use = H_tambak
DOCUMENT: The Product_use is mostly for export purposes. However, the model does not consider this aspect. Accordingly, the Product_use is represented by a cloud symbol.

○ Conv_1 = 0.45
DOCUMENT: The value of Conv_1 is equal to 0.45 (UNOCAL, 1990)

○ Conv_2 = 18.2
DOCUMENT: The Conv_2 is equal to 18.2 ton/MMSCF (Pertamina, 1985). MMSCF is million standard cubic feet.

○ Conv_3 = 0.022
DOCUMENT: The value of Conv_3 is equal to 0.022 ton per cubic meter (Lemhanas, 1988).

⊘ Conv_4 = GRAPH(TIME)
(1.00, 0.15), (2.00, 1.85), (3.00, 2.60), (4.00, 4.05), (5.00, 5.80), (6.00, 6.70), (7.00, 7.50), (8.00, 8.45), (9.00, 8.95), (10.0, 9.00), (11.0, 9.30), (12.0, 9.00), (13.0, 9.10), (14.0, 9.00), (15.0, 9.00), (16.0, 9.00), (17.0, 9.00), (18.0, 9.00), (19.0, 9.00), (20.0, 8.80), (21.0, 8.80), (22.0, 9.00), (23.0, 9.00), (24.0, 9.00), (25.0, 9.00)

⊘ Input_fertilizer = GRAPH(TIME)
(1.00, 1.5e+08), (2.00, 1.5e+08), (3.00, 1.5e+08), (4.00, 1.5e+08), (5.00, 1.5e+08), (6.00, 1.5e+08), (7.00, 1.5e+08), (8.00, 1.5e+08), (9.00, 1.5e+08), (10.0, 1.5e+08), (11.0, 1.5e+08), (12.0, 1.5e+08), (13.0, 1.5e+08), (14.0, 1.5e+08), (15.0, 1.5e+08), (16.0, 1.5e+08), (17.0, 1.5e+08), (18.0, 1.5e+08), (19.0, 1.5e+08), (20.0, 1.2e+08), (21.0, 1.2e+08), (22.0, 1.2e+08), (23.0, 1.2e+08), (24.0, 1e+08), (25.0, 9e+07)

⊘ Input_LNG = GRAPH(TIME)
(1.00, 620880), (2.00, 620880), (3.00, 620880), (4.00, 620880), (5.00, 745055), (6.00, 745055), (7.00, 745055), (8.00, 869230), (9.00, 869230), (10.0, 1e+06), (11.0, 1e+06), (12.0, 1e+06), (13.0, 1e+06), (14.0, 1e+06), (15.0, 1e+06), (16.0, 1e+06), (17.0, 1e+06), (18.0, 1e+06), (19.0, 1e+06), (20.0, 1e+06), (21.0, 1e+06), (22.0, 869230), (23.0, 869230), (24.0, 745055), (25.0, 620880)

⊘ Input_oil = GRAPH(TIME)
(1.00, 1.7e+08), (2.00, 1.7e+08), (3.00, 1.5e+08), (4.00, 1.4e+08), (5.00, 1.4e+08), (6.00, 1.1e+08), (7.00, 8.5e+07), (8.00, 6.8e+07), (9.00, 5e+07), (10.0, 5e+07), (11.0, 0.00), (12.0, 0.00), (13.0, 0.00), (14.0, 0.00), (15.0, 0.00), (16.0, 0.00), (17.0, 0.00), (18.0, 0.00), (19.0, 0.00), (20.0, 0.00), (21.0, 0.00), (22.0, 0.00), (23.0, 0.00), (24.0, 0.00), (25.0, 0.00)

⊘ Area_tambak = GRAPH(TIME)
(1.00, 2.00), (2.00, 20.0), (3.00, 100), (4.00, 1000), (5.00, 2000), (6.00, 2000), (7.00, 3000), (8.00, 5000), (9.00, 6000), (10.0, 7000), (11.0, 8000), (12.0, 9000), (13.0, 10000), (14.0, 11000), (15.0, 12000), (16.0, 13000), (17.0, 14000), (18.0, 15000), (19.0, 16000), (20.0, 17000), (21.0, 18000), (22.0, 19000), (23.0, 20000), (24.0, 21000), (25.0, 21000)

○ Oil_price = 16
DOCUMENT: The oil price is US $ 16.0 per barrel (Kantor Statistik Propinsi Kaltim., 1989)

○ LNG_price = 130
DOCUMENT: The price of LNG is US $ 130 per ton (Kantor Statistik Propinsi Kalimantan Timur, 1989).

