MANAGING CONFLICT IN NATIONAL PARKS:

THE CASE OF ENCROACHMENT IN KERINCI SEBLAT, INDONESIA

By

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Declaration

I hereby declare that this thesis has been composed by me and that all work presented in the thesis is my own unless specifically sated otherwise.

Edinburgh, 1 September, 1998 Tachrir Fathoni

ABSTRACT

Kerinci Seblat National Park (KSNP) is the largest national park in Indonesia. It surrounds Kerinci District, the biggest enclave inside any comparable national park in the world. For these reasons the people-park problems are potentially the most complex among all parks in Indonesia.

The greatest threat to the integrity of KSNP comes from encroachment which is largely aimed at the cultivation of cinnamon trees. Traditional approaches to park management and enforcement activities to exclude local people from the park have been unable to solve this problem. This study attempts to fill gaps in our knowledge of people-park interactions in KSNP and aims to incorporate encroachment problems in the park's management plan.

The objectives of this study were: (1) to examine characteristics of encroachment systems, people's attitude towards the Park and encroachment; (2) to measure the degree of people pressure on the park and analyse impacts of encroachment on soil properties; (3) to model historical land use dynamics in an attempt to predict future encroachment; and (4) to provide alternative management options for the Park using a multi-criteria decision making (MCDM) model, and define the trade-offs that will exist between economic, environmental and social variables associated with alternative options.

The results demonstrate that shortage of land and people's perception of cinnamon are significant factors influencing encroachment activities in KSNP. Land use dynamics in the District are strongly influenced by the twin processes of encroachment and forest degradation. The most critical zone for encroachment in the District is the area in the elevation between 500-1500 m with slope less than 40 percent. Due to human encroachment, the Park is now under serious population pressure. Therefore, four scenarios of land allocation for buffer and traditional use zones were produced to lessen the pressure. A model was developed for identifying the area most likely to be encroached in the future. These results were utilised in order to develop eleven alternative management options for resolving conflict between encroachment and sustainable park management.

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ABBREVIATION AND ACRONYM

AHP	Analytical Hierarchy Process
AMO	Alternative Management Options
BAKOSURTANAL	National Survey and Mapping Coordination Board
BAPPEDA	Provincial Development Planning Bureau
BAPPENAS	National Development Planning Bureau
BKSDA	Balai Konservasi Sumber Daya Alam (Regional Nature Resource conservation)
BPN	Badan Pertanahan Nasional (National Land Development Board)
BPS	Biro Pusat Statistik (Statistics Central Bureau)
CFR	Cropping-Fallow Ratio
CNPPA	Commission on National Park and Protected Areas
CP	Composite Programming
CPD	Critical Population Density
CR	Consistency Ratio
DAS	Water Catchment
DHV	Dwars, Heederik en Verhey
DTM	Digital Terrain Model
ESRI	Environmental System Research Institute
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GDRB	Gross Domestic Regional Brutto
GIS	Geographical Information System
GLM	General Linear Model
GRDP	Gross Regional Domestic Product
Ha	Hectare
HPH	Hak Pengusahaan Hutan (Forest Concession)
ICDP	Integrated Conservation Development Projects
IPAS	Integrated Protected Areas System
IPB	Institute Pertanian Bogor (Bogor Agriculture Institute)
IUCN	International Union for Conservation of Nature and Natural Resources
JANTOP	The Army Topographical Agency
KIA	Kappa Index of Agreement
KLH	Ministry of Ppopulation and Environment
KSDA	Regional Office for Nature Conservation
KSNP	Kerinci Seblat National Park

LA	Logit Analysis
LRA	Logistic Regression Analysis
MCDM	Multi-Criteria Decision Making
MCE	Multi-Criteria Evaluation
MIS	Management Information System
MoF	Ministry of Forestry
MPTS	Multi-Purpose Tree Species
MR	Multiple Regression
PHPA	Directorate General of Forest Protection and Nature Conservation
PPI	The Park Pressure Index
REPELITA	Five Year Development Plan
SBRLKT	Sub Regional Office of Land Rehabilitation and Soil Conservation
SPSS	Statistical Package for Social Sciences
TGHK	Tata Guna Hutan Kesepakatan (Forest Consensus Map)
TNKS	Taman Nasional Kerinci Seblat (Kerinci Seblat National Park)
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPT	Unit Pelaksana Teknis (Technical Management Unit)
WCMC	World Conservation Monitoring Centre
WLC	Weighted Linear Combination
WRI	World Resource Institute
WWF	World Wide Fund for Nature

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CHAPTER ONE

INTRODUCTION

This chapter provides a general overview of national park and biodiversity management issues at the global, national and case study level. The definition of national park and its implications on the historical park management approaches currently applied in most developing countries is explored. This is then followed by an overview of protected areas management based on the International Union for the Conservation of Nature and Natural Resources (IUCN's) categories and its application in Indonesia. It describes Indonesia's biodiversity resources compared to those of the rest of the world and discusses its general conservation policy. This discussion includes international, and Indonesia's, rules for managing protected areas; and provides an analysis general problems encountered in parks management especially in the study site. Finally the objectives and hypotheses of the study are presented followed by a summary of the structure of the thesis.

1.1. National Park Management Approaches

1.1.1. Definition of national park

The term national park was defined for the first time in 1969 by the General Assembly of the International Union for Conservation of Nature and Natural Resources (IUCN) in New Delhi (Zentilli, 1977; Reti, 1986). The definition of national park according to the New Delhi definition is as follows:

> *'A national park is a relatively large area: (1) where one or several ecosystems are not merely altered by human exploitation and occupation, where plant and animal species, geomorphological sites and habitats are of special scientific, educative and recreative interest or which contains a natural landscape of great beauty; and (2) where the highest competent*

authority of the country has taken steps to prevent or eliminate as soon as possible exploitation or occupation in the whole area and to enforce effectively the respect of ecological, geomorphological or aesthetic features which have led to its establishment; and (3) where visitors are allowed to enter, under special conditions, for inspirational, educative, cultural and recreative purposes'.

However, the need to accommodate the complexity of the real world and adapt with the growing ideas from many countries to involve the aspiration and necessities of the local people has made IUCN revise the definition of national park as:

> *'Natural area of land/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupations inimical to the purpose of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible'. (IUCN, 1994).*

The above definitions of national park have directed two different concepts and approaches for national park management: the traditional protective approach and the integrated approach as presented in the following sections.

1.1.2. Concept of national park: traditional protective approach

The first definition of national park emphasised that national parks should be free from all human exploitations and occupations, and steps should be taken by the highest competent authority of the country to eliminate such exploitation and occupation in the whole area. By this definition, parks have become 'isolated islands'. They are separate from people and from regional development. When this concept has been applied to developing countries, parks have often been disruptive to the traditional subsistence of the local people (Lusigi, 1981; West, 1991; Ghimire, 1991).

This traditional concept of a national park which is sometimes labelled 'a preservationist approach' (Machlis and Tichnel, 1985) or the 'fences and fines approach' (Wells *et al.*, 1992) emphasises the Park management's policing role for the essential defence strategy. In addition, this concept is also characterised by poor participation of local people (McNeely, 1994) even if they depend for their subsistence needs on resources within the Park. Furthermore, emphasising park management's policing role may lead to heavy handed law enforcement which in some circumstances has aggravated conflicts between local people and park managers in developing countries (Hough, 1988; Sharma, 1991).

Under this traditional concept of the Park, very little or no attention is paid to adjacent land uses because park managers have no control over the management of these areas. Therefore, park management is not involved in promoting compatible development for surrounding communities. As a result, local people generally view parks as a foreign idea merely to foster tourism while they are deprived of traditional resources (Machlis and Tichnel, 1985). The local people might perceive that the Parks threaten their own short-term benefit and socio-cultural well-being. Hence, new approaches, an integrated approach, to protecting biodiversity as well as the rights of people who live in and around the Parks are needed.

1.1.3. Integrated approach: a new concept of parks management

The traditional approaches to a park management, which largely ignored the role of local communities and were based on attempts to isolate national parks from surrounding communities through fencing and law enforcement have failed to resolving people-park conflict in many developing countries. This, according to McNeely (1989), is because biodiversity conservation in many categories of protected areas, including in national parks, is far more a social challenge than a biological one. It is not surprising therefore that such traditional approaches to park management were widely criticised during the Third World National Park Congress held in Bali, Indonesia (MacKinnon *et al.*, 1986). Indeed similar criticism was further reiterated during the Forth World Congress on National Parks and Protected Areas in Caracas, Venezuela (IUCN, 1993).

Many international organisations such as United Nations (UN) agencies, the World Bank, IUCN and World Wide Fund for Nature (WWF) have come to realise that national parks, especially in developing countries, cannot be managed successfully without taking into account the needs of local inhabitants (DHV, 1993). Therefore, in recent years, a growing volume of literature has argued for providing local people with access to national park resources in order to meet their subsistence needs (IUCN, 1980; Lucas, 1982; McNeely and Miller, 1984; Dasmann, 1985; West and Brechin, 1991; Wells *et al.*, 1992; Munasinghe and McNeely, 1994; CNP, 1997).

This shift in emphasis has become evident through the development of new approaches such as Integrated Conservation Development Projects (ICDPs), Integrated Protected Areas System (IPAS) and Buffer Zone (Wells *et al., 1992*). Their objective is to address the needs of nearby communities by emphasising local participation and by integrating conservation inside the Park with development outside the Park.

ICDPs are one of the major approaches proposed for effective management of biodiversity (The World Bank, 1993), and according to McNeely (1994) they have recently received increasing attention from multilateral institutions, conservation organisations and government agencies (Munasinghe, 1994). These approaches aim to achieve their conservation goals by promoting development and providing local people with alternative income sources. This concept might be suitable for use in any country in which a substantial number of people live in or near conservation areas. Indonesia in collaboration with the World Bank and WWF is currently testing the effectiveness of the ICDP's model for sustainable park management in six national parks, one of which is Kerinci Seblat National Park (KSNP) (The World Bank, 1996).

National parks are only one of the protected area categories which mainly emphasises for biodiversity conservation and tourism development. There are many other categories of protected area with different management priorities. A brief summary of these categories is necessary to avoid confusion on the understanding of variety of terminology applied in this study as presented in the following sections.

1. 2. An Overview of Protected Areas Management

1.2.1. Definition of protected area

The definition of protected area is derived from the workshop on Categories held at the IVth World Congress on National Parks and Protected Areas in Caracas in 1992 as:

> *'An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means' (IUCN, 1994).*

In fact, many countries have set up varieties of protected area terminology with different management purposes. Therefore, categorisation of protected areas as a guideline for all countries is necessary.

1.2.2. Protected area category

At the IVth World Congress on National Parks and Protected Areas, meeting in Caracas, Venezuela in February 1992, participants concluded that more and better managed protected areas were urgently needed. They emphasised that protected areas should not be islands in a sea of development but must be part of every country's strategy for sustainable management.

In reality, different countries have established national systems using widely varying terminology for protected area with different management purposes. Therefore, IUCN through its Commission on National Park and Protected Areas (CNPPA) has given international guidance on the categorisation of protected areas and the general purpose of each category (Phillips and Harrison, 1997). This guidance is intended to provide a basis for international comparison and is hoped to be a driving mechanism for governments in deciding the purposes of potential protected areas. The relationship between management objectives and the IUCN's category of protected areas is illustrated in Table 1.1.

Table 1. 1. Matrix of management objectives and IUCN protected area categories
(IA: Strict Nature Reserve; IB: Wilderness Area; II: National Park; III: Natural Monument; IV: Habitat/Species Management Area; V: Protected Landscape/Seascape; VI: Managed Resource Protected Area; 1: Primary objective; 2: Secondary objective; 3: Potentially applicable objectives)

Management Objective	IUCN Management Category						
	IA	**IB**	**II**	**III**	**IV**	**V**	**VI**
Scientific research	1	3	2	2	2	2	3
Wilderness protection	2	1	2	3	3	-	2
Preservation of species and genetic diversity	1	2	1	1	1	2	1
Maintenance of environmental services	2	1	1	-	1	2	1
Protection of specific natural/cultural features	-	-	2	1	3	1	3
Tourism and recreation	-	2	1	1	3	1	3
Education	-	-	2	2	2	2	3
Sustainable use of natural resources	-	3	3	-	2	2	1
Maintenance of cultural/traditional attributes	-	-	-	-	-	1	2

Source: IUCN (1994)

Table 1.1 indicates that each category of protected areas has specific main management purposes. These specific objectives are summarised from Table 1.1 and shown in Table 1.2 below.

Table 1.2. The summary of the main management purpose for each protected area category

Protected Area Category	The Main Management Purpose
Strict Nature Reserve	Science and preservation of biodiversity
Wilderness Area	Wilderness protection
National Park	Ecosystem protection and recreation
Natural Monument	Conservation of specific natural features
Habitat/Species Management Area	Conservation through management intervention
Protected Landscape/Seascape	Landscape/seascape conservation and recreation
Managed Resource Protected Area	Sustainable use of natural ecosystem

Source: IUCN (1994)

1.2.3. Comparison with the Indonesia's protected area categories

Based on the Indonesian Act No. 5 of 1990 concerning Conservation of Living Resources and Their Ecosystems, protected areas in Indonesia can be divided into two different categories: Sanctuary Reserves, which consist of strict nature reserves and wildlife sanctuaries, and nature conservation areas, which consist of national parks, grand forest parks and natural recreation parks. In reality, natural recreation parks are established in the form of recreation forest and hunting forest.

The Act also includes a biosphere reserve. In the field, however, this area is overlapping with other protected area categories such as Gn. Gede Pangrango National Park which has been established by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a biosphere reserve. Protection forest is an area mainly intended for preservation of water resources and soil degradation. However, it is not mentioned in the Act No. 5 but it is worthwhile to be considered as one of the protected area categories because of its function for soil and water resources preservation. It covers a vast area of approximately 30 million hectares of forest land throughout the country. The relationship between management objectives and Indonesia's category of protected areas is illustrated in Table 1.3.

Table 1.3. Matrix of management objectives and Indonesian protected area categories (A: Strict Nature Reserve; B: Wildlife Sanctuary; C: National Park; D: Grand Forest Park; E: Recreation Forest; F: Hunting Forest; 1: Primary objective; 2: Secondary objective; 3: Potentially applicable objectives)

Management Objective	Indonesian Management Category						
	A	B	C	D	E	F	G
Scientific research	1	2	2	3	3	3	2
Wilderness protection	2	1	2	2	3	2	2
Preservation of species and genetic diversity	1	1	1	2	2	2	2
Maintenance of environmental services	2	2	1	3	3	3	3
Protection of specific natural/cultural features	-	-	2	3	3	3	1
Tourism and recreation	-	3	1	1	1	1	3
Education	3	3	2	2	2	3	1
Sustainable use of natural resources	-	-	3	-	3	1	-
Maintenance of cultural/traditional attributes	-	-	-	-	-	-	2
The relevance to IUCN management category	IA	IB	II	III	III	IV	VI

Source: Adopted from the Indonesian Act No. 5 of 1990 and from Sumardja *et al.* (1982)

The main management purpose for each category of protected areas can be summarised from Table 1.3 as shown in Table 1.4 below.

Table 1.4. The summary of the main management purpose for each Indonesia protected area category

Protected Area Category	The Main Management Purpose
Strict Nature Reserve	Science and preservation of biodiversity
Wildlife Sanctuary	Wilderness protection species preservation
National Park	Ecosystem and species protection and recreation
Grand Forest Park	Recreation and wilderness protection
Recreation Forest	Recreation and education
Hunting Forest	Recreation and sustainable use of wildlife resources
Biosphere Reserve	Education and conservation of specific natural features

1.3. Indonesia's Policy for Protected Area Management

1.3.1. The legal framework

Indonesia has been in the forefront among tropical nations in establishing protected areas for conserving biodiversity. It has a long-standing formal policy for allocating state forest land to a number of categories pertaining to exploitation as well as protection. This policy is guided by Act No. 5 concerning Basic Provision for Forestry of 1967. This Law is the central legal framework for conservation, under which several categories of protected areas are recognised.

This Act is strengthened by Act No. 5 Basic Provision for the Management of Living Environment of 1982 and Act No. 5 concerning Conservation of Living Resources and Their Ecosystem of 1990. The latter provides the legal basis for a number of new protected area categories such as national parks, biosphere reserves and other protected areas which to a certain extent have been developed in line with the IUCN's category (MoF, 1992). It also provides a zoning concept within the conservation areas, including core zone, intensive use zone for recreation, wilderness and traditional management zone.

1.3.2. Institution for protected area management

The responsibility for the management of all protected areas in Indonesia lies with the Directorate General of Forest Protection and Nature Conservation (PHPA) within the Ministry of Forestry (MoF). Its responsibility covers planning and management of all conservation areas as well as planning and supervision of protection forests. At the provincial level, PHPA is represented by the Natural Resources Regional Office and Sub Regional Office (Balai and Sub Balai KSDA) under the authority of the Provincial Forestry Department (Kantor Wilayah Departemen Kehutanan). National parks are managed by a special body, the National Park Management Unit, which is directly responsible to the Directorate General of

PHPA. Beside receiving increasing attention from the people and the government, national parks, in general, are better managed than other protected areas. It may be expected therefore, that national parks are more likely to secure biodiversity conservation in the future than other protected areas in Indonesia.

1.3.3. Designation of Protected areas in Indonesia

At present, 363 protected areas, including marine reserves, covering nearly a total of 19.5 million hectares or about 10.2 percent of Indonesia's land area have been gazetted throughout the country (MoF, 1996). These conservation areas consist of six types of nationally protected areas as shown in Table 1.5. Currently, Indonesia has designated 33 national parks covering nearly 8.8 million hectares. In addition, another 30 million hectares of forest area are designated as protection forest. In total 49.5 million hectares of forest lands are included within the protected areas (BAPPENAS, 1993).

Table 1. 5. Protected areas in Indonesia

Protected Area	Number			Area (Ha)		
Category	Terrestrial	Marine	Total	Terrestrial	Marine	Total
National park	28	5	33	6,471,279	2,292,955	8,764,235
Strict nature reserve	173	5	178	5,881,933	204,750	6,085,683
Wildlife sanctuary	45	3	48	3,458,471	65,220	3,523,691
Recreation forest	73	10	83	273,568	432,574	706,142
Grand forest park	9	-	9	229,553	0	229,553
Hunting forest	12	-	12	146,043	0	146,043
Total	340	23	363	16,460,847	2,995,499	19,456,347

Source: Summarised from MoF (1996).

Table 1.5 shows that the 33 different national parks consists of together about 45 percent of all protected areas. This is because national parks have been given greater priority in government policy than other protected areas.

1.3.4. Comparison of Protected area: Indonesia and other countries

Recently, IUCN has developed a system classification for different types of protected areas in many countries based on their management objectives. This system forms the basis for United Nation List of National Park and Protected Areas. Only nationally protected areas of more than 1,000 ha that fall within IUCN management categories I to V are included in the list (UNEP, 1993). Based on this system, protected areas in many countries can be compared. The comparative protected area in Indonesia and many countries in Asia is shown in Table 1.6.

Table 1. 6. Comparative Protected area: Indonesia and the selected countries of Asia

Country	Number of protected areas	Area (ha)	Percentage of total land area
Indonesia *	340	19,456,347	10.2
Bangladesh	8	96,790	0.7
Brunei	5	77,742	13.5
China	396	28,357,804	3.0
India	362	13,770,557	4.4
Japan	684	4,663,543	12.7
Korea	26	756,833	7.7
Malaysia	51	1,488,047	4.5
Nepal	13	1,126,000	8.0
Pakistan	53	3,654,969	4.6
Philippines	27	572,866	1.9
Singapore	1	2,715	4.4
Sri Lanka	43	783,708	11.9
Thailand	90	5,513,986	10.8
Turkey	18	269,176	0.3
Viet Nam	59	897,498	2.7

Source : WCMC (1992) in UNEP (1993); * MoF (1996)

It is clear from Table 1.7 that there are five countries: Indonesia, Brunei, Japan, Sri Lanka and Thailand which have gazetted protected areas of more than 10 percent of their total land area as suggested by IUCN in the Bali Declaration of the Third World National Park Congress in 1982. Even though China and India both have a large number of protected areas i.e. 28,357,804 ha and 13,770,557 ha respectively, they still comprise less than 10 percent of their total land areas. Indonesia is the only country in Asia to have designated more than 100 units of protected areas (340 units) covering over 10 million hectares (19,456,347 ha) and representing more than 10 percent of its land mass.

The designation and management of protected areas in Indonesia has been increasing sharply over the past decade, supported by many international organisation such as WWF, the World Bank, FAO, IUCN, etc. Protected area designation is not only intended to cover terrestrial habitats but also marine habitats. Marine and coastal areas of greatest importance for conservation of biodiversity have been identified by Soegiarto *et al.* (1982). At present, about 2.9 million hectares of marine and littoral habitats were established in the form of varieties of protected area category (Table 1.5). This will be expanded to the total of 20 million hectares in the future (BAPPENAS, 1993). However, gazetting national parks and other protected areas is only the first step in protecting biodiversity. Species survival in the long-term will depend on the effective protection and management of the protected areas.

In planning the national system it was assumed that the establishment and administration of protected areas will cover all habitat types and their natural environment. As shown in Table 1.3 and Table 1.4 the purpose of management of most Indonesia's protected area categories is for the conservation of biodiversity. It indicates the important role of biodiversity in national development. Therefore, understanding issues of Indonesia's biodiversity resources as well as its role in the national development is an important factor to set up an appropriate management policy for people-park conflict resolution.

1.4. Indonesia's Biodiversity : Resources and Policy

1.4.1. Definition of biodiversity

The term biodiversity is defined by the Convention on Biological Diversity (CBD) at the 'Earth Summit' in Rio de Janeiro in June 1992 as:

> *'The variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems'* (Watson, 1995).