○ Fertilizer_price = 103
DOCUMENT: The price of fertilizer is US $ 103 per ton (Kantor Statistik Propinsi Kaltim., 1989).

○ Product_price = 10000
DOCUMENT: The Product_price (shrimp price) is US $ 10,000 per ton (field observation, 1990).

⊘ Oil_cost = GRAPH(Input_oil)
(1.00, 2.00), (2.00, 2.00), (3.00, 2.00), (4.00, 2.50), (5.00, 2.50), (6.00, 3.00), (7.00, 3.00), (8.00, 6.00), (9.00, 7.00), (10.0, 7.00), (11.0, 10.0), (12.0, 0.00), (13.0, 0.00), (14.0, 0.00), (15.0, 0.00), (16.0, 0.00), (17.0, 0.00), (18.0, 0.00), (19.0, 0.00), (20.0, 0.00), (21.0, 0.00), (22.0, 0.00), (23.0, 0.00), (24.0, 0.00), (25.0, 0.00)

⊘ LNG_cost = GRAPH(Input_LNG)
(1.00, 16.0), (2.00, 16.0), (3.00, 16.0), (4.00, 20.0), (5.00, 20.0), (6.00, 20.0), (7.00, 20.0), (8.00, 20.0), (9.00, 25.0), (10.0, 25.0), (11.0, 25.0), (12.0, 30.0), (13.0, 30.0), (14.0, 30.0), (15.0, 40.0), (16.0, 40.0), (17.0, 40.0), (18.0, 50.0), (19.0, 50.0), (20.0, 50.0), (21.0, 65.0), (22.0, 65.0), (23.0, 70.0), (24.0, 70.0), (25.0, 80.0)

⊘ Fertilizer_cost = GRAPH(Input_fertilizer)
(1.00, 50.0), (2.00, 53.0), (3.00, 54.0), (4.00, 55.0), (5.00, 56.0), (6.00, 57.0), (7.00, 58.0), (8.00, 59.0), (9.00, 60.0), (10.0, 65.0), (11.0, 70.0), (12.0, 71.0), (13.0, 73.0), (14.0, 75.0), (15.0, 77.0), (16.0, 78.0), (17.0, 79.0), (18.0, 80.0), (19.0, 81.0), (20.0, 82.0), (21.0, 83.0), (22.0, 84.0), (23.0, 85.0), (24.0, 86.0), (25.0, 95.0)

⊘ Product_cost = GRAPH(TIME)
(1.00, 4200), (2.00, 3725), (3.00, 3000), (4.00, 2375), (5.00, 1700), (6.00, 1450), (7.00, 1350), (8.00, 1425), (9.00, 1725), (10.0, 1775), (11.0, 1700), (12.0, 2025), (13.0, 2200), (14.0, 2275), (15.0, 2400), (16.0, 2500), (17.0, 2825), (18.0, 3150), (19.0, 3125), (20.0, 2875), (21.0, 3350), (22.0, 3350), (23.0, 3700), (24.0, 3325), (25.0, 4425)

Appendix 8.1. Equations of the Economic Submodel (Continued)

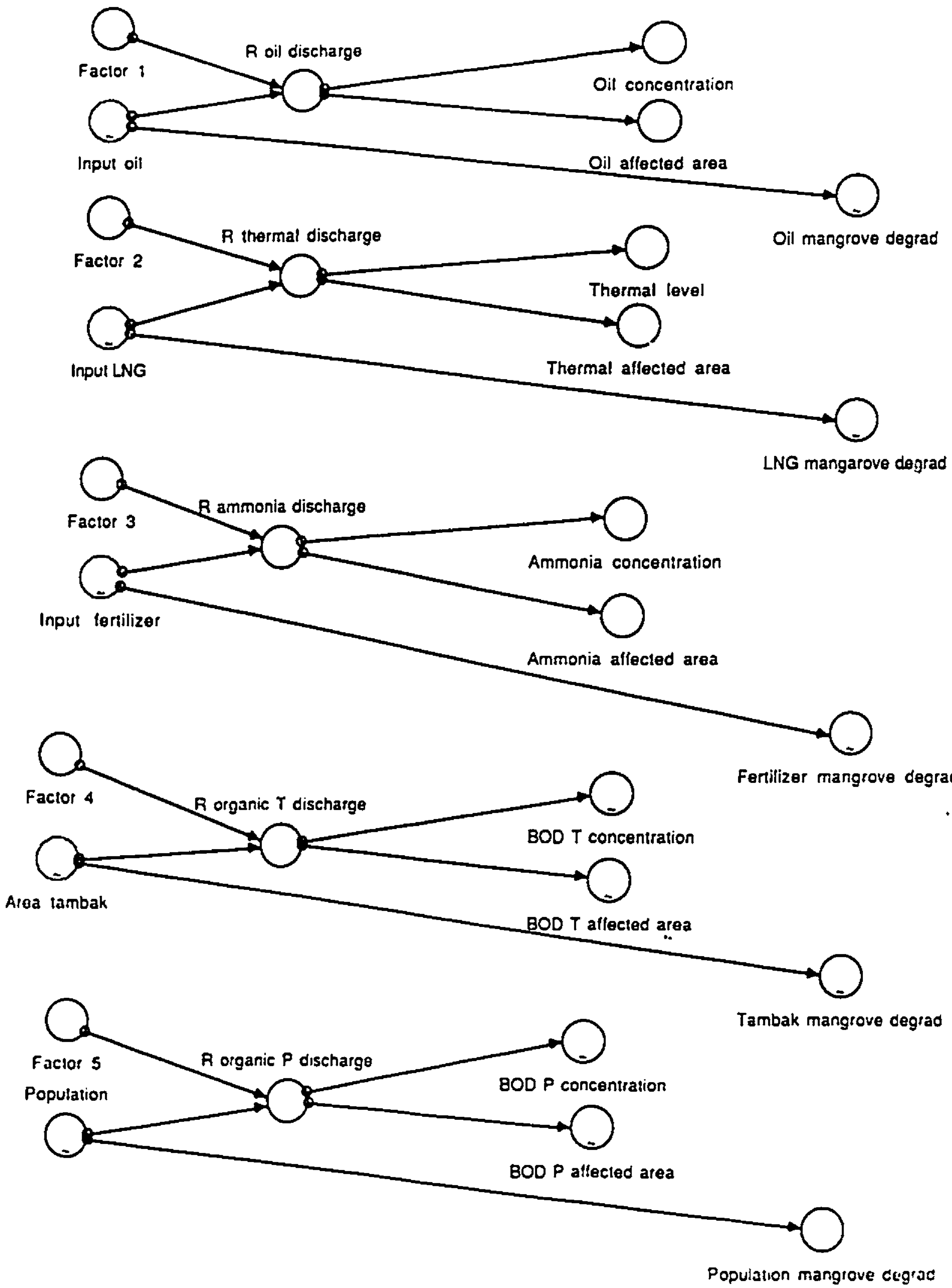
○ Oil_profit = H_oil*(Oil_price-Oil_cost)

○ LNG_profit = H_LNG*(LNG_price-LNG_cost)

○ Fertilizer_profit = H_fertilizer*(Fertilizer_price-Fertilizer_cost)

○ Tambak_profit = H_tambak*(Product_price-Product_cost)

○ Total_profit = Oil_profit+LNG_profit+Fertilizer_profit+Tambak_profit


Factor 1
R oil discharge
Oil concentration
Input oil
Oil affected area
Oil mangrove degrad
Factor 2
R thermal discharge
Thermal level
Input LNG
Thermal affected area
LNG mangarove degrad
Factor 3
R ammonia discharge
Ammonia concentration
Input fertilizer
Ammonia affected area
Fertilizer mangrove degrad
Factor 4
R organic T discharge
BOD T concentration
Area tambak
BOD T affected area
Tambak mangrove degrad
Factor 5
R organic P discharge
BOD P concentration
Population
BOD P affected area
Population mangrove degrad

○ Factor_1 = 0.55
DOCUMENT: Factor_1 is the conversion factor from Input_oil to the discharge rate of oil waste (R_oil_discharge), which is equal to 0.55 (UNOCAL, 1990).

○ Factor_2 = 432525
DOCUMENT: Factor_2 is the conversion factor from Input_LNG to the discharge rate of thermal waste (R_thermal_discharge), which is 432,525 cubic meter per MMSCF.