In short, biodiversity encompasses the variety and abundance of living organisms including plants, animals, and micro-organisms, as well as the ecosystems to which they belong (see also Halvorson, 1996; Abe, 1997). Biodiversity is usually considered at three levels of composition: genetic, species and ecosystem .

1.4.2. Biodiversity resources

Indonesia which contains nearly 10 percent of the world's closed tropical forests (UNEP, 1993; the World Bank, 1996) is one of the most important countries in the world for biodiversity (BAPPENAS, 1993; DHV, 1993). The country's more than 17,000 islands span two major bio-geographical zones, Indomalaya and Australasia, and cover seven major bio-geographic provinces as well as a great diversity of ecosystem types (MacKinnon and MacKinnon, 1986; Barber *et al.*, 1994 and 1995).

Although the archipelago comprises only 1.3 percent of the earth's land surface, it represents about 27 percent of the world's total species. This consists of an estimated 10 percent of the world's plant species, 12 percent of mammals, 17 percent of all bird species and 45 percent of fish species (BAPPENAS, 1993; The World Bank, 1996). A more detailed comparative analysis of biotic richness found in Indonesia and the rest of the world is presented in Table 1.7. The table shows that more than one third of the world's insect, mollusc, fish and amphibian species are found in Indonesia.

Table 1.7. Comparative biotic richness: Indonesia and the World

Group	Indonesia (Number of species)	World (Number of species)	Percentage** of world's species found in Indonesia
Bacteria, blue-green algae	300	4,700	6.38
Fungi	12,000	47,000	25.53
Sea grasses	1,800	21,000	8.57
Moss	1,500	16,000	9.38
Ferns	1,250	13,000	9.62
Flowering plants	25,000	250,000	10.00
Insects	250,000	750,000	33.33
Molluscs	20,000	50,000	40.00
Fish	8,500	19,000	44.74
Amphibians	1,000	4,200	23.81
Reptiles	2,000	6,300	31.75
Birds	*1,519	9,200	16.30
Mammals	* 515	4,170	11.99
TOTAL	325,350	1,194,570	27.24

Source : [(KLH, 1989; McNeely *et al*, 1990) quoted from BAPPENAS, 1993]
* UNEP (1993); ** Calculated from the data provided

1.4.3. The role of biodiversity for the National development

The biodiversity resources of Indonesia are economically important for the national development. Conservation of natural ecosystem and biological resources has strongly influenced many sectors of Indonesia's economy such as agriculture, forestry, livestock and fisheries. These sectors all together contributed about 19 percent of Gross Domestic Product (GDP) in 1993 (The World Bank, 1996). In addition, an estimated 40 million people directly depend on a wide range of biodiversity for subsistence. They utilise more than 6,000 species of plants and animals on a daily basis either cultivated or harvested directly from the wild (BAPPENAS, 1993). Therefore, conservation of biodiversity is fundamental to many sectors.

1.4.4. Policy for biodiversity conservation

The National policy for conserving biodiversity during the current five-year Development Plan (REPELITA VI: 1994/1995-1998/1999) and for the next twenty-five years Development Plan, has been outlined in the 'Biodiversity Action Plan for Indonesia'. Three main objectives of the Plan (BAPPENAS, 1993) are: (a) reducing the loss of terrestrial and marine habitats of primary importance for biodiversity; (b) collecting and making available biodiversity data and information for policy makers and the public; and (c) promoting the sustainable use of biological resources.

In order to attain these goals, the Plan has been further projected into four priority action components (BAPPENAS, 1993). The first priority is *in situ* conservation in national parks, reserves and protection forest; second, *in situ* outside the protected area network in forests, wetlands and agricultural landscapes; third, *in situ* conservation of marine and coastal resources; and fourth, *ex-situ* conservation including gene and seed banks, preservation of crop varieties, and captive breeding programmes. Public participation, particularly by communities dependent on, and living in, or adjacent to park and reserve areas, has been highlighted as an important prerequisite for implementing the Plan.

However, increasing demands for land and resources due to expanding human populations has caused conflicts between protected areas especially national parks and their surrounding communities. In order to successfully resolve, or at least manage, these conflicts, examination of the root of the problems is of vital importance. A review of some of these issues is presented in the next section.

1.5. Park Management Problems

National parks which were established more than 100 years ago in the United States, have been the most effective and widespread measure for conserving biodiversity and natural resources (McNeely, 1984). They are potentially refuges of peace and tranquillity, yet also places where conflict occurs (Lewis, 1996).

There is a tendency that many national parks in developing countries are at serious risk because of increasing pressure from expanding scale of human activities both inside and outside their boundaries (Croft, 1981; Blunden and Curry, 1990; West and Brechin, 1991; Craven and Wardoyo, 1993; Barzetti, 1993; Kemf, 1993; Brechin *et al.*, 1994; Hough, 1988; Lewis, 1996). As a result, conflicts of interest between the Park management and developing local economies are almost inevitable.

Every park has its own specific conflicts of interest related to the particular socio-economic and cultural situation of the surrounding communities, the bio-geographic condition as well as the management policy of the Park (Harmon, 1994; Lockhart, 1988). The main causes of people-park conflicts have been reported as related to wildlife (Studsrod and Wegge, 1995; Nepal and Weber, 1995), population pressure (Sharpe and Rodriquez, 1997), encroachment and shifting cultivation (Meganck and Gobel, 1985), poaching (Newmark *et al.*, 1993; Craven and Wardoyo, 1993), and erosion as well as pollution (Bailey *et al.*, 1997).

Every problem, however, is unique and site specific related to park management policy. Therefore, gaining a better understanding of the local people's needs and aspirations, the biodiversity resources and the management policy of the country is necessary for effective people-park conflict management in national parks.

1.5.1. General management problems

National parks throughout the world are beset by a variety of management problems. These range from social and cultural problems of competing park lands for economic benefits (DHV, 1993; Brechin *et al.*, 1994), to ecological problems such as threats to conservation of fragile vegetation (Sinha, 1992) and sensitive wildlife (Nepal and Weber, 1995), to administrative and institutional problems of inadequate manpower and funding (Allen, 1980; Dourojeanni, 1993). However, perhaps the most threatening of all park problems in developing countries is the adverse ecological impact of shifting cultivation and/or human encroachment (Meganck and Gobel, 1985) as presented in the following sections.

1. 5. 2. Shifting cultivation and encroachment problems

Shifting cultivation is defined by FAO (1982) as *'A farming system in which relatively short periods of cultivation are followed by relatively long period of fallow'*. The system thus involves the clearing of a plot of land, usually under some sort of forest cover, using it for a few years and then, as soil fertility decreases, abandoning it in favour of another newly-cleared plot.

Shifting cultivation according to Hatch (1980), however, can be accepted agricultural system as long as there is balance between the length of the crop and fallow period. Usually the main purpose of the fallow period is simultaneously to improve soil fertility and the soil's capacity to resist erosion. Hence, the relation between the cultivation and the fallow period is the most important factor governing shifting cultivation. Ruthenberg *et al.* (1980) and Lanly (1985) formulated the 'Cropping-Fallow Ratio model' (CFR or usually called R) to determine types of shifting cultivation. The cropping-fallow ratio (R) is defined by the length of the cultivation period divided by the sum of the length of the cultivation period and the length of the fallow period.

Using R as a yardstick, they suggested that, when: (1) $R < 0.33$, the corresponding system is shifting cultivation with long fallow agriculture; (2) $0.33 < R < 0.66$, there is short fallow agriculture, semi-permanent cultivation or stationary cultivation with fallowing; (3) $R > 0.66$, there is permanent cultivation with either single cropping or various degree of multiple cropping. Application this formula for encroachment systems in the study site reveals that most encroachment in KSNP is in the category of permanent cultivation.

The sustainability of a shifting cultivation system depends on the balance between population and the natural resources on which the system depends. Allan (1949) in Chidumayo (1987) developed a suitable measure of the carrying capacity under shifting cultivation using 'a Critical Population Density model' (CPD). This is proportional to the area required to support one person per year and to the number of plots required to allow a proper ratio of the years of fallow to the number of successive years of use. However, it is inversely proportional to the percentage of the territory which can be cultivated.

The population density any shifting cultivation system can support is a matter for debate as it is site specific related to the climate and soil fertility. Ruthenberg *et al.*, (1980) calculates that no more than 56 person per square kilometre can be supported. On the other hand, Lassailly-Jacob in FAO (1985) estimates that in the Ivory Coast, 83 persons per square kilometre is the limiting density for maintaining the environmental balance.

Encroachment, as defined in this study, refers to the illegal human occupation on a piece of forest land and its use for agricultural farming. Shifting cultivation, therefore, is potentially an encroachment activity. In areas with high population density and a short supply of land, such as in the study area of Kerinci Seblat National Park, shifting cultivation in its traditional form is neither appropriate nor possible, for it requires a large amount of land that can be held in long term fallow. Therefore, shifting cultivators are forced to break their own rules concerning preservation of species and ecological equilibrium. This leads to a shorter, or even absent, fallowing period and a smaller carrying capacity. In such conditions, shifting cultivation is an agent of forest and national park depletion.

Shifting cultivation, one of the oldest systems of agriculture, is widely practised in developing countries (Ruthenberg *et al.*, 1980). This system has been applied for many centuries before the idea of national parks and biodiversity conservation were accepted by developing countries. Unfortunately, needs and aspirations of shifting cultivators have often been overlooked when their farming lands were designated as national parks (Studsrod, 1995). Therefore, conflict in people-parks relationships and disruption of the Parks environment is almost inevitable.

A large number of people in developing countries depend upon natural resources in forests (Simon, 1988; Penzich *et al.*, 1994; Tisdell, 1995; Sharpe and Rodriquez, 1997), protected areas and national parks (Meganck and Gobel ,1985; Cincotta, 1994) for their subsistence needs. It is estimated about 500 million people or 40 percent of the total agricultural population of the Third World depend on shifting cultivation for their daily livelihood (Lanly, 1985). In areas all over the world where population density is high, shifting cultivation is one of important causes of the degradation of tropical rain forest (FAO, 1982; Agrawal, 1995; Brown and Pearce, 1996).

1.5.3. Source of forest degradation

Tropical deforestation in Southeast Asia and in Indonesia in particular is generally caused by encroachers and shifting cultivators through the conversion of forests to agricultural land. Even though tropical timber production is significant in large areas of production forest, it is not considered to be the major factor in overall tropical deforestation (Barbier *et al.*, 1996). The sources of deforestation in Indonesia, Brazil, Cameroon and all major tropical forest countries can be seen in Table 1.8.

Table 1.8 includes only Indonesia, Brazil and Cameroon since these countries cover the world's major tropical rain forests and account for the largest share in clear cutting by the forestry sector. It shows that conversion of forests to agricultural land both through shifting cultivators and permanent agriculture is the main source of forest degradation in Indonesia and all major tropical rain forest countries. This table shows that management of tropical rain forest in most developing countries contributed to a smaller percentage of forest degradation compared to that of shifting cultivation. Table 1.8 disproves the general opinion in which forest degradation is mainly due to the practical forest management.

Table 1.8. Sources of deforestation (%) in tropical countries, 1981-1988

Source	Indonesia*	Brazil	Cameroon	All major tropical forest countries
Forestry	9	2	0	2
Shifting cultivators**	59	13	92	na
	(67)	(23)	(95)	(47)
Permanent agriculture	21	76	8	36
Mining and related industries	< 0.3	< 3	0	na
Hydroelectric production	0	4 *	0	2*
Residual	11	2	0	13

Source: Barbier *et al.* (1996); * Data refer to '80-'90 period
** Figures in parentheses refer to the FAO (1980)

The area of deforestation in Indonesia is estimated at about 900,000 hectares each year, a rate of 0.8 percent per year (WRI, 1990), of which more than 50 percent is caused by shifting cultivation and encroachment (Barbier *et al.*, 1996; Repetto and Gillis, 1988). Data on the number of people involved in shifting cultivation and other information for selected Asia and the Pacific countries are given in Table 1.9.

Table 1. 9. Shifting cultivation in some Asia and the Pacific countries

Country	Shifting cultivators (1,000 people)	Percent* of total population	Area of shifting cultivation (1,000 ha)	Percent* of total land area
Indonesia	5,800	3.03	11,400	6.26
Bangladesh	150	0.13	1,400	10.75
Brunei	20	0.01	120	22.64
Fiji	100	13.53	200	10.93
India	3,110	0.35	4,900	1.65
Laos	1,000	22.38	3,000	12.99
Malaysia	1,640	8.73	4,700	14.30
Myanmar	3,000	6.87	15,400	23.42
Nepal	20	0.10	250	1.83
Papua New Guinea	1,000	24.65	4,000	9.39
Philippines	850	1.30	3,500	11.74
Solomon Islands	20	0.01	3	0.11
Sri Lanka	60	0.05	1,000	15.48
Thailand	1,000	1.78	4,000	7.83
Viet Nam	5,000	7.19	9,700	29.80

Source : [(FAO, 1992) quoted from MoF, 1993]
* Calculated based on land mass and population data 1992 from UNEP (1993)

Table 1.9 shows that more than 10 percent of the total land area for most countries listed above are under the influence of shifting cultivation. Indonesia is ranked first in terms of number of people and area affected by shifting cultivation. However, its shifting cultivation area compared to the total land is less than seven percent, which is much smaller than that of most countries shown in Table 1.9.

Based on the above analyses, it is appears that the most common conflict in people park relationships in Indonesia concerns the traditional use of land. Encroachment and shifting cultivation by subsistence farmers has been identified as a continuing danger to Indonesia's national parks. People who live in the surrounding parks usually have a low standard of living and a limited knowledge about ecosystems.

These conditions force them to utilise park areas to meet their immediate needs in unsustainable ways. Therefore, with such a large number of shifting cultivators, conflicts between park management and local economic development will remain an important issue for future park management in Indonesia.

1. 5. 4. KSNP management problems

Kerinci Seblat National Park (KSNP) covers early 1.5 million hectares and is the largest park in Indonesia. It is located in the Sumatra Biogeographical Region which holds about 30 percent of the nation's biodiversity. It surrounds Kerinci District, which is the largest enclave inside any comparable national parks in the world. The District bisects the Park almost completely and covers about 420,000 hectares with a total population of approximately 287,046 people (BPS, 1994). Therefore, it is the area in which people-park problems are potentially the most complex among parks in Indonesia.

The objective of Kerinci Seblat National Park management is to conserve biodiversity contained within the Park and adjacent areas especially the rare, endangered and unique species and habitats, maintain its ecosystem integrity and facilitate human use for research, recreation and education (The World Bank, 1993; PHPA, 1995).

At present, the greatest threat to the integrity of the Kerinci Seblat National Park comes from encroachment activities to cultivate high-profit cinnamon trees. It is not easy to give an accurate estimate of encroachers using the Park area for agricultural purposes because they are not inclined to have themselves registered and somewhat reluctant to participate in surveys. Several estimates have been made of the number of encroachers in Kerinci District which showed ever increasing totals from 1,763 households in 1984 (The World Bank, 1993) to 10,446 households in 1992 (PHPA, 1992) as presented in Table 1.10.

Table 1.10. Encroachment in Kerinci Seblat National Park by Province and District

Province	District	Households	Estimated Area (Ha)
West Sumatra	Pesisir Selatan	1,645	2,594
	Solok	1,335	2,752
Bengkulu	Rejang Lebong	906	2,390
	Bengkulu Utara	90	na
Jambi	Kerinci*	10,446	18,389
	Sarko	943	5,642
	Bungo Tebo	53	60
South Sumatra	Musi Rawas	219	500
Total		15,637	32,327

Source: PHPA (1992). Survey inventory of encroachment, summarised from the World Bank (1993); * The study area

The World Bank (1993) estimated that the rate of forest clearance for cultivation of cinnamon, cash and subsistence crops is as high as 1,500 ha per year over the whole park area. Table 1.10 shows that at least 32,000 ha has been lost to agriculture encroachment during the last two decades. This includes some 18,000 ha in Kerinci District alone, cultivated by more than 10,000 families. Therefore the park integrity is under serious risk which may lead to detrimental impacts on wildlife and ecosystems. In addition, conversion of natural forest into agriculture leads to a simplified ecosystem, less biodiversity and lower soil fertility (The World Bank, 1993).

Forest clearance has resulted in disruption and fragmentation of the Park. No matter how large an isolated fragment may be it is likely to lose some species after isolation (Turner, 1997). Smaller isolated forest blocks tend to lose species faster than do larger areas. The more fragmented the Park into separate blocks the more difficult it will be to protect and manage (MacKinnon *et al.*, 1986). Therefore, the general management objective of KSNP should be directed to protect contiguous natural habitat as much as possible, and to maintain corridors of natural vegetation for wildlife migration.

Increasing demands for land and resources due to expanding human populations in Kerinci District have caused spreading encroachment to other parts of the Park. Encroachment is more likely to have negative impacts on biodiversity conservation of the Park. It has also been a trigger factor of land use changes in Kerinci District for the last two decades. Unfortunately, its impacts both on land use changes and on soil properties in KSNP have not been studied.

Cinnamon seems to be part of the social and cultural background of the people surrounding the Park. The fact that cinnamon is the major plant cultivated in most encroachment areas indicates its important role in their livelihood. For this reason, the cultivation of cinnamon is likely to be a driving force for the local people to encroach the Park.

Traditional approaches to the Park management and enforcement activities to exclude local people from the Park have been unable to solve the problem to date. Therefore, an integrated program of National Park management which is compatible with the regional development is required. For this reason, understanding the linkage between the Park and surrounding communities, as well as people's attitudes both towards the Park and cinnamon, will be of importance in providing decision support systems for conflict resolution and sustainable park management. This challenge forms the basis for this thesis.

In general, encroachment problems encountered in KSNP, their causes and effects are summarised in Figure 1.1. The diagram shows that limited agricultural lands and the uncompleted Park boundary, low level education, income and perception of people surrounding the Park might increase forest clearance and people pressure on the Park. These factors might result in increased human encroachment on the Park.

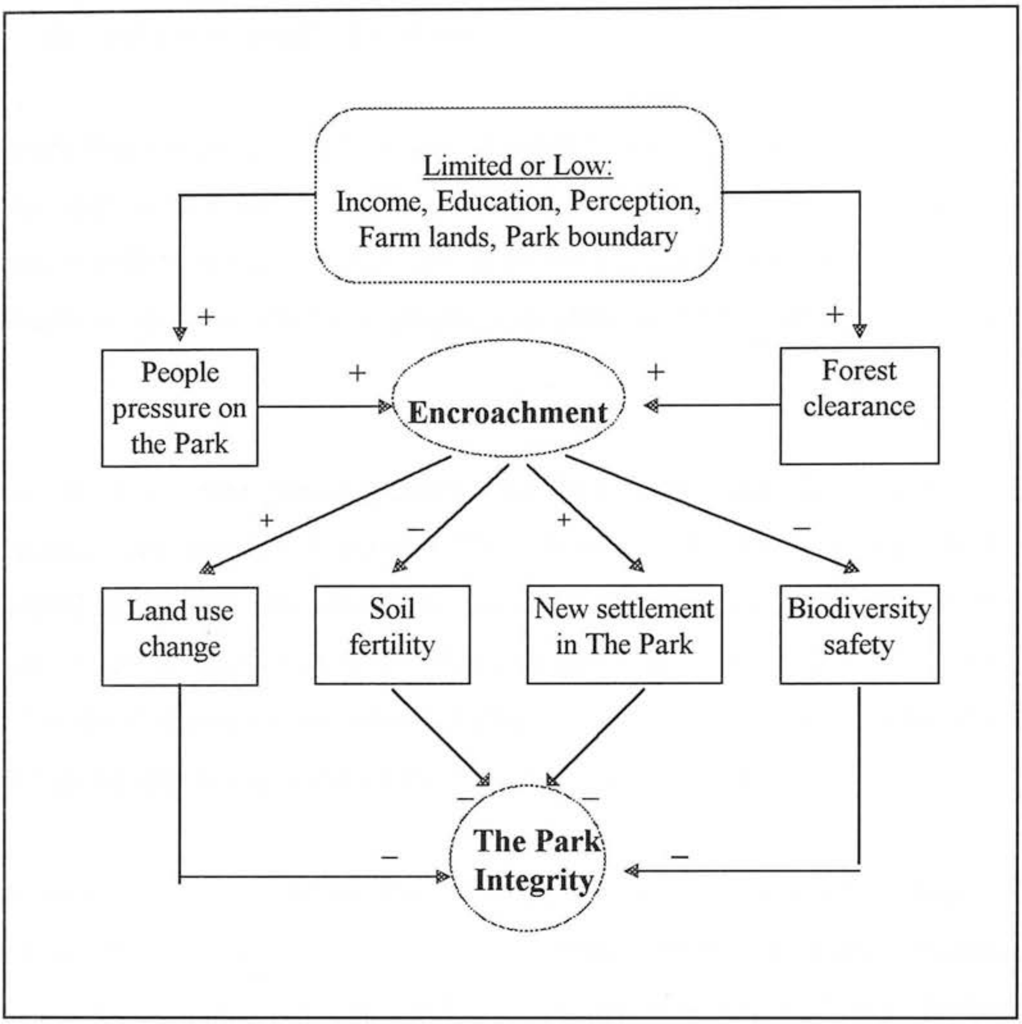


Figure 1.1. Flow diagram of encroachment problems in KSNP
(+: positive impact; - : negative impact)

Encroachment expansion on the Park may lead to increasing land use changes, decreasing soil fertility, expanding new settlements in the Park and enlarging the threat to the Park's biodiversity. All of which may result in the fragmentation of KSNP.

Based on the above mentioned problems, therefore, alternative approaches for resolving people-park conflicts need to be explored. Development alternatives from the past experiences of other developing countries could be of benefit in this study.

1. 5. 5. Approaches for conflicts resolution

Every park has unique and site specific problems related to the particular socio-economic and cultural situation of the surrounding communities, the bio-geographic condition as well as the management policy of the Park. Therefore, there will be no general solution that can resolve all people-park problems in all condition (Rapoport, 1974).