This is based on the calculation that at the current rate of LNG production (= 11,300,000 tonnes per year), which requires input of natural gas as much as 620,879 MMSCF per year, the total thermal waste (heated water with temperature at 45 Celcius degree) disharged is as much as 400,000 gpm (gallon per minute) or 2,016,000 cubic meter per day. Thus, Factor_2 is equal to 2,016,000/620,879*365 = 432,525 cubuc meter per MMSCF.

○ Factor_3 = 0.126
DOCUMENT: Factor_3 is the conversion factor from Input_fertilizer to R_ammonia_discharge, which is 0.126.

This is based upon the calculation that at the current rate of fertilizer production (9,150 tonnes of fertilizer per day), which requires natural gas as much as 9,150/0.022 = 415,910 cubic meter, the ammonia discharge is 52,225 cubic meter per day with concentration of 400 mg/litre (Lemhanas, 1988 and SEATEC, 1990). Thus, Factor_3 is equal to 52,225/415,910.

○ Factor_4 = 244550
DOCUMENT: Factor_4, which is the conversion factor from Area_tambak to the discharge rate of organic waste (R_organic_T_discharge), is 244,550 cubic meter/ha/year. This is calculated based the daily discharge rate of organic waste from a hectar of tambak, which is 670 cubic meter/ha/day (Twilley, 1989), times 365.

○ Factor_5 = 29.2
DOCUMENT: Factor_5, which is the conversion factor from the number of population to organic waste discharge (R_organic_P_discharge), is 29.2 kg BOD per capita per year. This is calculated based on the daily BOD discharge as much as 0.08 kg/capita/year (NAS, 1970) times 365.

⊘ Population = GRAPH(TIME)
(1.00, 679611), (2.00, 840619), (3.00, 1e+06), (4.00, 1.2e+06), (5.00, 1.3e+06), (6.00, 1.5e+06), (7.00, 1.6e+06), (8.00, 1.8e+06), (9.00, 2e+06), (10.0, 2.1e+06), (11.0, 2.3e+06), (12.0, 2.5e+06), (13.0, 2.6e+06), (14.0, 2.8e+06), (15.0, 2.9e+06), (16.0, 3.1e+06), (17.0, 3.3e+06), (18.0, 3.4e+06), (19.0, 3.6e+06), (20.0, 3.7e+06), (21.0, 3.9e+06), (22.0, 4.1e+06), (23.0, 4.2e+06), (24.0, 4.4e+06), (25.0, 4.5e+06)

○ R_ammonia_discharge = Factor_3*Input_fertilizer
○ R_oil_discharge = Factor_1*Input_oil
○ R_organic_P_discharge = Factor_5*Population
DOCUMENT: R_organic_P_discharge is the discahrge rate of organic watse from domestic activities or population (in ton per year).

○ R_organic_T_discharge = Factor_4*Area_tambak
○ R_thermal_discharge = Factor_2*Input_LNG
○ Ammonia_affected_area = R_ammonia_discharge/1275177
DOCUMENT: The Ammonia_affected_area is defined as R_ammonia_discharge/1,275,177. This is based upon the calculation that at the current production rate (3,339,750 tonnes fertilizer per year), which discharges ammonia as much as 19,127,659 cubic meter per year with a concentration of 400 mg/litre, the affected area is as large as 15 square kilometer (PT. Pupuk Kaltim, 1986; and field observation, 1989). Thus, the Ammonia_affected_area may be defined as R_ammonia_discharge divided by 19,127,659/15, which is 1,275,177.

○ Ammonia_concentration = R_ammonia_discharge/18216818
DOCUMENT: The Ammonia_concentration is ammonia concentration within the affected area (in mg/litre). It is defined as R_ammonia_discharge/18,216,818. This is based on the calculation that at the current rate of production (3,339,750 tonnes per year), which discharges ammonia as much as 19,127,659 cubic meter per year, the lowest ammonia concentration is 1.05 mg/litre (PT. Pupuk Kaltim and UGM, 1986; and field observation, 1990). Thus, the concentration of ammonia may be defined as R_ammonia_discharge divided by 19,127,659/1.05 (18,216,818).