However, there are three general principles that should be applicable to the majority of protected area conflicts (Lewis, 1996). These include: focusing on people's fundamental needs and concern rather than getting stuck arguing over people's proposals to satisfy their interest; involving all significantly affected stakeholders in fair and respectful process; and understanding the power that various stakeholders have and taking that into account when trying to resolve a conflict.

In all people-park conflicts management should be directed to a 'win-win' solution, in which all parties are satisfied with the resolution because they have gained something. Conversely, a win-lose outcome in which only one side of stakeholders are addressed should be avoided because it will generate other conflicts in the future.

A number of examples of methodological approaches for people-park conflict resolution in many countries have been reported. These include application of the participatory approach (Johnstone, 1982; Poffenberger, 1992; Glavovic, 1995; Zazueta, 1995; Lewis, 1996), land allocation model through buffer zone establishment (MacKinnon, 1982; Wind, 1991; Schelhas, 1992; DHV, 1993), people displacement (The World Bank, 1993; Marquardt, 1994; Pouna, 1996), park boundary revision (DHV, 1993), and application of multi-criteria decision making (MCDM) using a composite programming approach (Bailey *et al.*, 1997).

All of these general principles for conflict resolution will be taken into consideration in this study and will be further discussed in the relevant chapters for defining alternatives for conflict management in Kerinci Seblat National Park. The suitability of approaches for problems resolution, however, will be related to the study objectives and hypotheses proposed.

1.6. Research Objectives and Hypotheses

Study and reports on conflicts management especially due to encroachment problems in national parks around the world is very limited. Even though encroachment is the major problem faced by most Indonesia's park, this type of research has not been carried out to date. Therefore, this study attempts to fill the gap in our knowledge to incorporate encroachment problems in the sustainable park management.

The objectives of this study include the following:

(1) To examine principles of encroachment systems in KSNP and their impacts on land use dynamics as well as on soil properties of the Park;

(2) To measure the degree of people pressure on the Park as a tool for understanding people- park relationship problems;

(3) To assess the application of GIS based methods for national park management especially for buffer zone planning and monitoring of land use change in KSNP;

(4) To assess trends and the probability of likelihood of future encroachment risk in KSNP;

(5) To evaluate the potential solutions of encroachment problems by using a multi-criteria decision making (MCDM) model and define the trade-offs that will exist between economic, environmental and social variables associated with alternative options.

Through these objectives, this study will examine the hypotheses that:

(1) People's decisions to encroach the park are influenced by variety of factors related to their perception both of the Park and of cinnamon farming;

(2) It is possible to develop buffer zones for human requirement without any adverse impacts on the Park;

(3) It is possible to model encroachment risk using GIS-based methods and thereby to suggest alternatives management options as a trade-off for accommodating encroachment systems in a form of sustainable park management.

1.7. Thesis Structure

The thesis comprises ten chapters. The contents of these chapters are briefly explained below:

Chapter One presents a general introduction to the thesis, covering an overview on background and national park concept, management policy of biodiversity in Indonesia and around the world, problems encountered in parks management and in the study site. This chapter also outlines the objectives and hypothesis of the study and then summarises the thesis structure.

Chapter Two gives a brief description of the Kerinci Seblat National Park concentrating on the study site in Kerinci District. It presents the historical background of the designation of the Park, information on demography, socio-economic characteristics and bio-physical factors of the Park.

Chapter Three provides an overview of research methods applied to the study. Flow diagrams of the study procedure, sampling regime and questionnaire design are presented. The GIS softwares and methods utilised for spatial and statistical data analysis are also described here.

Chapter Four contains socio-economic data analysis resulting from the questionnaires. It details characteristics of the respondents, assesses people perception of the Park as well as of cinnamon cultivation, and measures the degree of population pressure on the Park.

Chapter Five deals with the land use dynamics in the study site. Land use change both in relation to slope and elevation and in relation to status of land (in the Park and in the enclave area) is analysed and measured. Images of each land use change are presented. Impacts of the Park boundary alteration on the composition of land use change is also highlighted.

Chapter Six is concerned with impacts of encroachment on soil chemical properties and forest succession of the Park. This includes the assessment of the correlation between the length of encroachment and soil chemical constituents in two different soil types and depths.

Chapter Seven is concerned with buffer zone establishment based on selected factors and under constraints consideration that can both increase the Park's ability to protect biological resources and provide subsistence and income-generating opportunities for the local people

Chapter Eight deals with building an intrusion model based on spatial analysis using GIS based method. It presents a mathematical modelling resulted from the Logistic Regression analysis. A prediction map for future encroachment is also presented.

Chapter Nine provides alternative management options derived from Composite Programming method for resolving conflict between encroachment and the Park management. Sensitivity analysis based on altering economic and environmental weighting factors is also performed.

Chapter Ten presents conclusions revealed from this study and gives suggestions for future research. Recommendations for sustainable park management relevant to people - park conflict resolution are offered.

1.7. Summary

In this chapter concepts and problems of a national park and protected area management for the global, national and case study level were introduced. Indonesian policy for biodiversity conservation and protected area management was presented and compared to other developing countries. Research objectives and hypotheses as well as the thesis structure were proposed.

The concept of national park has shifted from traditional to integrated management where local people are more accommodated as part of the conservation program. Many people in developing countries depend on the biodiversity and park resources. Therefore, social and economics problems facing many resident people surrounding the Park might jeopardise the effectiveness and very existence of the Park and increase public conflict with the Park management. Human encroachment which was largely aimed at the cultivation of cinnamon trees was the biggest threat to the integrity of Kerinci Seblat National Park. In the next chapter the characteristics of KSNP are described in order to provide further contextualisation of the study.

CHAPTER TWO

DESCRIPTION OF THE STUDY SITE

In this chapter Kerinci Seblat National Park as a whole and Kerinci District as the study site are described. In order to provide a general overview, the characteristics of KSNP, its management objectives, historical background and the Park settings are presented. Then, the physical and socio-economic aspects of the study site are examined. These include information on geographic position, climate, soil and geomorphology, slope and topography, biological resources, population, land use pattern and economic conditions

2.1. Kerinci Seblat National Park

2.1.1. Characteristics of KSNP

Kerinci Seblat National Park was chosen as a study area because of the fact that it is the largest park in Sumatra and is among the most important parks in Indonesia. The Park has high biodiversity value and it covers a whole spectrum of habitat types from lowland to alpine forests, representing the full floral diversity of tropical rain forest in southern Sumatra of dry lowland, hill and mountain forests (Laumonier, 1990; The World Bank, 1993). The benefits accruing to the surrounding area from the Park are numerous and include being water source for agriculture, domestic uses and industries but also as direct and indirect income sources for the surrounding communities. The Park has also been recognised as an area of national and global priority for conservation (FAO, 1982).

MacKinnon and MacKinnon (1986) state that many of the habitats and species protected within the Park are poorly represented or not found in other conservation areas in Sumatra or elsewhere in Asia, such as the Sumatran rhino (*Dicerorhinus sumatrensis*), Sumataran hare (*Nesolagus netscheri*), Clouded leopard (*Neofelis nebulosa*), Malay tapir (*Tapirus indicus*), Elephant (*Elephas maximus*) and Sumatran tiger (*Panthera tigris sumatrensis*). Moreover the Park serves as a genetic reservoir for endemic and endangered plant species such as the world's largest and most spectacular flowers, Rafflesia (*Rafflessia arnoldi*) and Amorphophallus (*Amorphophallus titanum*) as well as the endemic Kerinci pine (*Pinus merkusii Kerinci strain*) and for commercially important species such as dipterocarps, rattans and wild fruit trees (TNKS, 1995).

The Park is remarkable for its species richness with more than 4000 plants or about 1/60 of the world total plants, 180 birds or about 1/50 of all birds, including at least 14 of the 20 Sumatran mainland endemics, and 144 mammals or 73 percent of the Sumatran mammal fauna and 1/30 of the world total, including five island endemics (The World Bank, 1996).

During the decade following 1982, however, the Park has suffered from human interference resulting in loss of 17,1776 ha forest area and an expansion of 15,635 ha in encroachment (Chapter 5; TNKS, 1995). Today, the greatest threat to the integrity of the Park and its high biodiversity values comes from the human population living in the large, fertile enclave of Sungai Penuh inside the Park. This enclave has an area of 152,514 hectares and is the largest enclave inside any comparable protected areas in the world. The human problems associated with this enclave are compounded many times over by the fact that the Sungai Penuh area is amongst the world's most productive site for cinnamon production (Perbatakusuma *et al.*, 1993). Cinnamon (*Cinnamon burmannii*) growing is the main agricultural activity in this region. Cinnamon is also grown through Kerinci which supplies 69% of Indonesian cinnamon (Scholz, 1983). Encroachment into the Park in order to cultivate the high profit cinnamon trees causes serious land use conflict.

Given the great need to protect this biologically rich and economically important region, the people-park conflict resolution especially in Kerinci District needs to be well studied and if possible a management strategy aimed at reducing conflict should be designed.

2.1.2. The Park Management Objectives

The long-term objective of Kerinci Seblat National Park management is to conserve the biodiversity contained within the Park and adjacent areas. To attain this long-term objective, the strategic purposes for the Park management according to the World Bank (1993) and PHPA (1995) include the following elements:

(1) Legal establishment of the Park through boundaries demarcation;
(2) Effective protection for the long-term preservation of viable natural ecosystems, ecological functions and genetic variability;
(3) Protection of rare, endangered and unique species and habitats;
(4) Preservation of scenic and geological features and catchment functions;
(5) Regeneration of natural forest on degraded Park lands;
(6) Facilitating human use for recreation and education;
(7) Facilitating research; and
(8) Enlisting support for Park protection from neighbouring communities.

2.1.3. Historical background

Sumatra, one of Indonesia's seven major bio-geographic regions, supports a rich variety of the habitats and species. It contains approximately 30% of the Nation's species, most of it associated with the forests (BAPPENAS, 1993). Over recent decades, however, its forest cover has been greatly decreased as shown in Figure 2.1.

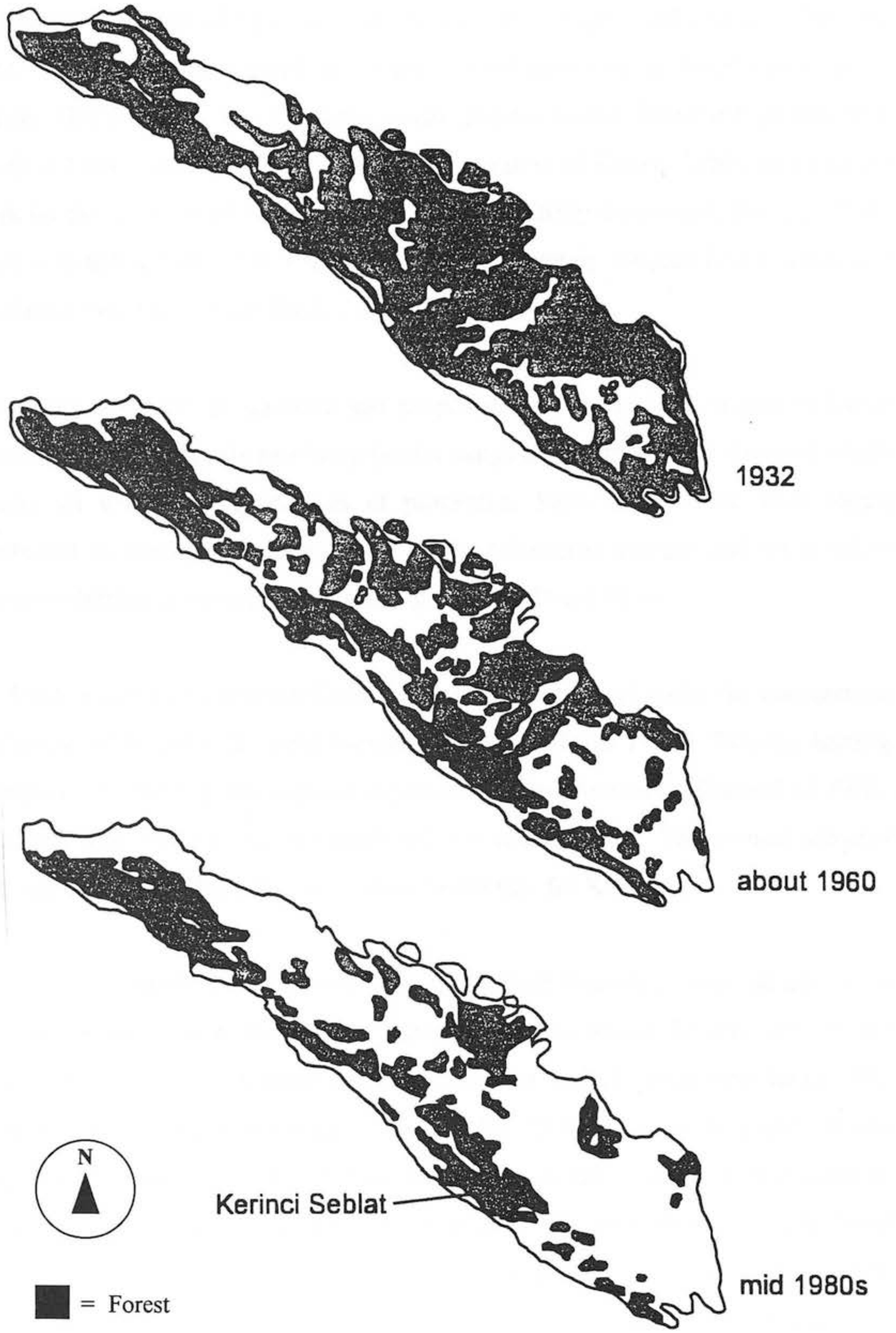


Figure 2.1. Forest lost in Sumatra over 50 years from 1932 to 1980 (shaded area is forest, modified from the World Bank, 1993)

In order to conserve all representatives of major habitat types and species in Sumatra, FAO and PHPA have carried out extensive field surveys over several years in the Kerinci Seblat region. The first management plan for Kerinci Seblat was produced by FAO in 1981. This was the basis for the declaration of Kerinci Seblat as a national park by the Minister of Forestry in 1982. When initially announced, the area of the Park was about 1,484,650 hectares, with approximately 300,000 hectares being of lowland forest (The World Bank, 1993; PHPA, 1995).

The Park combines 17 gazetted and proposed reserves such as protected forests (hutan lindung), Wildlife sanctuary (suaka margasatwa) and nature reserves (cagar alam), all with differing degrees of protection. Parts of the Park were legally protected as conservation areas based on the Ministerial decrees, and some others were established as protected areas dating from the Dutch times.

In 1984, a project to develop Kerinci Seblat was established under the management authority of BKSDA II (Balai Konservasi Sumber Daya Alam) Tanjung Karang, Lampung. BKSDA is the regional representative of Directorate General of PHPA covering several provinces with a sub office in each province. This project provided the data base for building the management authority for KSNP.

In 1985, the Ministry of Forestry revised the Park boundary maps based on the TGHK (Forest Consensus Map). Some protection forest in and around the designated Park were changed to production and limited production forest. This reduced of the Park area by about 30% to 1,057,170 ha. This boundary review continued throughout 1991 and 1992 in order to include some potential areas for biodiversity such as the lowland forests and exclude settlements from the Park. Based on the agreement between forest agencies, provincial authorities and concessionaires (there are 12 concessionaires/ HPHs bordering the Park), the Park boundary was further revised and rationalised in 1993/1994 to maximise biodiversity and minimise resettlement. This resulted in an increased of 1,556,467 ha.

In 1989, the World Wide Fund for Nature (WWF) was established in Kerinci to provide technical assistance in developing KSNP research and community development. In 1992, the Government of Indonesia received a grant from the United Nations Development Programme (UNDP) towards the costs for preparing an ICDP project with the World Bank as executor. Then, in 1993, a unit of management authority for managing KSNP (UPT TNKS) was established with the headquarters in Sungai Penuh, Kerinci (BAPPEDA and IPB, 1993).

At present, the process of the Park boundary demarcation is nearly completed and most boundaries adjoining settlements have been demarcated but not yet agreed upon by all stakeholders. This has great implications for conserving the Park's biodiversity. However, it also affects the surrounding communities because access to forest land became impossible and any settlement which post-dated the Park establishment and the boundary demarcation was illegal.

2.1.4. Park Setting

Kerinci Seblat National Park is located in the southern half of Sumatra with a latitude of 1° 05' to 3° 44' S and longitude of 100° 36' to 102° 48' E. It is the largest conservation area in Sumatra, covering nearly 1.5 million hectares and straddling the four provinces, nine districts (Kabupaten) and 36 Sub Districts (Kecamatan). The proportion of the Park areas in each province are as follows: Jambi 40% (588,462 ha), West Sumatra 25% (375,934 ha), Bengkulu 21% (310,579 ha), and South Sumatra 14% (209,675 ha).

The Park stretches over nearly 350 km along the Barisan mountain (Sumatra is 1719 km long) and reaches its maximum width of 70 km at the densely populated Kerinci valley. This valley bisects the Park almost completely. The main entry points to the region by air are the three provincial capitals Padang, Jambi and Bengkulu. From these cities Sungai Penuh, where the Head Quarters of the Park is located, can be reached by major roads.

The location of the whole Park area showing the forest concessions surrounding the Park and priority areas for the local development based on the World Bank's ICDP project is shown in Figure 2.2.

2.2. KSNP in Kerinci District

KSNP in Kerinci District, the focus of this study, is the highest part the Park's area, and contains Kerinci volcano (3,805 m), the highest mountain in Sumatra and second highest in Indonesia. The Park surrounds the fertile Kerinci valley, the biggest enclave in Indonesia, covering about 220,537 hectares. This valley, geographically situated in such a strategic location, has proved an ideal place for settlement and refuge since the Neolithic period.

People have been moving into Kerinci in small numbers over the centuries since 4000 years ago (Watson, 1984). At present, Kerinci District has a total population of approximately 287,046 people. More than 74 percent of the population depend for their livelihood on farming (BPS, 1994). This has consequently become one of the main threats to the Park integrity and focused the attention of the government and international organisations on the encroachment problem.

2.2.1. Geographical position

Kerinci District is situated in the western part of Jambi Province and BPS (1994) reported a total area of 420,000 hectares including the Park. This comprises eight percent of the total area of Jambi Province. Based on GIS analysis (see Chapter 5), however, the area of Kerinci District is 375,051 hectares. The latter figure was utilised for all subsequent analyses in the related chapters. The District stretches from $101^{\circ}08'$ to $101^{\circ}50'$ east longitude and from $1^{\circ}41'$ to $2^{\circ}26'$ south latitude.

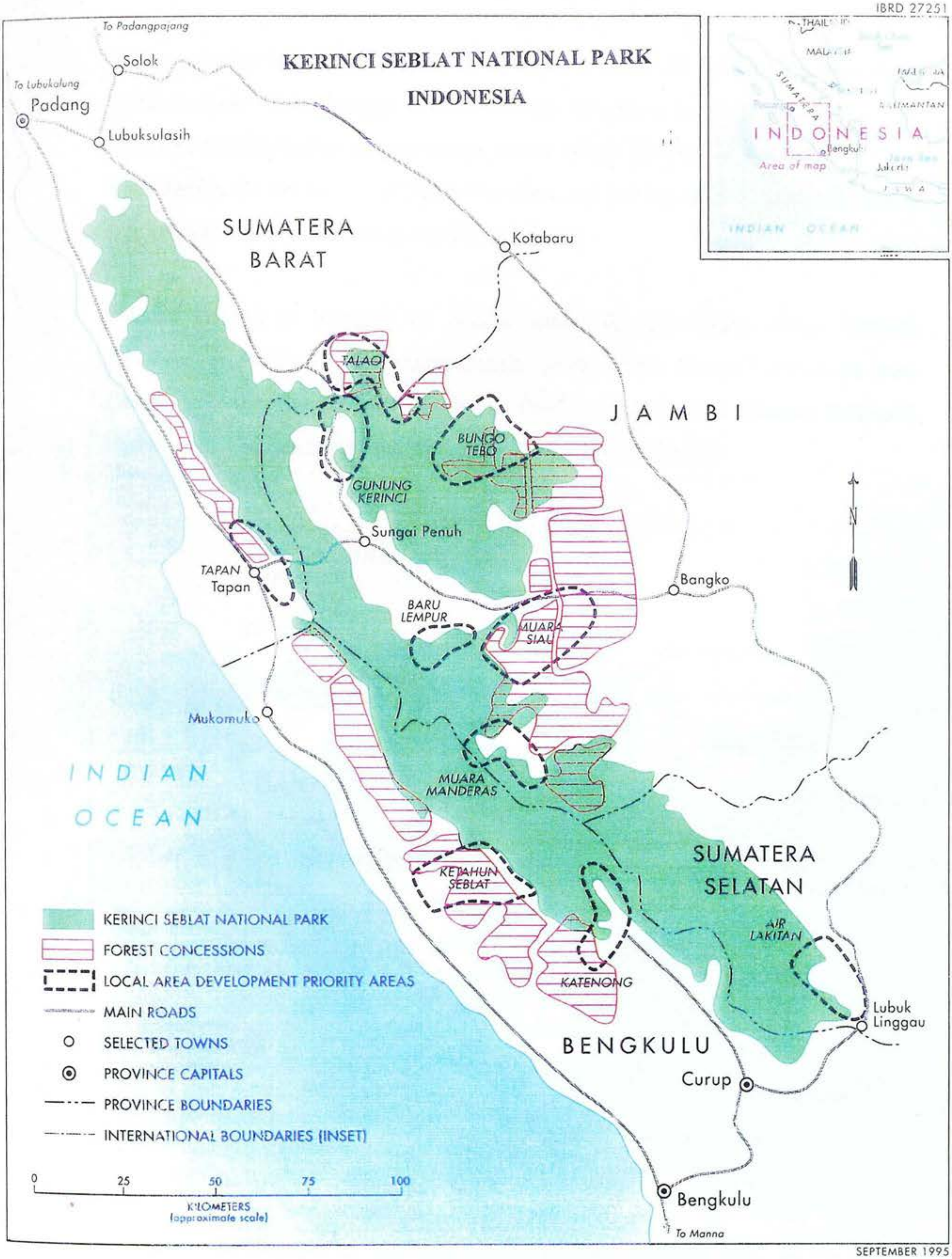


Figure 2.2. The location of Kerinci Seblat National park (The World Bank, 1996)

The maximum length of the District is approximately 88 km and the maximum width is about 55 km. Sungai Penuh, centrally located in the Kerinci Valley, is the principal administrative and economic centre of the District. It is situated 418 km from Jambi, the capital city of Jambi Province, and 217 km from Padang, the capital city of West Sumatra Province, via Muara Labuh.