⊘ BOD_P_affected_area = GRAPH(R_organic_P_discharge)
(679611, 0.00), (6.2e+06, 9.00), (1.2e+07, 16.5), (1.7e+07, 23.0), (2.3e+07, 29.5), (2.8e+07, 36.5), (3.4e+07, 51.5), (3.9e+07, 59.0), (4.5e+07, 69.5), (5e+07, 76.5), (5.6e+07, 84.5), (6.1e+07, 88.5), (6.7e+07, 89.0), (7.2e+07, 89.0), (7.8e+07, 89.0), (8.3e+07, 89.0), (8.9e+07, 89.0), (9.4e+07, 89.0), (1e+08, 89.0), (1.1e+08, 89.0), (1.1e+08, 89.0), (1.2e+08, 89.0), (1.2e+08, 89.0), (1.3e+08, 89.0), (1.3e+08, 89.0)
⊘ BOD_P_concentration = GRAPH(R_organic_P_discharge)
(2e+07, 0.25), (2.5e+07, 20.5), (2.9e+07, 39.5), (3.4e+07, 46.0), (3.9e+07, 52.0), (4.3e+07, 59.5), (4.8e+07, 65.5), (5.3e+07, 71.0), (5.7e+07, 76.0), (6.2e+07, 79.5), (6.7e+07, 85.5), (7.2e+07, 88.5), (7.6e+07, 92.5), (8.1e+07, 45.0), (8.6e+07, 45.0), (9e+07, 45.0), (9.5e+07, 45.0), (1e+08, 45.0), (1e+08, 45.0), (1.1e+08, 45.0), (1.1e+08, 45.0), (1.2e+08, 45.0), (1.2e+08, 45.0), (1.3e+08, 45.0), (1.3e+08, 45.0)
⊘ BOD_T_affected_area = GRAPH(R_organic_T_discharge)
(400000, 0.00), (5e+08, 4.00), (1e+09, 11.0), (1.5e+09, 16.0), (2e+09, 22.0), (2.5e+09, 32.0), (3e+09, 40.5), (3.5e+09, 47.5), (4e+09, 57.5), (4.5e+09, 69.5), (5e+09, 78.5), (5.5e+09, 88.5), (6e+09, 96.5)
⊘ BOD_T_concentration = GRAPH(R_organic_T_discharge)
(400000, 0.25), (5e+08, 1.75), (1e+09, 30.0), (1.5e+09, 36.0), (2e+09, 37.0), (2.5e+09, 38.0), (3e+09, 39.0), (3.5e+09, 45.0), (4e+09, 45.0), (4.5e+09, 45.0), (5e+09, 45.0), (5.5e+09, 45.0), (6e+09, 45.0)

○ Oil_affected_area = R_oil_discharge/3116667
DOCUMENT: The unit of Oil_affected_area is in square km. It is defined as R_oil_discharge divided by 3,116,667. This is based upon the calculation that at the current production rate of oil, which discharges oil waste into the coastal water as much as 93,500,000 barrels with an oil concentration of 5 ppm, the Oil_affected _area is as large as 1.0 times 30 square kilometer (UNOCAL, 1990 and field observations, 1989 and 1990). Thus, the number of 6,233,333 is obtained from 93,500,000 divided by 30.

○ Oil_concentration = R_oil_discharge/18700000
DOCUMENT: The Oil_concentration is the concentration of oil waste within the upper layer (1meter) of water column of the coastal water (in mg/litre or ppm). It is defined as R_oil_discharge divided by 18,700,000.

This is based on the calculation that at the current production rate (76,500,000 barrels of oil per year), which discharges oil waste as much as 93,500,000 barrels of oil waste with oil concentration of 50 ppm, the lowest oil concentration within the affected area is 5 ppm. Thus, the number of 18,700,000 is obtained from 93,500,000 divided by 5.

○ Thermal_affected_area = R_thermal_discharge/6075695500
DOCUMENT: The Thermal_affected_area is defined as R_thermal_discharge/6,075,695,500 (in square kilometer).

This is based upon the calculation that at the current rate of LNG production, the affected area by thermal waste is as large as 3.142 (pi number) times 3.75 x 3.75 kilometer (Universitas Mulawarman, 1983 and field observation, 1990). Thus, the affected area can be estimated as R_thermal discharge devided by 44.2, which is 6,075,695,500.

○ Thermal_level = R_thermal_discharge/7257993000
DOCUMENT: The thermal level in the receiving coastl water is defined as R_thermal_discharge/7,257,993,000 (in Celcius degree).

This is based on the calculation that at the current rate of production, which discharges thermal waste (heated water) as much as 268,546 million cubic meter per year, the lowest thermal level within the affected area is 37 C degree (Universitas Mulawarman, 1983). Thus, the thermal level can be estimated as R_thermal_discharge divided by 37, which is 7,257,993,000.

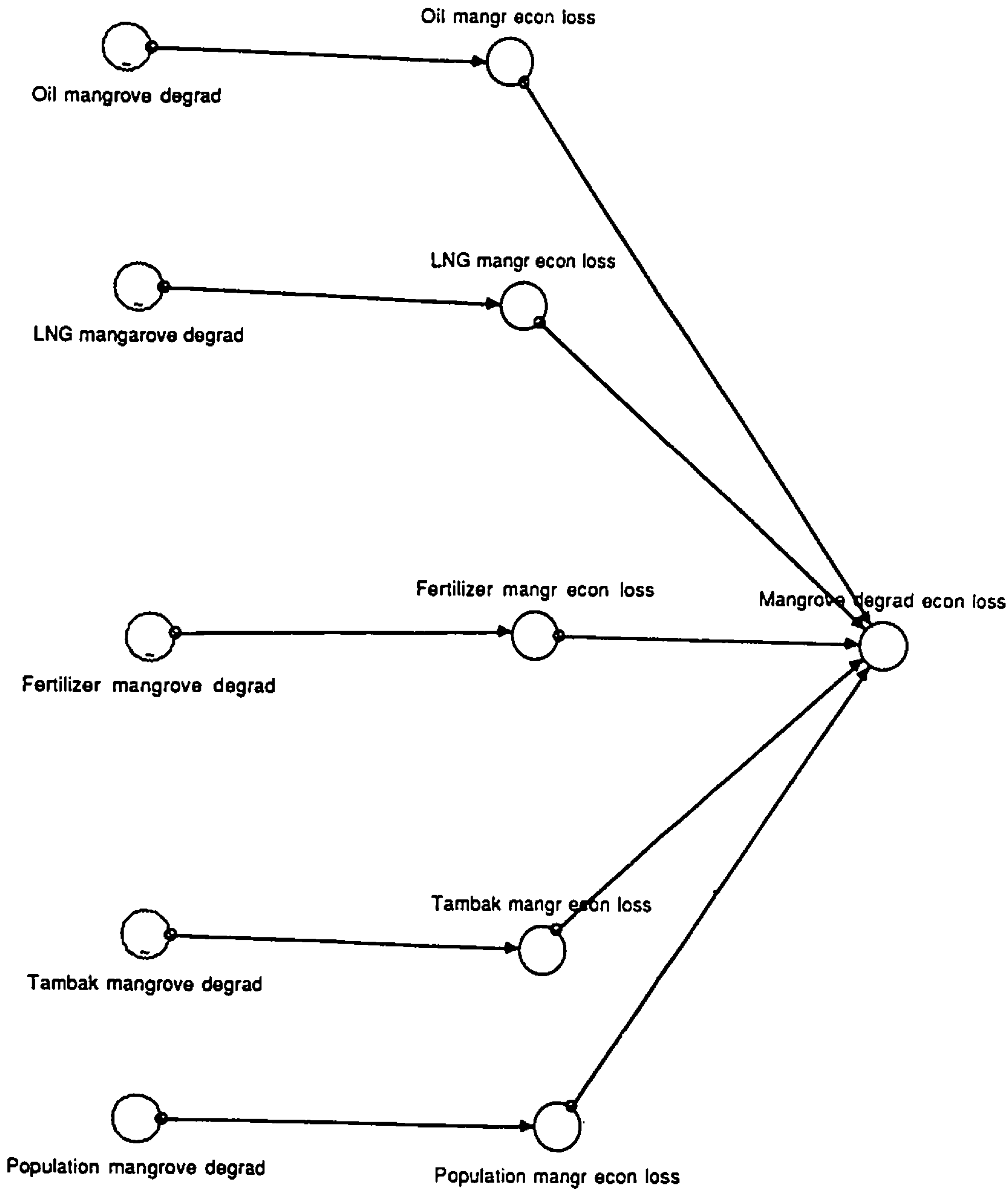
Ø Oil_mangrove_degrad = GRAPH(Input_oil)
(30000, 1515), (43333, 1560), (56667, 1650), (70000, 1860), (83333, 2175), (96667, 2385), (110000, 2520), (123333, 2610), (136667, 2760), (150000, 3000)