Kerinci District is bounded by several other districts: Solok (West Sumatra Province) in the north, Sorolangun Bangko in the south, Bungo Tebo in the east, Bengkulu Utara (Bengkulu Province) and Pesisir Selatan (West Sumatra Province) in the west. The location of the study area is shown in Figure 2.3.

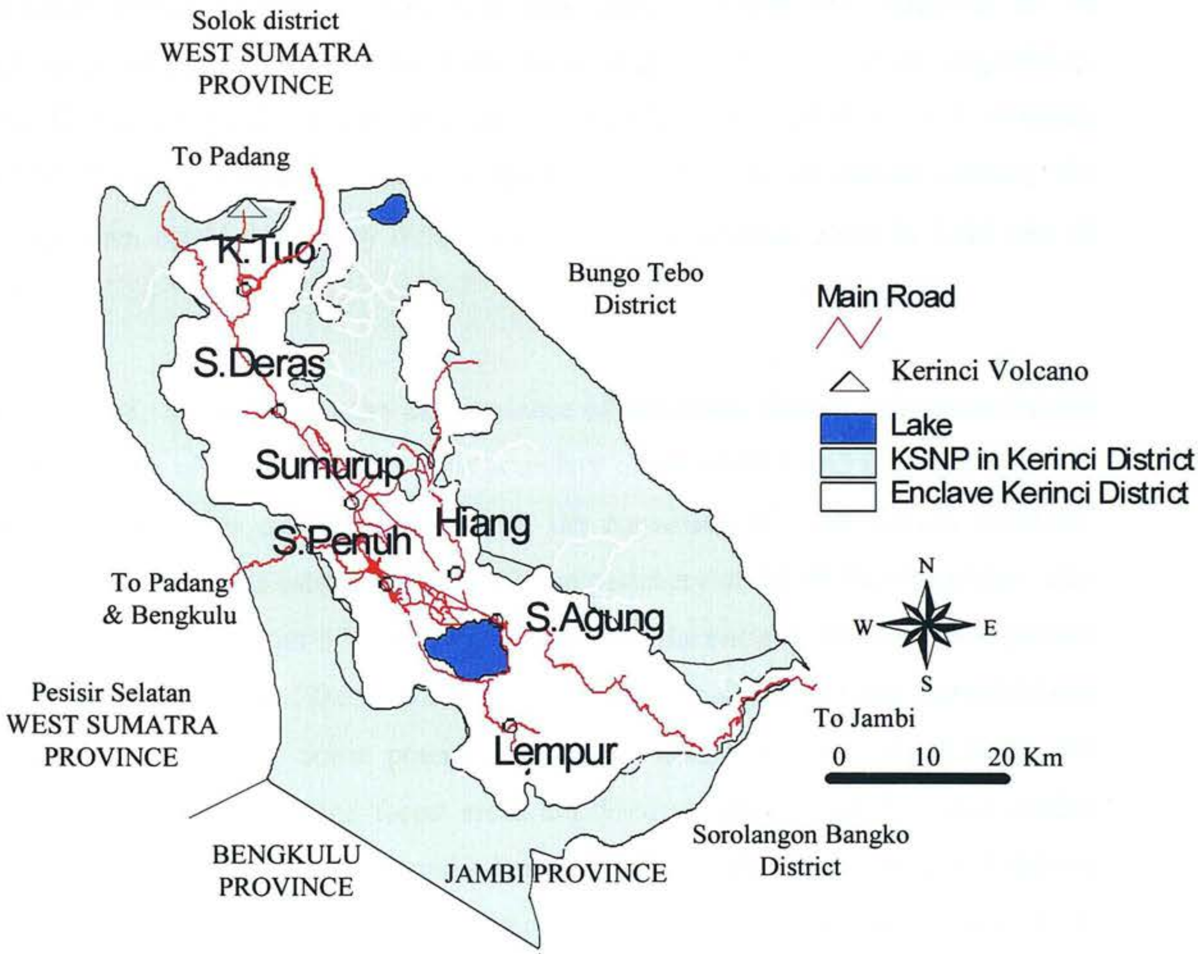


Figure 2.3. KSNP in Kerinci District, the study site

Given its geographical position, the development of the Park should have a great influence on the livelihood of the surrounding people, simply because they live in an area which cannot be enlarged. Since human encroachment is now prohibited in the Park, increased agricultural productivity will depend upon new farming systems with high production levels being developed. With this in mind land allocation for buffer zone establishment is not only aimed at protecting the Park's integrity but it also aims to provide an alternative to help surrounding people meet their subsistence needs.

2.2.2. Establishment of Kerinci enclave

The historical background of the Kerinci enclave was well known since the Dutch colonial period because it was very independent minded and reluctant to be administered by the Dutch. After some battle with the Dutch's military expedition, the Kerinci people finally surrendered to the Dutch administration in 1903 (Watson, 1984). To protect forest ecosystem in the Kerinci valley and the natural habitats, the Dutch then established many different types of conservation areas in 1926 and in 1929.

Since 1958, 13 years after the independence of Indonesia, Kerinci was incorporated in the district of Jambi Province. The boundary of the District and the enclave of the Kerinci valley was established based on the consensus of many parties involved. When the KSNP was established in 1982, the periphery of the enclave boundary abut with the Park was about 375 km length. However, the enclave boundary was revised many times such as in 1985, 1992 and 1995 to exclude settlement and encroachment areas and to include some potential areas for biodiversity. In the TGHK, the boundaries of the Park and forest areas are discussed and signed by many parties involved such as the Forest Service, the District authority, the Land Development Board etc. At present, based on the latest consensus of TGHK, the process of the enclave boundary demarcation is nearly completed.

2.2.3. Climate

The climate in Kerinci District is typical of tropical areas and shows local variation. The raining season starts in November to April, whilst the dry season starts in May to October. The annual average rainfall varies, depending on the location, between 1,250 mm and 3,000 mm. The maximum temperature is 32° C and the minimum is 16° C with the average of 22.5° C at 830 m in Sungai Penuh. The relative humidity is in the range 62 - 87 percent. Table 2.1. shows mean monthly rainfall, number of rain days, average rainfall and maximum rainfall at the weather station in Sungai Penuh for between 1985 and 1994, the most recent data for which data are available.

Table 2.1. Mean monthly rainfall (RF, mm), number of rain days (RD, days), average rainfall (AR, mm/rain day) and maximum rainfall (MR, mm/rain day) in Sungai Penuh weather station, Kerinci for ten years (1985-1994).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
RF	202	96	175	128	118	63	76	59	85	109	183	169	1463
RD	16	10	15	12	11	7	8	7	9	11	15	14	135
AR	13	10	12	10	11	9	9	9	10	10	12	12	11
MR	69	37	59	34	45	27	40	26	42	51	49	53	69

Source: Department of Public Work, Kanwil Propinsi Jambi, Hydrology Sub Project (1995).

There are two different systems frequently utilised in Indonesia to define the climatic type of a region: Oldeman's classification and Schmidt and Ferguson's classification. Both classifications are based on the relative proportion of the number of dry months and the number of wet months. However, they differ in their definition of a dry month and wet month, used to describe the climate type. Oldeman et al. (1980) defines a wet month as having rainfall equal or more than 200 mm while a dry month is less than 100 mm. While Schmidt and Ferguson is more than 100 mm and less than 60 mm for defining wet and dry months respectively. Furthermore, Schmidt and

Ferguson categorise the climate types based on the value of Q, the porportion between the number dry months and the number of wet months, which is formulated :

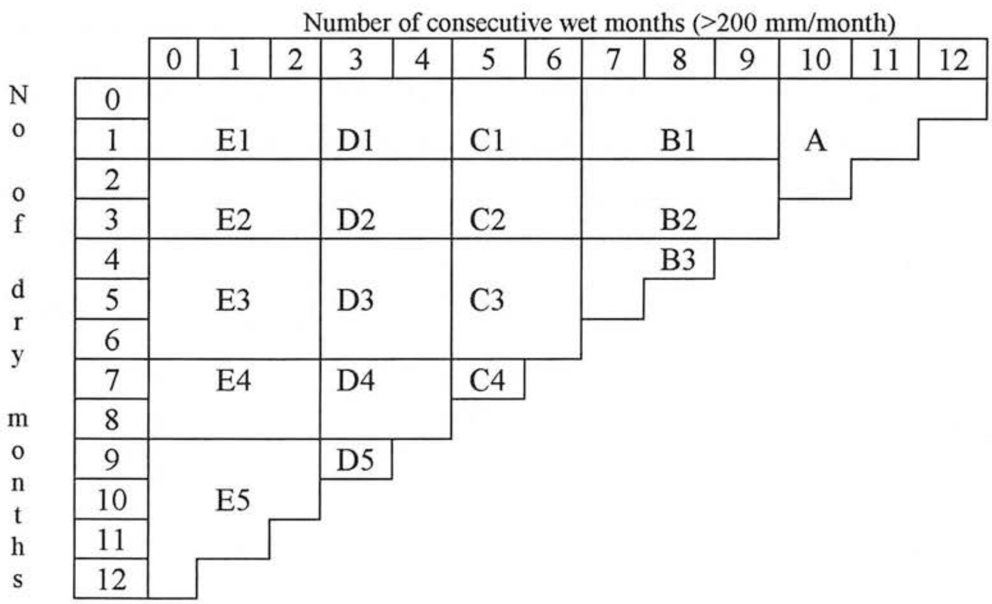
$$Q = \frac{\text{Number of dry months}}{\text{Number of wet months}} \times 100\,\% \qquad (2.1)$$

The way Schmidt and Ferguson classify the climate types is shown in Table 2.2 and Oldeman's criteria is described in Table 2.3.

Table 2.2. The classification of climate according to Schmidt and Ferguson

Climate Type	Q value (x 100 %)
A	$0.000 < Q < 0.143$
B	$0.143 < Q < 0.333$
C	$0.600 < Q < 1.000$
D	$1.000 < Q < 1.670$
E	$1.670 < Q < 3.000$
F	$3.000 < Q < 7.000$
G	$Q > 7.000$

Table 2.3. The classification of climate according to Oldeman (adapted from Oldeman *et al.*, 1980, 1982 and Fletcher and Gibb (1990)



Based on Schmidt and Feguson's classification, the type of the climate in the study area varies from type A in Sungai Penuh, Kayu Aro and Semurup regions, and type B around the Siulak Deras and the remaining regions. Whereas according to Oldeman's classification, climate type in Sungai Penuh and Lempur is E3, in Kayu Aro is C2 and in Sumurup is E4. This difference is due to the different criteria used to determine the number of wet and dry months. These climate types are important factors that should be considered in the Park planning programs.

2.2.4. Soil and geomorphology

Based on the LRep soil maps, soils in the Kerinci District vary according to the geomorphology of the area. The geomorphological structure of the District is dominated by central Barisan Selatan mountain range, a chain of active and dormant volcanoes with several peaks over 2500 m including Kerinci volcano. The soil types of the area are dominated by Andosol (Inceptisols) soil (65.10%) and Latosol (Oxysols) soil (21.12%). The rest are podsolic, alluvial, complex of podsolic, latosol and litosol (13.78%). These types of soils may be considered as susceptible to erosion (Dep. PU, 1992).

In the northern part of the valley, poor podzolic soils are associated with the granite massif. Further north, the valley ends up with a highland plateau (1500-1600 m) piled up by the andesitic tuffs of Gunung Tujuh, the Kerinci volcano complex. Whereas south of the lake Kerinci and south east towards the Merangin valley, the area is characterised by rich andosols from volcanic origin (Aumeeruddy, 1992).

2.2.5. Slope and topography

Slope and topography are determinants for the analysis of land use dynamics in Kerinci District. Most of the Park area is hilly, whilst the Kerinci enclave is mostly flat. There are seven mountains (Gn.) with a height of more than 2000m: Gn. Kerinci

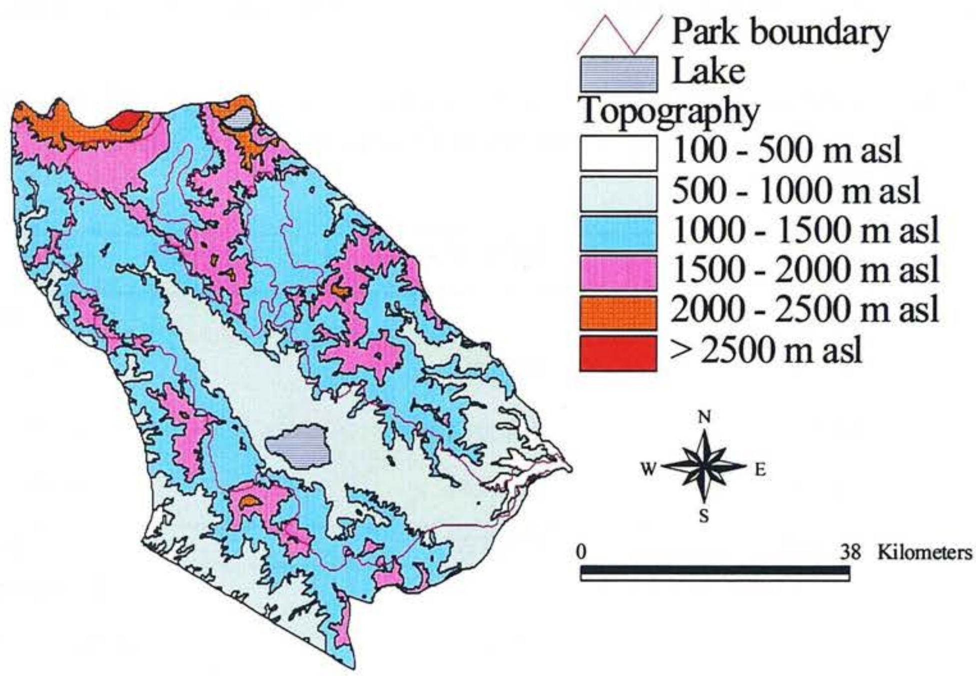


Figure 2.4. The distribution of topography class in Kerinci District

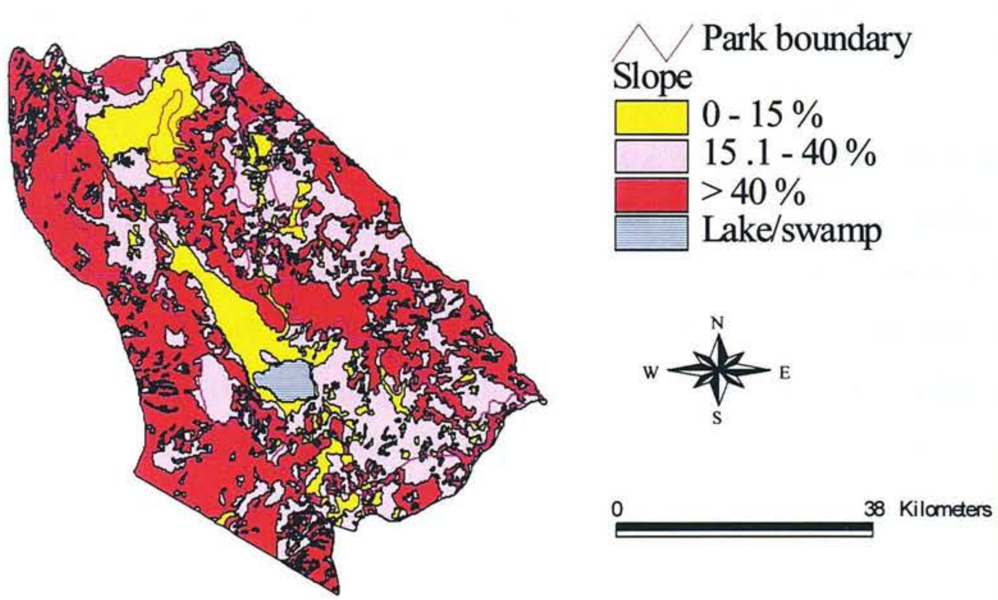


Figure 2.5. Slope class distribution in Kerinci District

(3,805 m), Gn. Masurai (2,900 m), Gn. Tujuh (2,605 m), Gn. Raya (2,550 m), Gn. Sumbing (2,441 m), Gn. Patah Sembilan(2,241 m), and Gn. Sangeti (2,112 m).

Table 2.4. The distribution of slope steepness and topography of the Kerinci District (based on the GIS analysis in this study, see Chapter 5)

Factor	Area (Ha)	%
Slope		
0 - 15 %	47,999	13.05
15 - 40 %	136,438	37.09
> 40 %	183,386	49.86
Total	367,823	100.00
Topography		
100 - 500 m	8,159	2.19
500 - 1000 m	112,345	30.12
1000 - 1500 m	171,930	46.09
1500 - 2000 m	69,386	18.60
2000 - 2500 m	10,112	2.71
> 2500 m	1,119	0.29
Total	373,051	100.00

Kerinci valley is surrounded by forested mountains and deeply depressed between the steep slopes of the Western and the Eastern Barisan mountains. Based on the GIS analysis of this study, 183,386 ha (almost 50%) of the District is has a slope of more than 40% and 247,547 ha (67.69%) is located over 1000 m above sea level. The detailed area and the percentage of slope steepness (excluding the lakes) and topographical distribution for the whole area of Kerinci District are shown in Table 2.4. and Figures 2.4 and 2.5.

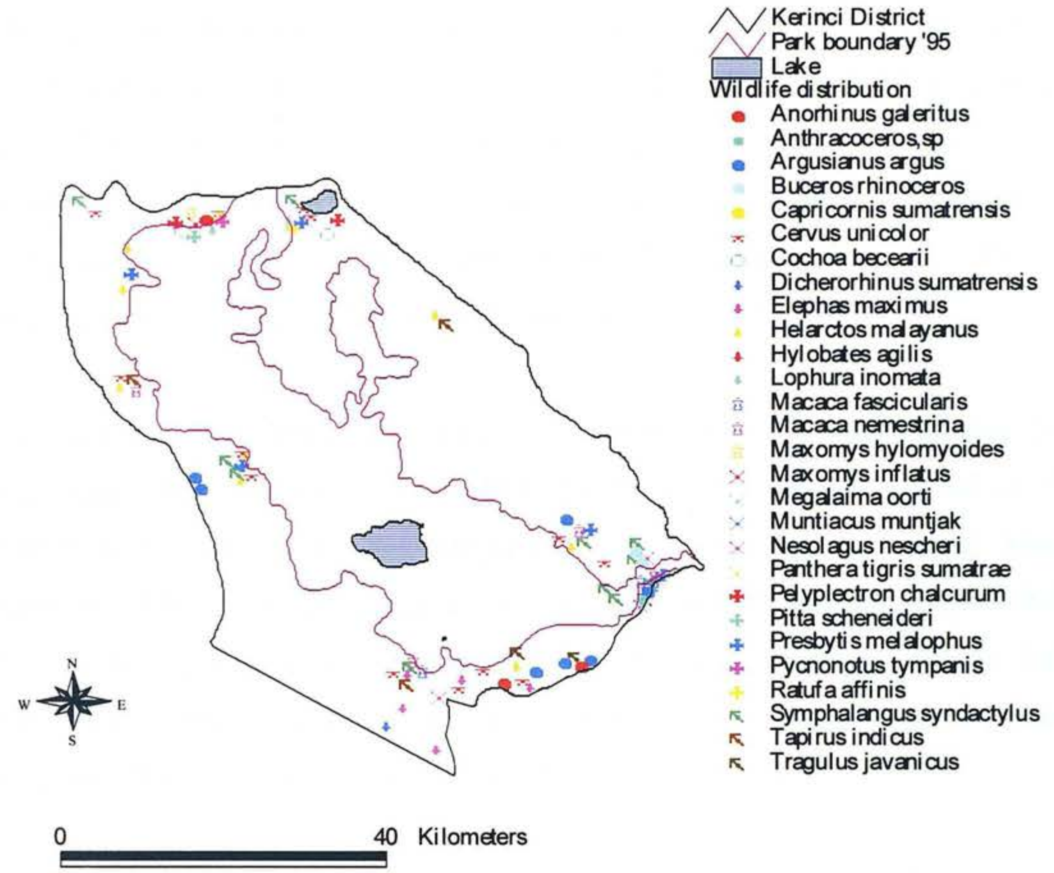


Figure 2.6. The distribution of wildlife in Kerinci Seblat National Park

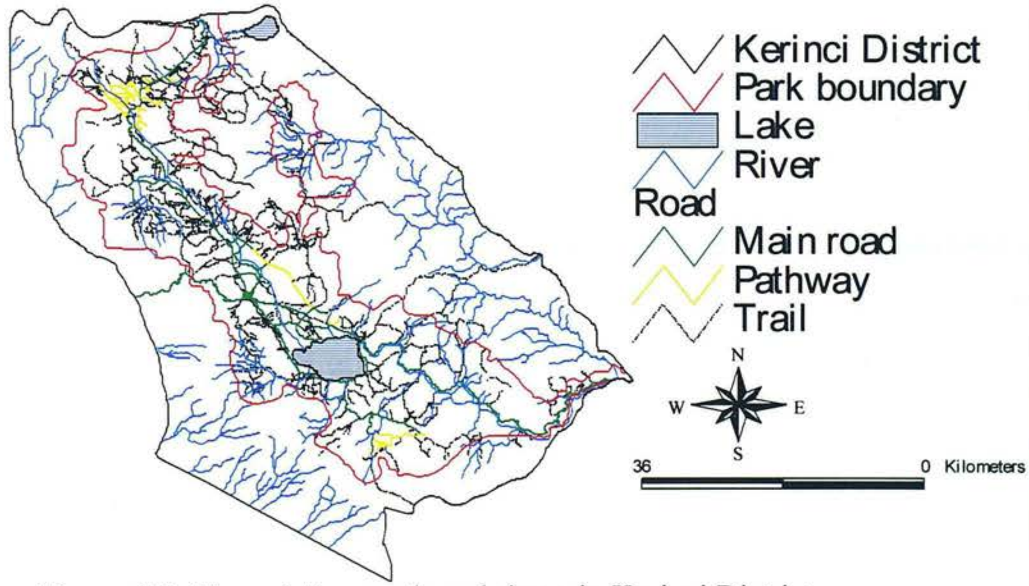


Figure 2.7. The existing roads and rivers in Kerinci District

2.2.6. Hydrology

The Park serves as an important water regulator for seven sub water catchments (Sub DAS). The area and the average water debit (Q) for some Sub DAS according to Dep. PU (1992) are as follows: Siulak Deras (88,342 ha with Q = 33 m^3/second); Batang Sangir (27,508 ha with Q = 7.6 m^3/second); Batang Tebo (34,924 ha with Q = 9.6 m^3/second); Batang Merangin (135,000 ha); Batang Tabir (24,900 ha); Indrapura (53,900 ha); and Majunto (27,300 ha).