Ø LNG_mangarove_degrad = GRAPH(Input_LNG)
(1.00, 510), (2.00, 515), (3.00, 510), (4.00, 500), (5.00, 495), (6.00, 495), (7.00, 490), (8.00, 595), (9.00, 630), (10.0, 625), (11.0, 610), (12.0, 620), (13.0, 615), (14.0, 605), (15.0, 605), (16.0, 610), (17.0, 610), (18.0, 595), (19.0, 605), (20.0, 685), (21.0, 700), (22.0, 715), (23.0, 725), (24.0, 735), (25.0, 745)

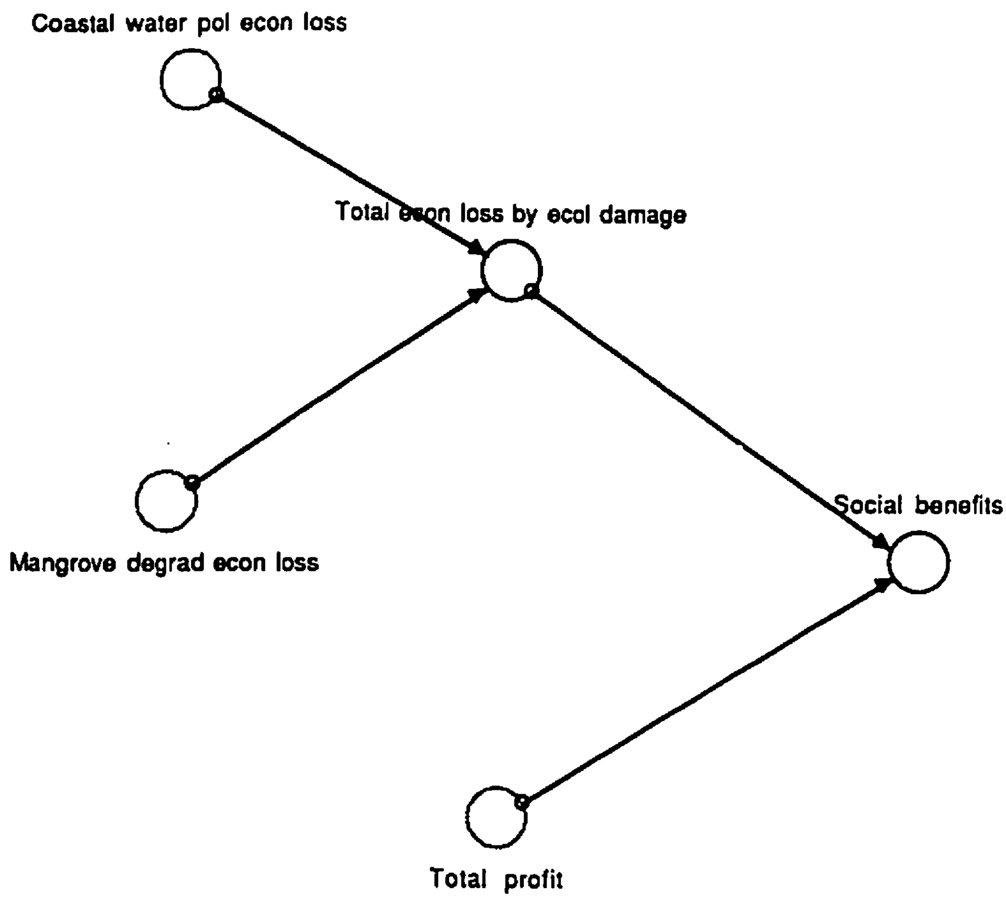
Ø Fertilizer_mangrove_degrad = GRAPH(Input_fertilizer)
(1.00, 400), (2.00, 400), (3.00, 390), (4.00, 400), (5.00, 395), (6.00, 400), (7.00, 395), (8.00, 400), (9.00, 395), (10.0, 400), (11.0, 545), (12.0, 670), (13.0, 700), (14.0, 700), (15.0, 720), (16.0, 730), (17.0, 725), (18.0, 730), (19.0, 735), (20.0, 725), (21.0, 740), (22.0, 730), (23.0, 740), (24.0, 735), (25.0, 745)

Ø Tambak_mangrove_degrad = GRAPH(Area_tambak)
(1.00, 250), (2.00, 2375), (3.00, 4625), (4.00, 6250), (5.00, 7375), (6.00, 9875), (7.00, 12500), (8.00, 14250), (9.00, 16250), (10.0, 18625), (11.0, 21125), (12.0, 22875), (13.0, 25000), (14.0, 0.00), (15.0, 0.00), (16.0, 0.00), (17.0, 0.00), (18.0, 0.00), (19.0, 0.00), (20.0, 0.00), (21.0, 0.00), (22.0, 0.00), (23.0, 0.00), (24.0, 0.00), (25.0, 0.00)

O Population_mangrove_degrad = Population*(2/10000)
DOCUMENT: The degradation of mangrove due to the increase in population is equal to 2 ha for each 10,000 people.