There are nine lakes within the District, two of them are relatively large: Kerinci Lake and Gunung Tujuh Lake (at the top of Gn. Tujuh) with a total area of 5,140 ha. The Park is also a source of water supply for many rivers such as: Batang Sangir, Indrapura, Silaut, Menjunto, Selagan, Siulak Deras, Siulak Gedang, Sangkir, Pulau Tengah, Jujun, Temiai, Kerinci, Lempur, Penetai, Imat, Mesago, Batang Tebo, Batang Tabir, Batang Merangin, and Batang Hari. These rivers flow to three different directions: West Sumatra, Jambi and Bengkulu (TNKS, 1995).

Rivers and roads are probably important factors influencing the distribution of encroachment areas in Kerinci District, since they may provide access to new settlers or opportunities for extending present agricultural activities. Roads in Kerinci are divided into three categories (Bappeda and IPB, 1994): main road (201.20 km), pathway (42.70 km) and trail (118.80 km). The existing roads and rivers in Kerinci District are shown in Figure 2.7.

2.2.7. Biological resources

The Park plays an important role for the protection of endemic and endangered species of flora and fauna in the District. As part of the KSNP, species in Kerinci are not much different from that of KSNP. Specific biological inventory data for Kerinci District is very limited.

Table 2.5. Endangered species in KSNP, Kerinci District and their degree of rarity

Species	Degree of Rarity*	Habitat Type		
		Low land	Hilly	Mountainous
MAMMAL				
Nesolagus netsheri	I	-	x	x
Cuon alpinus	V	x	x	-
Mustela lutreolina	K	x	x	x
Aomyx cinerea	K	x	-	-
Lutra perspicillata	K	x	-	-
Lutra sumatrana	K	x	-	-
Felix temminchi	I	x	x	-
Felix mormorata	I	x	x	-
Neofelis nebulosa	V	x	x	-
Panthera tigris	E	x	x	x
Elephas maximus	E	x	x	x
Tapirus indicus	E	x	x	-
Dicerorrhinus sumatrensis	E	x	x	x
Capricornis sumatrensis	E	-	x	x
AVIVAUNA				
Lophura inornata	V	x	x	-
Cairina scutulata	V	x	x	-
Rhinoplax vigil	K	x	x	-
Cochia beccarii	I	x	x	-
Otus stresemanni	I	x	x	x
Pitta schneideri	E	x	x	-

Source : Perbatakusuma *et al.* (1993); The World Bank (1993). * Based on the Red Data Book category of the IUCN. I = Indeterminate, E= Endangered, V= Vulnerable, K= Insufficiently known

The wildlife recorded are based on information from the local people and staff members of WWF and KSNP and are shown in Figure 2.6. The degree of rarity based on the Red Data Book of the IUCN for wildlife endangered species in Kerinci District and their distribution according to altitudinal habitat is shown in Table 2.5. The Park's vegetation is dominated by tropical primary forest, however, depletedformation and abandoned areas can also be recognised (Suherman *et al.*, 1995).

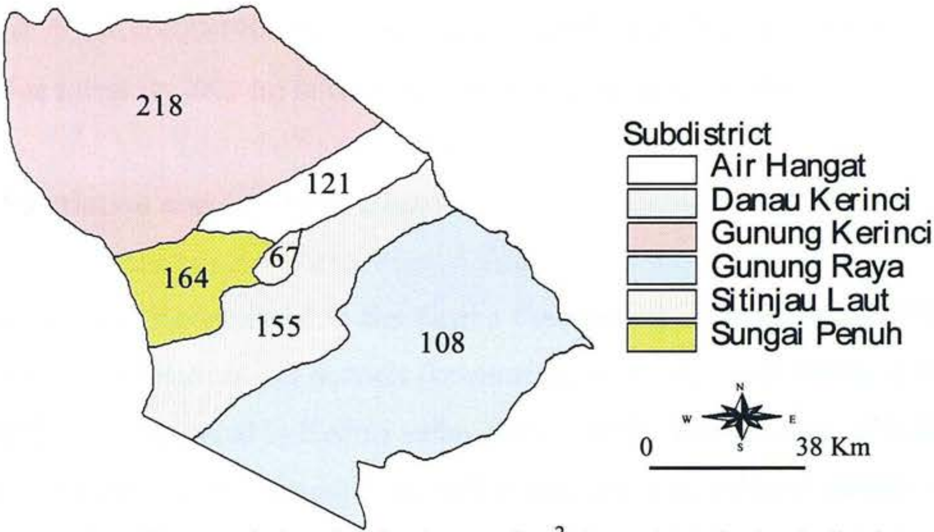


Figure 2.8. The population density (person/km^2) in each Kerinci sub district (BPS, 1995)

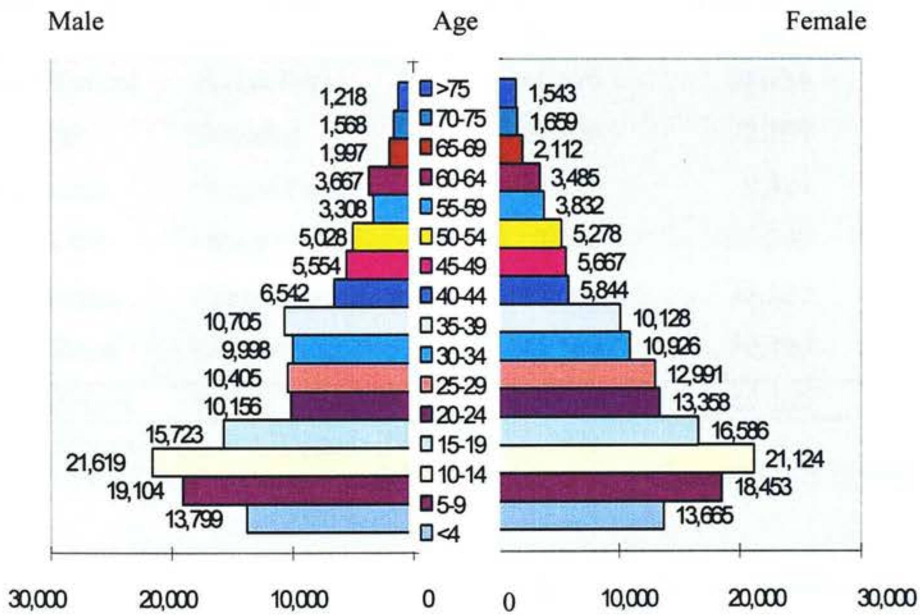


Figure 2.9. Age structure of the population composition in Kerinci District in 1994 (BPS, 1995)

Vegetation formations in Kerinci according to altitudinal range can be classified into five categories: lowland forest (0-150 m) near Muara Imat; hill forest (150-800 m) such as in Bukit Tapan and Muara Sako; sub Montana forest (800 -1400 m) and Montana forest (1400-1900 m) as in Gunung Tujuh complex; and upper Montana and alpine forest (> 2000 m) in Gunung Kerinci (Laumonnier, 1990).

2.2.8. Population and administration

Kerinci has been incorporated in the district (kabupaten) of Jambi since 1958. The District is divided into six sub districts (kecamatan). In 1994, a population of 287,046 inhabitants was registered in Kerinci valley (BPS, 1995). With an area of 2,205 km^2 (58.80 % of the Kerinci District), the valley supports a population density of 130 people/km^2, an area of comparatively high density in rural Sumatra.

Table 2.6. The area of KSNP in each sub district of Kerinci

Sub District	Capital City	Total Area (Ha)	Area of KSNP (Ha)	Percent* (%)
Gunung Kerinci	Siulak Deras	144,690	96,785	66.89
Air Hangat	Semurup	40,600	22,160	54.58
Sungai Penuh	Sungai Penuh	36,450	9,825	26.29
Sitinjau Laut	Hiang	7,100	940	13.23
Danau Kerinci	Sanggaran Agung	49,600	35,590	71.54
Gunung Raya	Lempur	141,560	80,480	56.85
Kerinci District	Sungai Penuh	420,000	245,760	58.56

Source: Bakosurtanal and Bappeda Tk. I Jambi (1990)
* : % of the Park area in each Sub District to the total area of Sub District

The area of each sub district including its KSNP content is presented in Table 2.6. Whilst the population density in the enclave of each sub district and the composition of the population in the District in 1994 are shown in Figure 2.8 and Figure 2.9 respectively.

Between 1971 - 1994, the human population in Kerinci, has shown an annual growth rate of 2.31 % and 2.34 % for male and female respectively, or on average 2.32 % per year for all the population (Table 2.7). The population increased by almost 100,000 people (51.43 %) within 20 years between 1971 and 1991. However, the growth rate decreased from 3.38 % between 1971-1981 to 1.32 % between 1981 - 1991 and tended to further decrease in the subsequent decades as shown in Table 2.7. The decreasing rate of population growth in Kerinci is much higher than in other areas of Indonesia which decreased by 14.66 % from 2.32 % to 1.98 % between 1980-1990 (BPS, 1994). This is because many people have migrated out of Kerinci to find better jobs. The proportion of incoming and outcoming migrants in Kerinci District between 1980-1990 is - 0.42 % per year (BAPPEDA and IPB, 1994).

Table 2.7. Population of Kerinci District (1971-1994)

Year	Population				
	Male	Female	Total	Growth rate (%/year)*	
				5 years	10 years
1971	91,704	95,370	187,074	-	-
1976	106,893	112,750	219,643	3.48	-
1981	122,316	127,928	250,244	2.79	3.38
1986	133,647	141,944	275,591	2.03	-
1991	139,979	143,316	283,295	0.56	1.32
1994	140,395	146,651	287,046	0.44	-
2001**	141,237	147,795	289,302		
2006**	147,928	149,223	297,151		
Growth rate*	2.31	2.34	2.32		

Source: BPS Kabupaten Kerinci (1995); * Calculated from the data provided
** : projection based on the previous population growth rate

The available agricultural lands in Kerinci District amount to about 174,220 hectares of which only 153,700 hectares is productive. These farms support a total of 67,846 households. This situation has caused population pressures on the farm lands and resulted in increased encroachment and settlement inside the Park. The pressures are not evenly distributed around the Park but concentrated in the areas most suitable for agriculture. The ranked of population pressure on the farming lands for each sub district of Kerinci is presented in Table 2.8.

Table 2.8. Population pressure on the farming lands

Sub District	Farming area (Ha)	Population (household)	Farm-Population ratio (Ha/hh)	Population pressure rank
Gunung Raya	61,160	10,183	6.01	I
Gunung Kerinci	47,905	19,177	2.50	II
Sungai Penuh	26,625	14,140	1.88	III
Air Hangat	18,440	11,018	1.67	IV
Danau Kerinci	14,010	8,492	1.65	V
Sitinjau Laut	6,160	4,866	1.26	VI
Total	174,220*	67,846	2.49	

Source: Adapted from Perbatakusuma, *et al.*(1993). * : only 153,700 Ha is productive
Population pressure I : the lowest, VI : the highest.

Table 2.8 shows that the degree of population pressure varies between the different sub district of Kerinci. This variation could be related to different types of land use patterns in each Sub District. Scheneider quoted by Perbatakusumah *et al.* (1993) revealed that the maximum carrying capacity of productive lands in Kerinci District is 73,190 households. Based on population growth rate (2.3 %/year or 1,582 households/year) with the assumption that there is no inward migration and no improvement in agricultural technology, Kerinci District will attain its maximum carrying capacity in 2.7 years. Unfortunately annual data on inward and outward migration are not available. Increasing inward migration will shorten the period needed to attain the maximum carrying capacity. Conversely, application of agricultural technology and family planning and increasing outward migration lead to slow down the achievement of the maximum carrying capacity.

2.2.9. Land use pattern

The evolution of land use pattern in Kerinci District has developed since 1920's when farmers expanded their agricultural lands for the cultivation of tree crops as a consequence of the promotion of export crops by the colonial government (Watson, 1986). By 1930's, tobacco, rubber, coffee and cinnamon were introduced in some areas especially in Kayu Aro plateau and Lempur, and this resulted in a change of ownership and exploitation rights. The farms then became the subject of investments, transfers and the more elaborate concept of private property. Finally, cinnamon cultivation was boosted during 1970's coffee boom and resulted in increased forest clearance and encroachment. Since the designation of Kerinci Seblat as a national park in 1982, stronger efforts have been carried out to halt human encroachment in the Park.

For the objective of this study, land use of Kerinci District was classified into ten categories: sandstone, shrub, lake, forest, tea plantation, encroachment, settlement, swamp, rice field and abandoned land. The area and the percentage of each category as well as the rate of land use change between 1982-1991 are shown in Table 2.9.

Sandstone is located around Kerinci volcano at the elevation more than 2000 m. While rice fields occur mostly in the enclave area around Kerinci lake at elevations of less than 1000 m and in the northern part of the enclave at higher elevations of between 100-1500 m. Forest area occurs mostly outside the enclave at various elevations ranging from 100 to more than 2500 m. Abandoned land and encroachment areas are distributed around the main settlements of Kerinci District at elevations between 1500-2000 m.

The evolution of land use pattern in Kerinci District over a 10 year period since the Park designation in 1982 until 1991 is presented in Table 2.9 and illustrated in Figure 2.10 and Figure 2.11.

Table 2.9. Land use development in Kerinci District 1982-1991 (Calculation was made from images cross tabulation 1982 and 1991, Ramdhani, 1997)

Land use types	1982		1991		Land use change (1982-1991)		Rate of change
	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)	(Ha/ yr)
Sandstone	147	0.04	144	0.04	- 3	- 2.04	- 0.3
Shrub	12,394	3.32	6,348	1.70	- 6,046	- 48.78	- 604.6
Lake	5,179	1.38	5,186	1.39	+ 7	+ 0.14	+ 0.7
Forest	268,468	71.98	232,727	62.38	-35,741	- 13.31	-3,574.1
Tea plantation	3,250	0.86	3,325	0.89	+ 75	+ 2.31	+ 7.5
Encroachment	51,678	13.86	90,931	24.38	+39,253	+ 75.96	+3,925.3
Settlement	2,175	0.58	1,660	0.44	- 515	- 23.69	- 51.5
Swamp	3,270	0.88	3,273	0.89	- 3	- 0.09	- 0.3
Rice field	16,842	4.51	20,487	5.49	+ 3,645	+ 21.64	+ 364.5
Abandoned land	9,648	2.59	8,970	2.40	- 678	- 7.03	- 67.8
Total	373,051	100	373,051	100	42,986	11.52	4,299

Table 2.9 shows that more than 85 % of Kerinci District area is forest and encroachment. However, for a decade after the designation of KSNP in 1982, the forest area decreased sharply by 35,741 hectares (13.31%) at the annual average lost rate of 3,574 hectares. Shrub also decreased by 6,046 hectares (48.78 %) with the average loss rate of 606 hectares per year. On the contrary, encroachment area increased sharply by 39,253 hectares (75.96 %) at the average expansion rate of 3,925 hectares per year. In addition, the rice field area also expanded by 3,645 hectares (21.64%) at the annual average rate of expansion of 364 hectares.

The table shows that the area of forest loss together with shrub loss during a decade from 1982 to 1991 is almost the same size as the area of encroachment expansion. This suggests that the expansion of encroachment may due be to the expense of forest lands and shrub land. This assumption and the analysis of land use dynamics in Kerinci District is discussed in detail in Chapter 5.

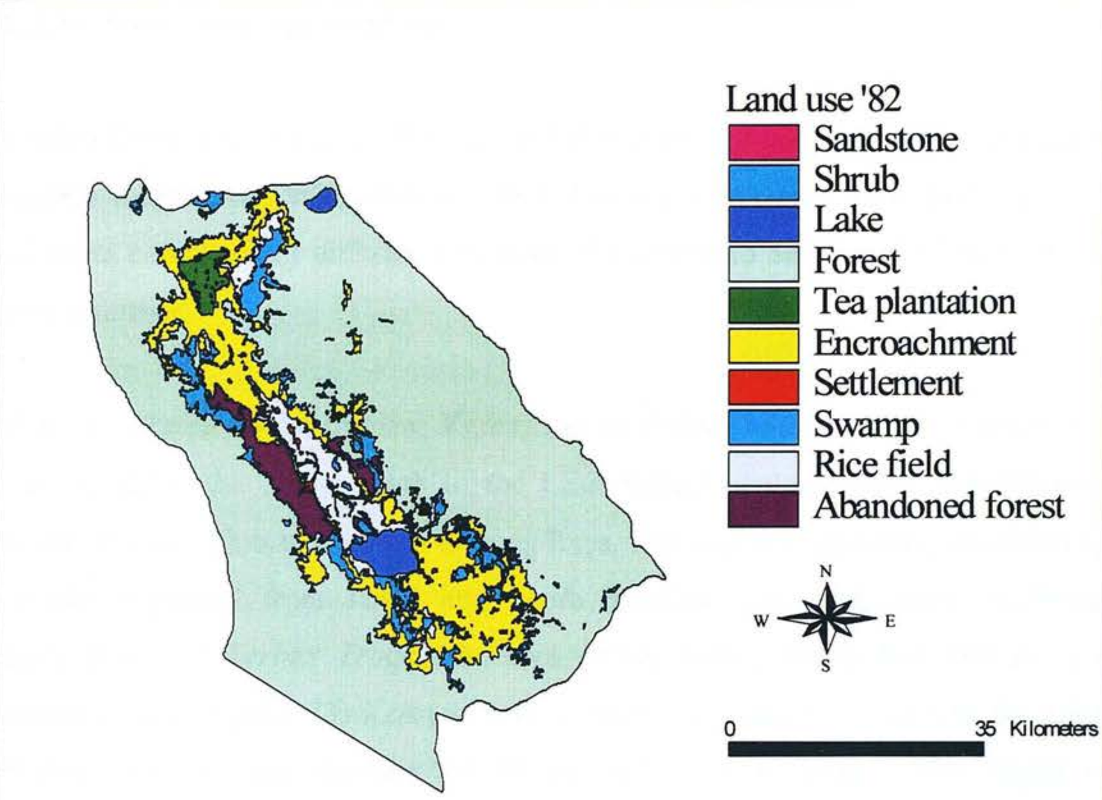


Figure 2. 10. Land use pattern in Kerinci District in 1982

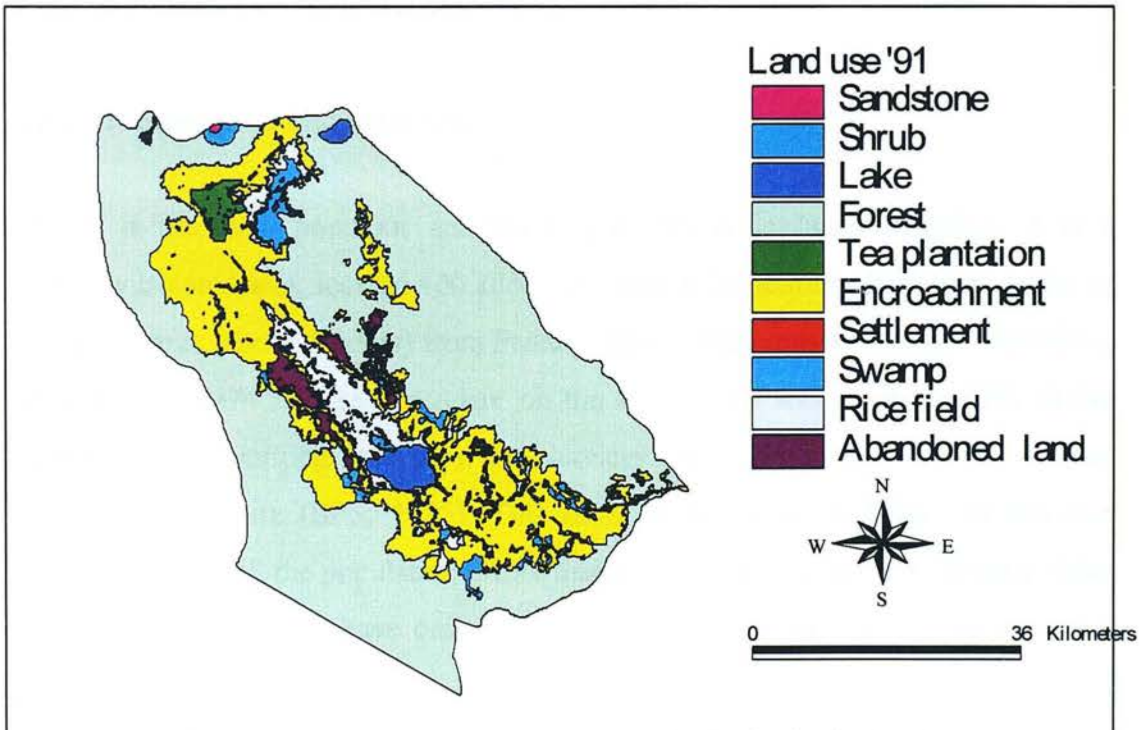


Figure 2. 11. Land use pattern in Kerinci District in 1991

2.2.10. Socio-economic conditions

Kerinci District according to Watson (1981) is a land of heterogeneity where many dialects separate one village from another. This could be due to successive waves of migrants coming from different provinces of Sumatra to settle in Kerinci over the past centuries.

From an ethnicity point of view, Kerinci can be divided into three main regions: (1) *Kerinci Hilir*, the region south to the Lake Kerinci, includes three sub districts: Danau Kerinci, Sitinjau Laut and Gunung Raya. This region is essentially occupied by people originated from Jambi and South Sumatra, practising more traditional agriculture; (2) *Kerinci Tengah*, includes mainly Sungai Penuh Sub District, the capital of the District; (3) *Kerinci Hulu or Mudik*, the region far north to the Lake Kerinci, includes sub districts: Air Hangat and Gunung Kerinci. This region is essentially occupied by people of Minangkabau, Batak, Java and China origin, who practise more modern agricultural systems (Watson, 1981; Aumeeruddy, 1992; Perbatakusuma *et al.*, 1993; Idham, 1995).

2.2.10.1. Education and work force

Kerinci is the most populous and the largest district in Jambi Province. It is a relatively isolated area, located 400 kilometres (about 10 hours by bus) from Jambi or 250 kilometres (about 6 hours) from Padang. With a such remote location, therefore, most people (>74 %) are dependent on the agricultural sector, about 17% of the population are working in trades and services and 9 % others rely on various development sectors (BPS, 1995). This situation seems to contribute to the low education level of the population. More than 84 % of the people are illiterate, have never been to school or have only graduated from the primary school as shown in Table 2.10.

Table 2.10. Education level of people of Kerinci District in 1994

Education level	Number of people	Percentage (%)
No school	50,798	17.70
Primary school	192,137	66.93
Junior high school	12,898	4.52
Senior high school	27,264	9.50
Graduate	3,857	1.35
Total	287,046	100.00

Source: Adapted from BPS Kerinci (1995)

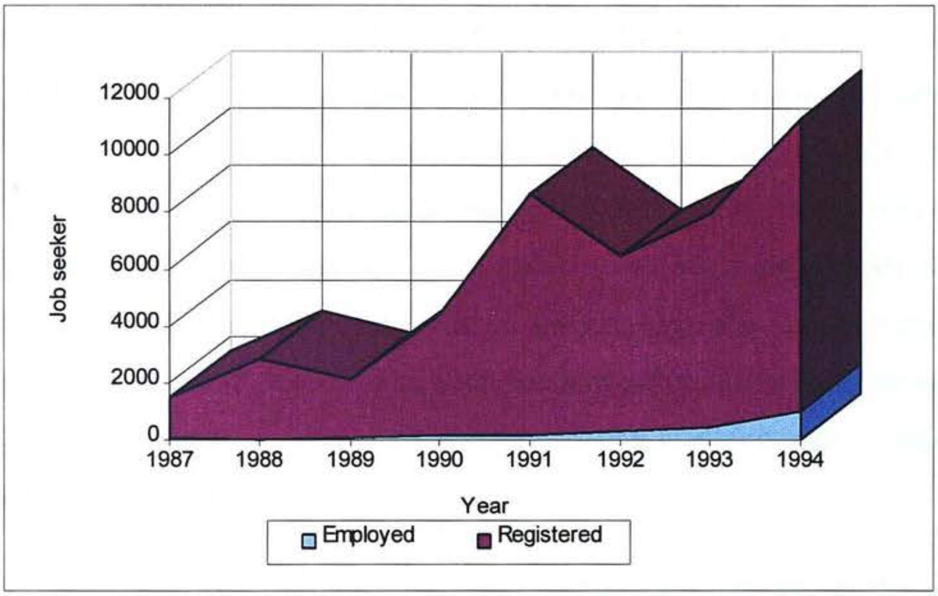


Figure 2.12. The number of job seekers in Kerinci (1987-1994).

The rate of population growth in Kerinci District is much higher than the rate of job creation in all sectors of the development. Therefore, unemployment is relatively high. From a total of 10,312 job seekers registered in the Department of Work Force Kerinci in 1994, only 1,019 people (9.88 %) has been employed (Dep. of Work Force 1993; BPS, 1995). As a result, encroachment on the Park and on the surrounding government's forest for cash crops and cinnamon is inevitable. The number of people seeking jobs registered in the Department of Work Force Kerinci between 1987-1994 based on the available data from the Department of Work Force Kerinci (1993) and BPS Kerinci (1995) is shown in Figure 2.12.

2.2.10.2. Agricultural systems

Agriculture is the main local economic activities in the District. There are two main systems of agriculture in Kerinci: wet rice cultivation and dry land cultivation. The former consists of about 18 % of the agricultural areas of the District and is essentially situated on the valley floor. The later consists of perennial crops farming (76 %) and annual crops (6 %) associated with the establishment of cinnamon plantation, situated mainly on the surrounding hills (Savoure, 1992).

There is a general rule or '*adat*' in Kerinci that rice fields or '*sawah*' are considered as a family inheritance (*harta pusaka*) which cannot be sold. Due to the limited area, *sawah* is not divided and given to every family member, therefore, it is not a personal but a group or family belonging. It is managed following the 'take-a-turn' system (*gilir ganti*) by all family members. The problem arises when the number of people entitled to manage the '*sawah*' exceeds its carrying capacity. This causes a long waiting list. In Sumurup, for example, each family member has to wait between 4-12 years for their next turn (Idham, 1995). This situation may also lead to intensifying encroachment on the Park.

In dry land cultivation, cinnamon growing is the main activity in the District. Cinnamon requires special natural conditions to grow well such as drained soils with the altitude preferentially between 500 to 1500 m (Zamarel and Hamid, 1990), relative humidity between 70-90 %, the rainfall between 2000-2500 mm/year and soil pH between 5.0 - 6.5 (Kanwil Dep. Dag, 1994). These conditions are found in other parts of Sumatra but Kerinci is better suited for the development of cinnamon. The District, therefore, produces more than 69 % of all Indonesian cinnamon (Scholz, 1983).

Cinnamon uses a great deal of land because it is generally harvested between 7 to 25 years old and thereby occupies the land for a long time. To alleviate the problem of widely spaced returns, Kerinci farmers preferred to plant cinnamon associated with other tree crops such as coffee and annual crops as a strategy for generating annual or pluriannual incomes and diminishing market risk.

Cinnamon is cultivated for the bark. The older the tree, the thicker the bark and the better the quality. The quality of the bark is sorted into 5 classes according to thickness: KM (> 5 mm), KF (3-5 mm), KA (1.5-3 mm), KB (1-1.5 mm) and KC (< 1 mm). In Kerinci District, it is the quality class KA is mainly produced.

Cinnamon prices for KA category rose from Rp. 367/kg in 1980 to Rp 2,582/kg in 1990, an increase of more than 600 % within 10 years, and then to Rp 3,587/kg in 1994 a further increase of 39 % (Dinas Perdagangan, 1995; Dinas Perkebunan, 1995). The cinnamon price rose sharply in 1987 by almost 80 % from the price of 1986. This resulted in large increase of the area of encroachment by 39,253 hectares (75.96 %) between 1982-1991 at the average expansion rate of 3,925 hectares per year mostly at the expense of the forest of the Park. The change of cinnamon prices between 1980 and 1994 is presented in Figure 2.13.

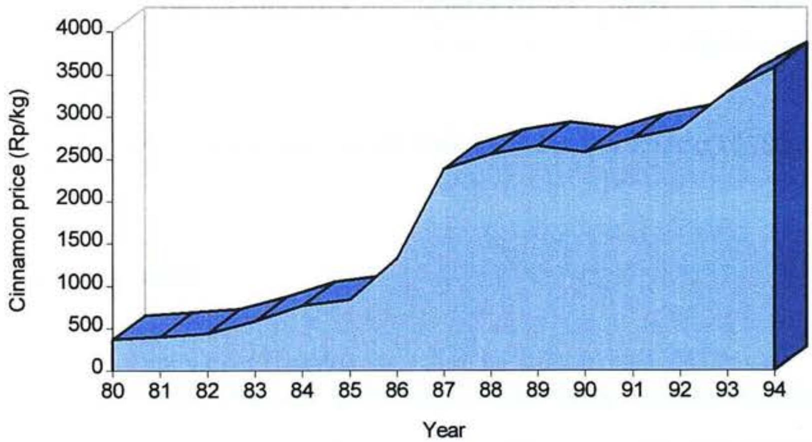


Figure 2.13. The change of cinnamon prices between 1980 and 1994 in Kerinci (**Source:** Dinas Perdagangan, 1995; Dinas Perkebunan, 1995)

Cinnamon is one of the important sources of income for the District. The production of cinnamon increased sharply and attained its maximum in 1988 of 10,052 ton with a total value of Rp 19,934 million, and then decreased 5,778 ton with a total value of Rp 15,731 million in 1994. The evolution of cinnamon production and its value in Kerinci from 1981-1994 (calculated from the data of Dinas Perkebunan, 1995 and Dinas Perdagangan, 1995) is shown in Figure 2. 13.

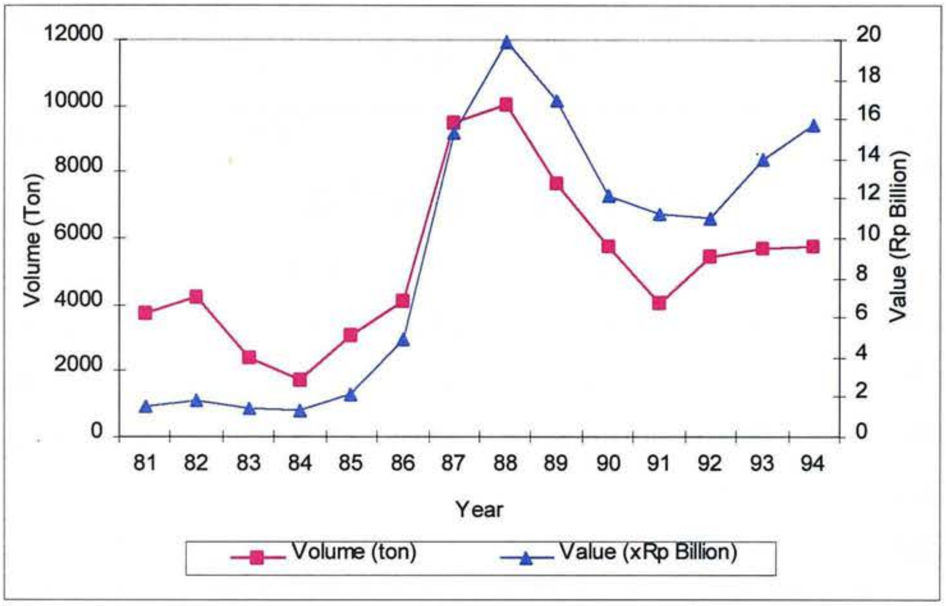


Figure 2.14. Cinnamon production and its value in Kerinci District (1981-1994)

2.2.9.3. Economic growth

Gross Regional Domestic Product (GRDP) is generally applied in Indonesia to evaluate the economic growth rate of a region (Bakosurtanal and Bappeda, 1990; Bappeda and IPB, 1994). GRDP is calculated based on the total value of goods and services produced by a region in a certain time. The calculation can be carried out either using a fixed and constant price in a defined year or using current prices. The GRDP of Kerinci District based on the constant price in 1983 is shown in Table 2.11.

Table 2.11 shows that the GRDP of Kerinci increased by seven percent per year from Rp 72,300 million in 1985 to Rp 107,300 million in 1992. The agricultural sector is the most important sector in Kerinci, contributing 50.30 % (Rp 36,367 million) of the total GRDP in 1985. The average growth rate of agricultural sector between 1985-1992 is 6.70 percent per year. In 1992, the agricultural sector contributed 49.59 % (Rp 53,431 million) of the total GRDP.

Table 2.11. Gross Regional Domestic Product (GRDP) of Kerinci District based on the constant price in 1983 (in Rp million)

Sector	1985	%	1992	%	Growth rate (%/year)
Agriculture	36,367	50.30	53,431	49.59	6.70
Industry	2,698	3.73	3,688	3.42	5.24
Trade and services	15,067	20.84	24,364	22.61	8.81
Tourism	1,407	1.95	2,060	1.92	6.63
Transportation	4,804	6.64	9,511	8.83	13.99
Others	11,957	16.54	14,690	13.63	3.26
GRDP	72,300	100.00	107,744	100.00	7.00

Source: Adapted and calculated from Bappeda and IPB (1994)

The second biggest contribution to the GDRB of Kerinci is the trade and services sector with the total contribution amounted to Rp 24,354 million (22.61 %) in 1992. Tourism has not been developed well in Kerinci as shown by the relatively small contribution to the GDRB (1.92 % in 1992). It might due to the location of KSNP being far away from any entry points such as Padang and Jambi. The existence of KSNP is not strong enough to attract tourists to the Park. In fact, Kerinci has a large potential for tourism especially for those who have special interests, such as mountaineering around Kerinci volcano, canoeing in Kerinci lake etc. Therefore it is a great challenge especially for the Park authority to develop tourism with special interest program and to promote an integrated Park with other development sectors, both to conserve biodiversity and at the same time to increase the regional economic income through tourism.

2.3. Summary

In this chapter the bio-physical and socio-economic characteristics of KSNP as a whole and in particular for the Park in Kerinci District, as the study site, were presented. Historical background to forest degradation in Sumatra and land use patterns in correlation with population pressure were also highlighted. These factors have been taken into consideration in establishing the objectives of KSNP management.

Most people in the study site are dependent on the limited agricultural lands as their income sources and cinnamon is amongst the most famous commodities. The population density in Kerinci is very high and more than 80 % of the people have a low level of education. Environmental factors in Kerinci District were best suited to the growth of cinnamon. These facts, supported by the continuously increasing price of cinnamon and limited agricultural farming, have been considered as stimulating factors for the high rate of land use change. This assumption, however, needs to be proven. In the next chapter research methodological approaches are presented in order to assess the study hypotheses.

CHAPTER THREE
OVERVIEW OF RESEARCH METHODS

This chapter provides an overview of the research methods applied to generate information required to examine the hypotheses presented in Chapter One. The study was conducted in Kerinci Seblat National Park, Jambi Province, Indonesia. Collection of primary data was undertaken in Kerinci District in 1995. Three main groups of methodological approaches were utilised to meet the research objectives: socio-economic analysis, GIS-based analysis and Multi-Criteria Decision Making (MCDM). The procedure of the study regime is defined and summarised in Figure 3.1. The research methods performed in this study and statistical analysis utilised for evaluating maps and numerical data are described in the relevant sections below.

3.1. Socio-economic Analysis

3.1.1. Village selection

The study of the characteristics of households was designed in order to assess the socio-economic condition of households residing around the Park boundary, their general attitudes and opinions about park management, to elucidate the nature of the encroachment system, ascertain the characteristics of their farming lands and their perception of cinnamon farming. Understanding these variables was felt to be important in determining the factors which drive the local people to encroach the Park.

In order to explore the people-park relationship, village samples were selected based on their closeness to the Park boundary. This was because the closer the villages

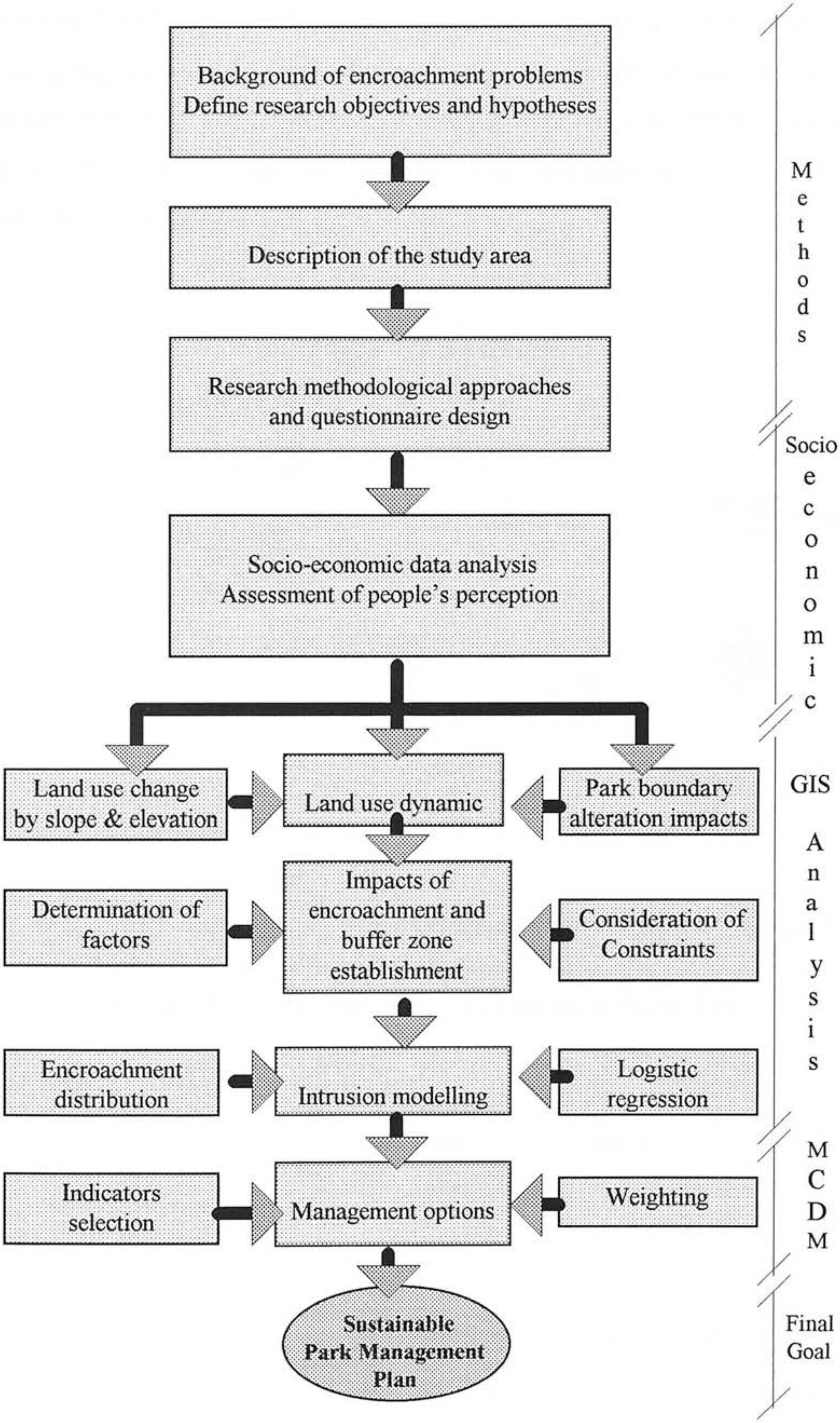
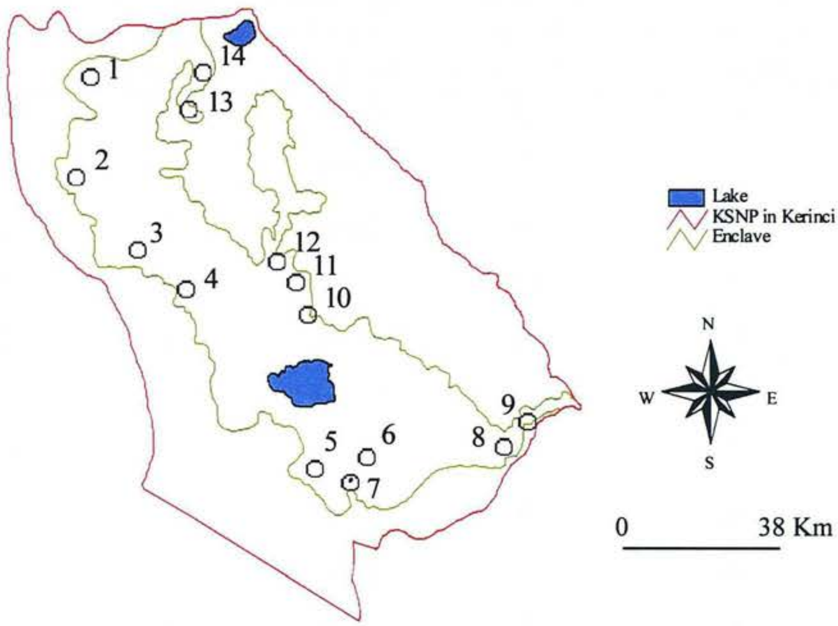


Figure 3.1. Flow diagram of the study procedure

were to the Park the greater the probability of people-park interaction occurring. Villages located within two kilometres of the boundary was included in the random sampling process. A list of villages located around the Park boundary was obtained from the KSNP authority. Fourteen villages were randomly selected out of the total 34 villages around the Park boundary. The case study area and selected villages are shown in Figure 3.2.



1. Bedeng VIII, 2. Suko Pangkat, 3. Sungai Gelampeh, 4. Kampung Baru, 5. Tanjungsam, 6. Lempur Mudik, 7. Lempur Hilir, 8. B. Merangin, 9. Muara Imat, 10. Pungut Hilir, 11. Pungut Tengah, 12. Pungut Mudik, 13. Pendung, 14. Pesisir Bukit.

Figure 3.2. Case study area and selected villages

3.1.2. Household selection

Within the sample villages, household respondents were selected on the basis of stratified random sampling with strata being the farming status: encroacher and non village authorities. Whilst a list of encroacher households was obtained from the KSNP's survey report (KSNP, 1995). A random sampling method was applied to obtain a minimum of 10 percent of the total households in every stratum of the selected villages. The number sampled and total households in the study villages is shown in Table 3.1.