Oil mangr econ loss
Oil mangrove degrad
LNG mangr econ loss
LNG mangarove degrad
Fertilizer mangr econ loss
Mangrove degrad econ loss
Fertilizer mangrove degrad
Tambak mangr econ loss
Tambak mangrove degrad
Population mangrove degrad
Population mangr econ loss

Appendix 8.3. The Diagram of RDA Submodel (Continued)



Appendix 8.3. Equations of the RDA Submodel (Continued)

- Oil_mangr_econ_loss = Oil_mangrove_degrad*(216.7+15.0)
  DOCUMENT: The US $ 216.7 is the economic value of one hectare of mangrove per year, consisting of traditional uses (e.g. hunting and gathering); fisheries; and selective cutting. The US $ 15.0 is the economic value of the capturable biodiversity of one hectare of mangrove per year. This calculation is based on the empirical study of mangrove economic valuation on Bintuni Bay, Irian Jaya, Indonesia (Ruitenbeek, 1991).

- LNG_mangr_econ_loss = LNG_mangarove_degrad*(216.7+15.0)

- Fertilizer_mangr_econ_loss = Fertilizer_mangrove_degrad*(216.7+15.0)

- Tambak_mangr_econ_loss = Tambak_mangrove_degrad*(216.7+15.0)

- Population_mangr_econ_loss = Population_mangrove_degrad*(216.7+15.0)

- Mangrove_degrad_econ_loss =
  Oil_mangr_econ_loss+LNG_mangr_econ_loss+Fertilizer_mangr_econ_loss+Tambak_mangr_econ_loss+Population_mangr_econ_loss

- Total_econ_loss_by_ecol_damage =
  Coastal_water_pol_econ_loss+Mangrove_degrad_econ_loss

- Social_benefits = Total_profit-Total_econ_loss_by_ecol_damage

Appendix 8.3. Equations of the Resource Damage Assessment Submodel (RDA) (Continued)

○ Oil_pol_econ_loss = IF Oil_concentration>5 THEN Oil_affected_area*205000 ELSE 0
DOCUMENT: The total area of the fishing ground of Muara Badak, Bontang, and Sangkulirang subdistricts is about 200 square km (Naamin and Uktolseya, 1976). The value of total catch from such a fishing ground is US $ 4,108,281 (Dinas Perikanan Dati II Kabupaten Kutai, 1988). Thus, the use (at the moment only for fisheries) value of the coastal water is defined by US $ 4,108,281/200 = US $ 205/square km.

The number 5 is maximum allowable concentration of oil in the coastal water for fisheries purposes (Governor Decree, 1988).

○ Thermal_pol_econ_loss = IF (Thermal_level - 30)>5 THEN Thermal_affected_area*205000 ELSE 0
DOCUMENT: The number 30 represents the avragae ambient temperature of the receiving coastal water (Universitas Mulawarman, 1983; Unocal, 1990; and field observations, 1989 and 1990). The rest of logical expressions are the same as the Oil_pol_econ_loss.

The number 5 represents the allowable maximum difference between the ambient temperature and the heated water (Zieman and Wood, 1975).

○ Ammonia_pol_econ_loss = IF Ammonia_concentration>1 THEN Ammonia_affected_area*205000 ELSE 0
DOCUMENT: The number 1 represents the allowable maximum concentration of ammonia in the coastal water for fishreies uses (Governor Decree, 1988).

○ BOD_P_pol_econ_loss = IF BOD_P_concentration>45 THEN BOD_P_affected_area*205000 ELSE 0

○ BOD_T_pol_econ_loss = IF BOD_P_concentration>45 THEN BOD_T_affected_area*205000 ELSE 0
DOCUMENT: The number 45 represents the maximum allowable concentration of BOD in the coastal water for fisheries uses (Governor Decree, 1988).

○ Coastal_water_pol_econ_loss = Oil_pol_econ_loss+Thermal_pol_econ_loss+Ammonia_pol_econ_loss+BOD_T_pol_econ_loss+BOD_P_pol_econ_loss

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