Table 3.1. Number of sampled households in the study villages

Village	Number of households	Number of sampled households	Percentage of total households	Number of sampled encroachers	Number of sampled non-encroachers
Lempur Mudik	240	24	10.00	13	11
Lempur Hilir	109	11	10.09	7	4
Tanjungsam	122	13	10.66	6	7
Muara Imat	155	16	10.32	11	5
B. Merangin	320	33	10.31	19	13
Bedeng VIII	162	17	10.49	12	5
Suko Pangkat	78	9	11.54	5	3
Pungut Hilir	76	8	10.53	6	2
Pungut Mudik	84	9	10.71	3	6
Pungut Tengah	87	9	10.34	7	2
Pesisir Bukit	262	27	10.30	18	9
S. Gelampeh	349	35	10.02	15	21
Pendung	205	21	10.24	9	13
Kampung Baru	176	18	10.23	7	11
Total	2425	250	10.31	140	110

Stratified random sampling was utilised for this study because of its advantages in representing each population group compared to either simple random sampling or a systematic sample (Weber and Oliver, 1990). Therefore, using stratified random sampling, each group of encroacher and non-encroacher households will be proportionally represented in this study.

All respondents comprising 140 encroachers and 110 non encroachers were interviewed both formally and informally, covering the nature of their encroachment, socio-economic situation, and perceptions toward the Park and cinnamon cultivation. Interviews were carried out with the head of the household irrespective of their sex. This was because usually the decisions concerning the farm and encroachment activities are taken by the head of the household.

Structured questionnaires (Appendix 1) were used during formal interviews. This method is more quantitative, less vulnerable to interviewer's bias and allows for more sophisticated statistical analysis (Gardner, 1978). Before interviews began, each respondent was given a brief background and objective of the study. Then respondents were asked to answer the questions as prepared in the questionnaire.

The survey was aided by one or two staff members of KSNP in every sub region of KSNP. Their main duties were to introduce respondents and farms and to translate the questionnaires into the local language for illiterate respondents. Therefore, a total of six staff members of KSNP assisted in the interviews conducted between March-June 1995.

An informal approach to the survey was also performed in an attempt to investigate the deeper details of the individual attitudes and feelings and to explore information not covered in the formal interviews. The informal discussion occurred during informal meetings in the village. A group discussion mostly headed by an informal leader (*kepala adat*) ensued at the village level in order to explore their activities, ideas and any problems they had especially those related to the Park management system. The size of group discussion varied from village to village but was between 10 to 20 people. In addition, informal observations on respondent's farms were carried out in order to cross-check the information given related to the encroachment and farming. This technique was adopted because data generated from observations will be of importance as complementary data collected from the questionnaires (Rowntree, 1981).

Secondary data related to the Park's resources, Socio-economics and farm production for the whole area of Kerinci District were collected from many different sources and organisations such as Ministry of Forestry records, Kerinci Seblat National Park reports, Agriculture Department records, World Wide Fund for Nature (WWF) publications, Bogor Botanical Garden reports, research reports carried out in the study area and from related Departments in Kerinci District.

Both secondary and primary data obtained from the interviews, questionnaires and field observations were transferred on to spreadsheets and analysed using statistical packages: Microsoft EXCEL Version 5.0 (Microsoft Corporation, 1984-1993) and SPSS (Statistical Package for Social Sciences) for Windows Release 6.1 (SPSS Inc., 1989-1994).

Standard statistical technique were used to test effects of socio-economic factors (i.e. age, education, knowledge, shortage of land, perception on cinnamon, occupation, gender and income) on respondents' encroachment activities and their attitudes towards the Park. Finally, respondents' attitudes towards KSNP were compared to that of previous researchers' findings in other protected areas around the world.

3.1.3. Questionnaire design

In order to generate information needed to test the hypotheses, questionnaires (Appendix 1) were prepared. The questions were designed to be straight forward and unambiguous. To test for clarity, the questionnaires were piloted for 20 households during preliminary site observation and suitable modifications were made before conducting the formal interviews.

All questions were designed to enable respondents to present one of the following five answer types: (1) open answer; (2) yes or no answer; (3) respondents' most preferred answer (one from many choices); (4) agree and disagree answer; and (5) a number of point scale answer (e.g. on 11-point scale where 11 is the best or most important). In addition closed or precoded questions were introduced to minimise subjective answers that would be difficult to analyse.

The questionnaire comprised three modules. Module one sought information from the respondents on factual matters such as household size and farm information, respondents knowledge on conservation issues, participation on park management programmes and patterns of resources use. Module two was concerned with people's attitudes and responses to the Park management, perception of the effects of the Park on the community, household and environmental level as well as the perception of management of encroachment problems by the Park authority. Module three concentrated on respondents' attitudes and response to cinnamon cultivation. The questions related to the economic, social and cultural, as well as technical aspects of cinnamon cultivation.

3.1.4. Bio-physical impacts of encroachment

3.1.4.1. Impacts on soil properties

Encroachment and shifting cultivation in the tropics causes soil exhaustion to a new piece of bare land as soon as the yield of the existing land declines (Nye and Greenland, 1960). As Beets (1990) noted, soil fertility usually declines rapidly after as little as three years of cultivation. However, most of the encroachment in KSNP is somewhat different from the traditional shifting cultivation in other regions as cinnamon is permanently cultivated in the encroachment areas.

The study on bio-physical impacts of encroachment was designed to assess the impacts on the soil properties of the Park. Sampling method is an important factor for soil analysis because any results obtained from the analysis can only be reliable if the sampling has been properly carried out (Shirlaw, 1962; Hodgson, 1978).

The principles of soil sampling were outlined by Cline (1944) and have not changed materially up to now. There are a number of different designs which can be used for soil sampling. Stratified sampling design was suggested by Klute (1986) in order to increase the precision and to reveal conclusion about each of the sub populations separately.

Sample plots in this study were designed on the basis of stratified random sampling with strata being the soil types of the Park (Andosol/Inceptisols and Latosol/Oxysols), the length of encroachment which is characterised by the age of cinnamon cultivation (1- 35 years) and the type of land cover (primary forest, secondary forest and shrub). Andosol and Latosol soil were selected for soil sampling because they represent a large area in the study site and cover all age categories of cinnamon plants.

To locate sample plots, respondents' farms were classified according to their soil types and the age of cinnamon cultivation. Simple random sampling was then performed in each stratum to define respondents' farms as plots. A random numbers table was used to determine the positions of soil samples within the plots. The starting points were usually from South West corner of the plot. The first two digit number obtained from the table of random numbers served as the X axis and the next two digit number read as the Y axis. The joint point between X and Y axis was the position of sample plot. Soil samples taken from the undisturbed forest served as control samples.

A composite method was adopted to sample soil from the KSNP both under cinnamon plantation and under different types of forest cover. Two soil types, Andosol and Latosol soil, were sampled from areas of different ages of cinnamon cultivation: 1, 5, 10, 15, 20 and 25 years old. The same method was also applied to sample soil from primary forest, secondary forest and shrub.

There were three replicates in every plot. Hodgson (1978) suggested taking samples from different depths of soil. A sample at two different soil depths, 0-20 cm and 20 - 40 cm, was taken from each replicate. Therefore, the sample included 20 plots comprising of 120 samples. The soil sampling regime is summarised in Figure 3.3.

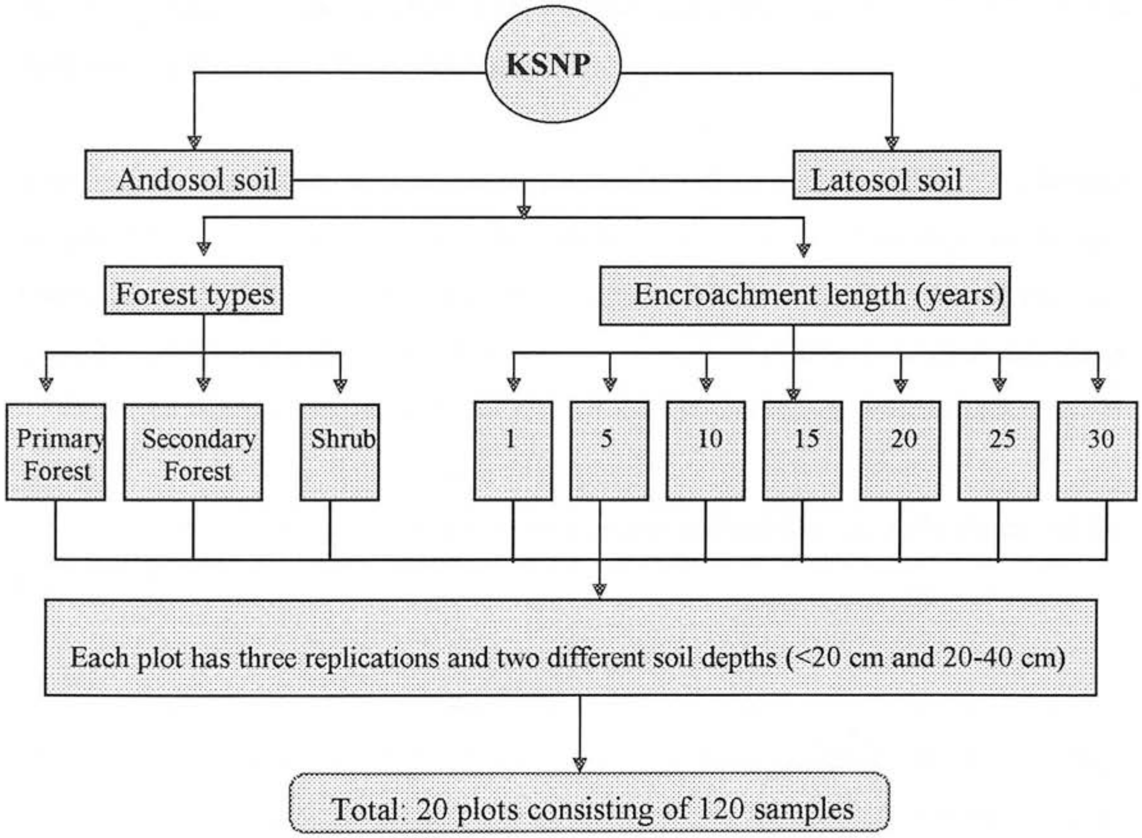


Figure 3.3. The soil sampling regime adopted in KSNP

Soil samples were taken from the designed sites as shown in Figure 3.3. using a soil auger. The auger was pushed vertically into the soil to the required depth and twisted around. Great care was taken to avoid contamination during sampling. The samples were taken from the entire thickness of every horizon, starting at the surface and leaving a clean step at the base of the first horizon (20 cm) before sampling the one below. Although many standard soil analyses require only a few grams of soil, samples weighing one kilogram for each sample were taken from every plot as suggested by Hodgson (1978). Each sample was thoroughly mixed since only a very small quantity of soil was required for actual analysis.

After collection, the samples were packed in a polythene bag to maintain original moisture and labelled based on the plot number and sample depth using waterproof ink. The polythene bags were then tightly sealed and transported to the Soil Research Institute's laboratory in Bogor for analysis.

The analysis was carried out on the most essential soil nutrient for plant growth such as: pH, N, P, K, Ca, Mg and organic matter as a standard soil analysis (Lutz and Chandler, 1946, Jones and Wild, 1975; Miller and Donahue, 1990; Syers and Rimmer, 1994) with the help of the Soil Research Institute in Bogor. Standard methods for soil analysis, such glass electrode for pH analysis, Kjeldhal method for N total, EDTA method for Ca and Mg, molybdenum blue technique for P and ammonium acetate extraction for K analysis were applied (Dewis and Freitas, 1970; Page *et al.,* 1982).

The sample data were transferred on to spreadsheets and analysed using the MINITAB for Windows Release 11.1 statistics package (Minitab Inc., 1996). Analysis of Covariance (orthogonal designs) in MINITAB was applied to ascertain effects of the length of encroachment (1- 30 years) and covariates (i.e. soil types and soil depths) on the soil properties and its chemical contents (i.e. pH, N, P, K, Ca, Mg and organic matter). In addition, analysis of Variance of General Linear Model (Anova GLM) in MINITAB was used to test influences of land cover types and soil depths on the same soil properties. The results were then compared to that of similar researchers in other countries.

3.1.4.2. Impacts on vegetation

From the perspective of biodiversity conservation, encroachment can be a threat, both because of its present effects (habitat clearance or simplification, hunting, human and wildlife conflicts) and its future effects (population growth, migration, development such as access road). Both sets of effects have the potential to fragment the Park, speed species loss and prevent animal and plant dispersal (The World Bank, 1993).

The impacts of encroachment on forest succession were analysed based on vegetation sampling. Sample plots were set up in three different land covers: primary forest, secondary forest and shrub. Tree species and number of trees within 10 x 10 m square plots were recorded. The same variables for pole and sapling were recorded in 5 x 5 m square plots. Whilst the number of seedlings of each species were recorded in 2 x 2 m square plots. Each land cover type contained three plots. Some species were identified in the field using a tree field guide manual for Indo-Malay flora. Unrecognised species were collected and sent to Bogor Herbarium Bogoriense for identification. Unfortunately some of these samples went missing. Species recorded in each type of land cover were analysed and compared to identify trends of forest succession in the Park. A Pearson correlation analysis was utilised to test the correlation of vegetation composition between primary forest, secondary forest and shrub. Then Sorensen, Simple Matching and Barono-Urbani and Buser techniques were used to test the species similarity index of the plots.

3.1.5. Park Pressure Index (PPI)

In most developing countries, the dependency of the people within or near the Park on the Park's resources is significant (Meganck and Gobel, 1985; West and Brechin, 1991). Increasing demands for land and resources due to expanding human populations will probably cause the pressure of the surrounding communities on the Park to escalate. A general model of the relationship between people and their rural environment was formulated by Sumarwoto (1984) and is encapsulated in the concept of the Park Pressure Index.

The Park Pressure Index (PPI) was adopted here to measure people-park relationship and the degree of population pressure on the Park. This index was based on Sumarwoto's model which includes three measures of population pressure:

(1) PPI < 1, the Park was not under pressure by the surrounding people;

(2) PPI = 1, the Park is at the limit of people pressure; and

(3) PPI > 1, the Park is under pressure by the surrounding people.

The Park Pressure Index was calculated using the following model:

$$PPI = \frac{a\,Po\,Pt\,(1 + r)^{t}}{Lt} \tag{3.1}$$

Where:

PPI : Park pressure index, the degree of population pressure on the Park

a : Minimum area of farming needed for one person to support a perceived adequate level of living.

Po : Percentage of farmers in the total population

Pt : Total population in year t (people)

r : Population growth rate (%/year)

t : time factor (year)

Lt : Total of productive land in year t (ha)

The data required for the analysis of PPI index were obtained from various sources listed below. Population growth rate, the total population and the percentage of farmers in the total population were derived from the statistic year book of Kerinci (BPS Kerinci, 1995). The minimum area needed (2.7 ha) for one person in Kerinci to meet subsistence need was based on the study results of Schneider (1992). The total productive land was analysed using GIS method described in Chapter Five. The results of the PPI index may be an important factor in the development of plans to reduce conflict between encroachment and the Park management.

3.2. GIS Based Analysis

3.2.1. GIS definition and its application in park management

A Geographic Information System (GIS) is a computer-based information system designed to facilitate integration and analysis of geographically referenced data. It possesses the capacity to store, evaluate, combine and extract information from maps and associated attribute data (Aronoff, 1989; Goodchild, 1992; McKendry *et al.*, 1992; Haines-Young, *et al.*, 1993). At present, GIS is used variously in decision support systems, forms of Management Information System (MIS), and in systems with advanced geo-modelling capabilities involving the integration of spatially referenced data in a problem-solving environment (Fotheringham and Rogerson, 1994; Eastman, 1995; Aspinall, 1995).

The role of GIS in modelling different management scenarios in space and over time is becoming increasingly important for making actual management decisions. It is particularly relevant to the field of resource management because of its powerful analytical ability for data capture, analysis and display (Miller *et al.*, 1994). GIS has been widely utilised as a tool to aid the planning, management and monitoring of national parks and other protected areas in many countries around the world (Bridgewater, 1993; Price and Heywood, 1994; Walsh *et al.*, 1994; Schneider and Robbins, 1995). Some of them are discussed below.

Jordan (1994) assesses potential conflicts between different groups: in this case, the Park management and villagers living in Sagarmatha National Park, Nepal. Jordan's (1994) GIS model of deforestation risk, initially developed in England, was tested in the field leading to an improvement in predictive value. Brown *et al.* (1994) give a concise account of the use of GIS for providing information necessary to help resolve conflicts between forestry and wildlife conservation interests in an area that includes logging leases and two national parks in the Rocky Mountains of British Colombia, Canada. Walsh *et al.* (1994) present a summary of a major ongoing research programme conducted over many years in Glacier National Park, USA. Their current work focuses on the construction of alpine tree line models in relation to topoclimatic factors and snow cover. All of these studies indicated the importance of GIS as a tool for developing management strategies in both protected areas and adjacent lands. However, there are also potential errors using GIS as a tool for analysis, especially during data transformation, processing and overlaying using different scales or resolutions.

In this study, GIS based methods were applied to incorporate encroachment problems into the Park management policy and decision support system. For this purpose, the study used GIS based methods as the basis for four main groups of analysis: (1) analysis of land use dynamics and land use change in relation to the site's slope and elevation; (2) impact assessment of the Park's boundary alteration on land use composition; (3) design of the suitability of areas for buffer zone based on the defined factors and constraints; and (4) developing an encroachment risk model for KSNP. Based on these GIS analyses, alternative management options were offered as a trade-off for incorporating encroachment problems into sustainable park management. The GIS methodological approaches used in this study are described below.

3.2.2. Software and module choices

A number of GIS software tools were utilised in this study including ARC INFO Version 3.4D Plus (ESRI, 1992), ARC VIEW Version 2.1 (Environmental System Research Institute, Inc. 1992-1995), EXPTOVEC Version 2.11 (University of Berne, 1993), and IDRISI for Windows Version 2.0 (Clark University, 1987-1997). The ARC INFO software produced by the Environmental System Research Institute (ESRI) was used for digitising maps and storing associated attribute data. ARCVIEW was utilised to display some basic images from the ARC INFO.

EXPTOVEC and ARCIDRIS module were applied to facilitate conversion of ARCINFO vector files into raster based spatial image files.

The IDRISI for windows, a raster or grid-based geographic information and image based processing system, developed by The Graduate School of Geography at Clark University, USA was selected for data analysis because it offers special facilities for analysis of complex relationships of natural resource management, including a multi-objective decision support system and simulation modelling. However, it also has some drawbacks for the analysis such as limitation in the number of polygons which can be accommodated in the vector-raster transformation process.

A number of modules in IDRISI for Windows were utilised in this study for data base management as well as spatial GIS data analysis. These included: Overlay, Reclass, Crosstabutation and Crossclassification, Distance Operation, Contraction by Pixel Thinning, Query, Multi- Criteria Evaluation (MCE), Weight, ArcIdris, Data Import, Buffer, Boolean, Pairwise Comparison, Weighted Linear Combination (WLC), Pointras, Lineras, Polyras, Subtract, Edit and Assign. The main function of each module is summarised in Appendix 2.

The general model for spatial analysis of GIS in this study is summarised in Figure 3.4, adapted from Ramdhani (1996). However, every sub-model such as intrusion modelling, buffer zone establishment and land use dynamics analysis required specific procedures as well as software modules to be developed. The nature of these dependent on the objectives of the analysis. The procedure and software modules utilised for each sub-model in this study analysis are briefly described below. More detailed flow diagrams of the analysis procedures are shown in the related chapters.

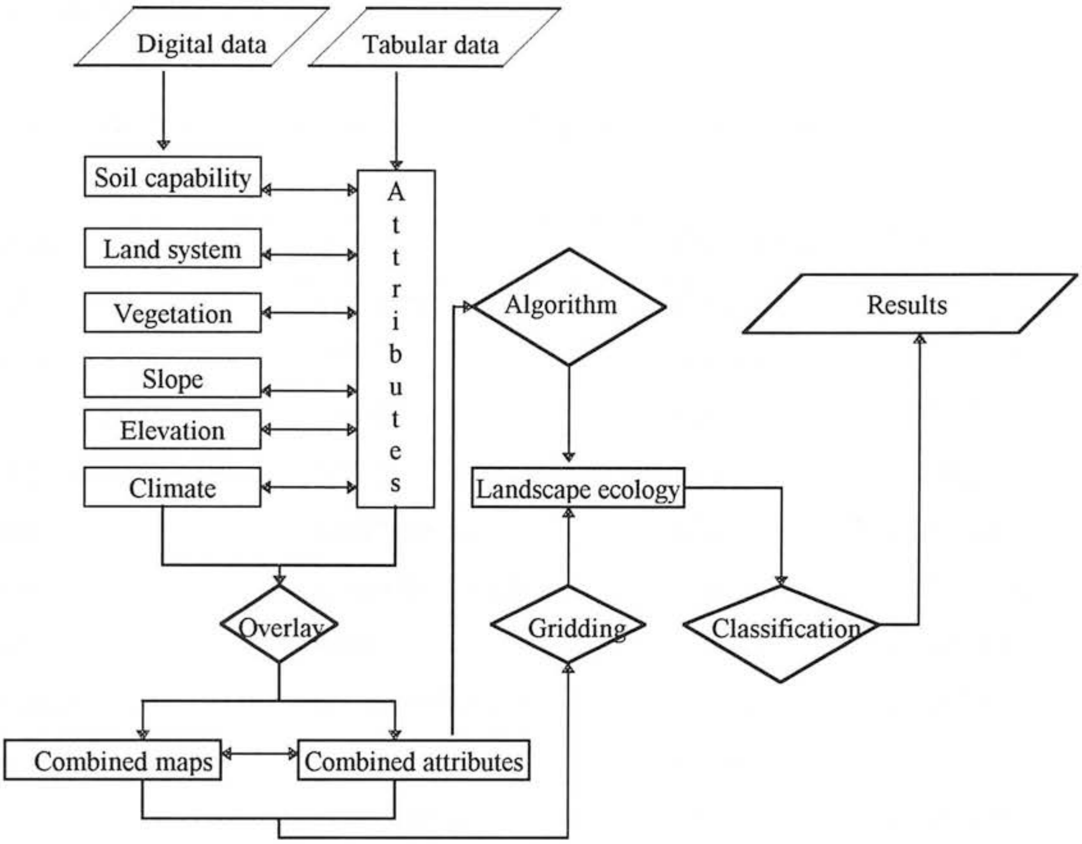


Figure 3.4. General model for spatial analysis with GIS

3.2.3. Data: sources and preparation

For the purpose of GIS data analysis a number of spatial as well as site attribute factors were considered. These factors were maps of land uses for two years (1982 and 1991), a digital terrain model (DTM), soil, rivers, roads, the Park's boundary, slope, elevation, lake, wildlife distribution and administrative boundary. All of them were found to be important elements in the decision making of the people-park conflict management in KSNP.

The data sources for these included various agencies such as Army Topographical Agency (JANTOP AD), National Survey and Mapping Coordination Board (BAKOSURTANAL), KSNP, National Land Development Board (BPN), and World

Wildlife Fund for Nature (WWF) in Sungai Penuh. The data sources and the spatial data format for the GIS analysis are shown in Table 3.2.

Table 3.2. Data sources and the spatial data format for GIS analysis

Coverage	Sources	Description	Scale
Land use 1982	JANTOP AD	Polygon	1 : 50,000
Land use 1991	BPN	Polygon	1 : 25,000
Park boundary 1982	KSNP	Line	1 : 50,000
Park boundary 1995	KSNP	Line	1 : 50,000
Roads	JANTOP AD	Line	1 : 50,000
Rivers	BAKOSURTANAL	Line	1 : 250,000
Slope	BPN	Polygon	1 : 100,000
Elevation	BAKOSURTANAL	Polygon	1 : 250,000
Wildlife distribution	KSNP, WWF	Point	
DTM	JANTOP AD	Grid	1 : 50,000
Population	BPS, BAKOSURTANAL	Point	1 : 50,000
Lakes	JANTOP AD	Polygon	1 : 50,000
Administrative boundary	BAKOSURTANAL	Polygon	1 : 250,000

Digitising and spatialisation of all the above data were carried out with the help of WWF Kerinci using ARC INFO GIS software system. Even though transforming paper based maps into digital spatial data is not a difficult task, it is time consuming and prone to error generation.

The Kerinci land use map 1982 was derived from JANTOP AD map (scale 1 : 50,000). Whilst the land use map 1991 was derived from the National Land Development Board (BPN) scale 1 : 25,000. Both of these land use maps were produced by the GIS Department of the WWF Sungai Penuh, Kerinci. A ground check was carried out during the production of these land use maps. The digitisation and the production processes of these land use maps were carried out by many people under the co-ordination of the Head of the GIS Department. Some of the staff members, however, only involved in the production of one land use map. Therefore, the difference of the maps source and of the personnels involved during the production process of land use map 1982 and 1991 might result in the lack of accuracy in the land use maps produced.

All data layers were transferred into a uniform co-ordinate system to facilitate subsequent analytical procedures. Then, EXPTOVEC, ARCEDIT and ARCIDRIS modules were applied to facilitate conversion of data base attributes as well as vector files into raster based value and spatial image files. These raster based files then enabled advanced analysis using the IDRISI GIS software system to produce desirable combined images, tables, and modelling. The procedure of data preparation and data development is summarised in Figure 3.5 below.

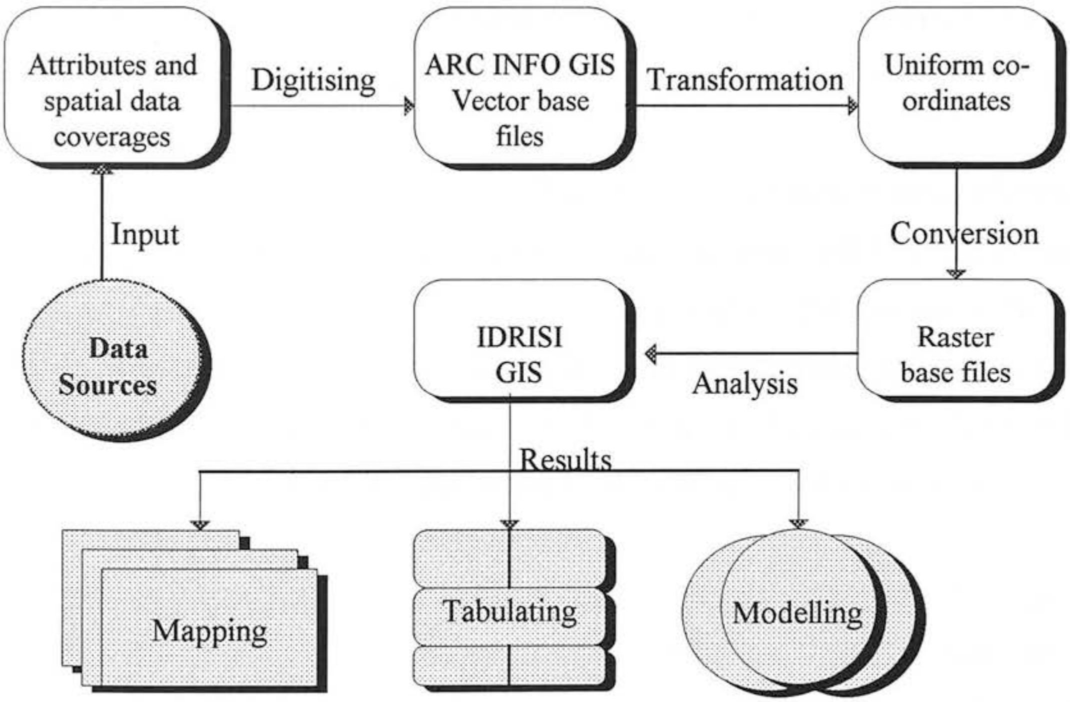


Figure 3.5. Flow diagram of the process of data set development

3.2.4. Land use dynamics

IDRISI GIS software has the capability for analysing the dynamics of temporal and spatial patterns of change and assessing their potential impacts. It can also be utilised to examine land use dynamics, particularly in association with topographic variables, such as slope and elevation (Eastman, 1995; Schneider and Robbins, 1995).

Land use images from 1982 and 1991 were utilised in this study as base images for assessing land use dynamics in KSNP. The work conducted for this study included four main stages of analysis:

(1) Land use dynamics of different land use categories;
(2) Land use dynamics in relation to elevation and slope;
(3) Land use change based on the land status both in the Park and in the enclave area;
(4) Impacts of the Park's boundary alteration on land use composition.

The land use dynamics between different land use categories were evaluated based on spatial crosstabulation of the two images in order to map each land use category change over a 10 year period using the Crosstab module. This module creates an image or table showing all possible combinations of the categories in the two original images. Then, the query module was applied to measure the total amount of area in which these changes occurred in order to quantify trends in land use change.

Land use dynamics in relation to elevation and slope were analysed using Overlay and Boolean operation modules. Then, the area of expansion or loss for each land use type based on slope and elevation categories was examined using the Query area module. Furthermore, images showing areas of significant land use change by slope and elevation regimes were created. This analysis allows land use changes in areas of critical high slope and elevation to be identified.

Land use change in Kerinci District both in the Park and in the enclave area was assessed using the overlay and subtract modules. Then, the area of change was measured based on the query area module, and mapped. Understanding the tendency of land use change in relation to the land status is of importance in order to aid decisions to conserve the Park's biodiversity.

Finally, impacts of the Park's boundary alteration in 1995 on land use composition both in the Park and in the enclave were analysed using the images crossclassification module. The area of loss or gain for every land use type both in the Park and in the enclave area was measured, tabulated, mapped and compared to that of the area before the boundary alteration.

Based on these analyses, some conclusions regarding the sustainability of current land use trend were presented. The flow diagram of the procedure of land use dynamics analysis based on GIS methods is shown in Chapter Five.

3.2.5. Buffer zones establishment

National parks throughout the world are being threatened as population growth and expansion resulting in conversion of forest lands into agricultural farms. Therefore, buffer zones establishment around a national park is necessary to increase a park's capability to protect its biodiversity and, at the same time, provide subsistence as well as income generating opportunities for local people (Wind, 1991; Sayer, 1991; Schelhas, 1992).

One of the important factors in park management includes efforts to identify socio-economic and bio-physical factors suitable for buffer zones. IDRISI GIS can play an important role in exploring suitability of different areas for buffer zones because it includes a number of modules that enable the incorporation of desired factors and constraints in the model.

The work conducted here in developing a suitable map and land allocation for a buffer zone in KSNP involved five main strategies:

(1) Determination of buffer zone criteria based on a number of factors and constraints using Multi-Criteria Evaluation (MCE) module;
(2) Creation of distance images to comply with the rule for each factor and classification of types of membership function curves and their inflection control points to standardise factor maps using the Fuzzy set module;
(3) Defining the relative importance factors, weighting factors based on the value of eigenvector, and Consistency Ratio (CR) for each MCE scenario using a Pairwise comparison module;
(4) Developing four scenarios (base line scenario, constraint base scenario, economic base scenario and environmental base scenario) of suitable maps for buffer zones using WLC and Boolean methods;
(5) Measuring and comparing the most suitable area for buffer zones resulting from each scenario using Query module.

The criteria needed to define suitable areas of the buffer zone were related to three main factors: a management factor (proximity to the Park boundary), economic cost related factors (proximity to settlements and proximity to roads), and ecological factors (proximity to wildlife corridors, suitability to slope and elevation). These data were derived from interviews with people surrounding the Park, questionnaire data and data deducted from the land use maps. The selection of these factors was aimed to increase the effectiveness of buffer zone management and at the same time to enhance the Park's capability to protect its biodiversity and natural resources.

Buffer zones serve as habitat extensions to protect the existing wildlife in the Park. Its management will be supervised by the Park staff, therefore it should be close to the Park boundary to maintain the interaction with the Park and to ease supervision. Proximity to park boundary was subjectively selected as a maximum of 2 km as a management factor. For economic reasons such as cost of transportation of agricultural products and time needed by farmers to travel back and forth to the farms, proximity to settlement and road was selected as economic and cost related factors. Based on the GIS analysis (Obermeyer and Pinto, 1995) of deduced data from land use maps, most encroachment areas are situated within 5 km distance from roads and rivers. The closer the buffer zone is to the settlement and road the more efficient it is for farmers and economical to transport the products. Proximity to wildlife was subjectively decided to be more than 2 km with the assumption that the farther the buffer zone from wildlife corridors the better to protect wildlife. Areas of more than 40 % slope was defined for soil conservation. While the elevation less than 1500 m was selected based on the suitability for plant growth.

In order to encourage people's participation in the Park management, their existing encroachment areas should be included in the buffer zone programme. This is intended to intensify farming systems to generate more income opportunities for local people as well as to provide a more secure legal aspect on their farms.

Encroachment images resulted from the analysis of land use dynamics served as a reference basic to facilitate subsequent analysis. Therefore, the excluded encroachment area from the Park due to the Park boundary alteration was defined as a constraint. Constraint based scenario analysis needs Boolean images with pixels coded as 1 (involved in the spatial analysis process) and other excluded pixels coded as 0.

Seven factors of raster based images (the Park boundary image, settlement image, wildlife distribution image, road image, slope image, and elevation image) were utilised for further GIS analysis to meet these buffer zone criteria. Using these factors and constraint images, subsequent analysis, as mentioned above, were applied. The flow diagram of detailed procedure of buffer zone analysis using GIS based methods is shown in Chapter Seven.

The proximity of the buffer zone to each factor as designated in the rules was compiled by creating distance and buffer images for every factor using Distance and Buffer modules. Then the Fuzzy set module was utilised to standardise the images.

GIS spatial analytical hierarchy process (AHP) was applied to evaluate the relative importance between two determining factors in the matrix. A pairwise comparison nine point continuous scale (Saaty, 1977) was used as a reference basis. In addition, a Consistency Ratio (CR) was utilised as a tool to test the level of acceptance of the weighting factor.

GIS based analysis can not proceed to the fourth step (developing scenario for suitability area analysis using MCE module) unless the value of the weighting factor was tested and accepted within the range of significant levels of CR, ($CR < 0.01$ is very significant, $CR < 0.05$ is significant and for $CR > 0.1$, the weighting factor is not accepted).

Furthermore, buffer zone suitability areas were developed and analysed based on four types of scenario:

(1) Baseline scenario: all factors were considered of equal importance and the analysis was carried out using the Weighted Linear Combination (WLC) method;

(2) Economic base scenario: economic and cost related factors were prioritised after the management factor and the WLC method was applied for the analysis;

(3) Ecological base scenario: ecological factors were prioritised over management factor and the analysis was done using the WLC method;

(4) Constraint base scenario: the constraint image was prioritised than other factors and the analysis was performed using Boolean overlay method.

Images produced from each land allocation scenario provided the basis for designing alternative management options to resolving conflicts of human encroachment and sustainable park management.

3.2.6. Modelling of encroachment risk

Much present modelling activity based on GIS makes extensive use of overlay. However, it has limited application if operated solely as a process of identifying areas where particular combinations of condition exist within the basic data layers of a geographic database (Burrough, 1986). Therefore many researchers have used arithmetical calculations derived from GIS based analysis as an alternative modelling approach (Thomas and Huggett, 1980; Winston, 1995; Obermeyer and Pinto, 1995; Mackey, 1996; Martin, 1996; Mitasova *et al.*, 1996; Longley and Batty, 1996;; McDonald and McAleer, 1997. Sangawongse, 1997) .

A great variety of variables influence the likelihood of encroachment in KSNP. These include physical environmental conditions of the Park, socio-economic condition of people surrounding the Park as well as the operation of a range of policies by the government especially the Park authority.

Since the model of encroachment risk in this study is intended to provide a general indication of where future encroachment may be expected, assumption and input limitation is necessary. In order to simplify the model in this study, physical and environmental factors of the Park were the only variables considered for building the model.

Physical and environmental factors which characterise encroachment areas in KSNP were identified in two ways: the questionnaire based analysis of encroachers' farms and the picture elements (pixel) based analysis derived from the encroachment Boolean images in 1982 and 1991. Based on these analyses, seven physical and environmental factors were identified which directly influenced people's accessibility to the Park leading to the existence of encroachment area in the Park. These factors were proximity to roads, proximity to rivers, proximity to settlements, degree of slope, level of elevation and distance to encroachment area in 1982 as well as in 1991. Therefore, they were taken into consideration for building the model of likelihood of future encroachment risk.

In order to enter these factors into the GIS data base, seven images related to these factors were utilised as data sources for building the model. They included: Boolean encroachment 1982, Boolean encroachment 1991, road image, river image, settlement image, slope image and elevation image.

Characteristics of picture elements (pixels) in Boolean encroachment images both in 1982 and in 1991 were defined as reference basis for building intrusion modelling. Any pixel in the Park which had the same characters with those of Boolean encroachment was considered as the area of likelihood of future encroachment risk.

The characteristics of every pixel in KSNP were derived from those seven images using the Contract module, Distance operation and Query module. From the Query file, the data then transferred to Excel file, DBase file and finally to an SPSS file for subsequent analysis. Furthermore, Logit analysis (Hosmer, 1989, Hair *et al.,* 1995) in SPSS was applied for building a Logistic Regression model. From this the likelihood of future encroachment risk could be calculated using the equation model of Norusis (1993) below.

$$\text{Probability of encroachment occurrence (P)} = \frac{e^{\beta_0 + \beta_1 X_1 \ldots\ldots \beta_n X_n}}{1 + e^{\beta_0 + \beta_1 X, \ldots, \beta_n X_n}} \tag{3.2}$$

or equivalently,

$$\text{Probability of encroachment occurrence (P)} = \frac{1}{1 + e^{-z}} \tag{3.3}$$

In this expression Z is the linear combination:

$$Z = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots\ldots + \beta_{n\,Xn} \tag{3.4}$$

Where :

e is the base of the natural logarithms, approximately 2.718

Z is dependent variable

X is the independent variable

β_0 and β_1 are coefficients estimated from the data

Based on these equations, the encroachment risk map in KSNP was created using the IDRISI Scalar and Transformation modules. A macro command was created for this purpose. The detailed modelling procedure and transformation process are presented in Chapter Seven.

3.3. Multi-Criteria Decision Making (MCDM)

3.3.1. Background

The origins of the MCDM techniques according to Bailey *et al.* (1977) can be traced back to the field of operation research (OR), which was designed for studying highly structured problems. In this case linear programming (LP) was the most commonly used method. This approach analyses problems by maximising a single objective such as profit maximisation or cost minimisation based on a set of constraints (Romero and Rehman, 1989). Methodologically, MCDM is considered as an extension of the traditional linear programming method (Romero and Rehman, 1989). However, the techniques different as MCDM based techniques model many problems by seeking to optimise several objectives simultaneously based on acceptable trade-offs between conflicting objectives. Therefore, any solution produced from MCDM represent a satisfactory compromise rather than an optimal solution.

3.3.2. MCDM analytical procedures

Multi-criteria decision making (MCDM) is the final step of analytical process in this study for managing conflicts and resolving problems of encroachment in KSNP. The results of the socio-economic as well as the GIS analysis described in the previous sub chapters served as the basis of an analytical frame work for the decision support system.

The Composite Programming (CP) approach, one of MCDM techniques, was selected in this study because it offers decision makers the opportunity to choose the optimal solution which is the closest point to the ideal point (Zeleny, 1976) or the best compromise solution based on the optimum values of various objectives (Bailey *et al.*, 1997). It also offers flexibility in use of indicators for qualitative elements and capable of handling both qualitative and quantitative indicators of the system (Tecle, 1993).

Qualitative data can almost always be converted into some kind of quantitative data simply by recording instances of a particular trait or characteristic. In the decision-making approach, the procedures for qualitative weighting and scoring priorities are commonly utilised. A number of method has been developed for this purpose such as 'Cardinal scoring' (Leopold, 1971), 'Bi-polar scale' (Moore and Golledge, 1976), Constrained weighting and Analytical Hierarchy Process (Saaty, 1977).

The measurement of complex entities using the index system of qualitative aspects through a single number, however, is subject to criticism. Hymen and Stiftel (1988), argues that a systematic bias through selection of indicators is inherent in any index construction. It might also loose significant details which are only observed when the data is preserved in a qualitative form. Even though the criticism is undeniable, Bailey *et al.* (1997) stated that the concept of a 'quality index' is remain a useful tool in the multi- criteria decision-making analysis if it is properly constructed. To minimise a such bias, therefore, the choice of indicators in this study was validated as far as possible through expert and the Park authority consultation.

To attain the optimum solution for encroachment problems in KSNP, the Composite Programming analysis in this study was divided into three main working stages:

3.3.2.1. A descriptive stage

The present condition of the Park was analysed to develop indicators that characterise the Park's condition and its problems. Thirteen basic indicators were selected to represent the characteristics of the quality of the Park. Then, these 13 basic indicators were compounded to form six sets of second-level quality indicators which included economics, regional development, recreation, wildlife, habitat and soil.

Furthermore, these second-level indicators were further compounded to form two sets of third level indicators (socio-economics and ecological indicators). These complex criteria were thus decomposed into their primary analytic components, measurable elements of these components were selected and compounded to form indices of overall quality.

3.3.2.2. An evaluative stage

Based on the indicators selected in the first stage, measurement approaches were carried out for the indicators. Measurement was also applied to 11 selected alternative management systems and their target areas. The relative importance of each basic indicator and each second level indicators in contributing to the composite values of the third level of indicators were also estimated. In this stage, inputs from the Park staff and their opinions were explored for the measurement approaches.

3.3.2.3. A decision stage

The values for six basic indicators were normalised and compounded into higher level indices and the composite distances from the ideal point were calculated for each management option. The results were displayed graphically and the relative performance of different options assessed. Sensitivity analysis of the results under different priorities were explored by varying weighting factors. The flow diagram of the Composite Programming procedure and the formula utilised for the measurement process are detailed in Chapter Eight.

3.4. Summary

In this chapter research methodological approaches including types of data required to test the hypotheses, methods for data collection as well as software utilised for data analysis were presented. In order to attain the research objectives, three main methodological approaches were described. They included questionnaires and field observation for data collection and analysis of socio-economics and biophysical issues of the Park; application of GIS-based methods for prediction and analysis of land use changes as well as establishment of four buffer zone scenarios; and Multi Criteria Decision Making (MCDM) for the analysis of management options in an attempt to resolve people-park conflict in KSNP. Data collected and the results of the socio-economics analysis are presented in the following chapter.

CHAPTER FOUR
SURVEY RESULTS AND ANALYSIS

4.1. Introduction

Sustainable park management in a densely populated area such as in Kerinci Seblat National Park can only be successfully implemented if attempts are made to involve relevant stakeholder groups at every stage. Understanding needs and characteristics of the surrounding people is necessary as a background information for people-park conflict resolution and sustainable park management.

Three questionnaire survey modules (Appendix 1) were undertaken to assess the characteristics of household respondents. Interviews were carried out with encroacher and non encroacher respondents as described in Chapter three (Research Methods). These included surveys on: (1) household composition, farming and encroachment systems as well as their participation in the Park management programme; (2) perceptions on cinnamon plantations which are assumed as driving factors for encroaching the Park; and (3) attitude on the present park management system. The survey data were analysed using the EXCEL and SPSS computer packages and where necessary statistical analyses such as the Pearson correlation and the Chi-square (χ^2) test were applied.

This chapter presents the survey results and a discussion on the above subjects including encroachment systems encountered in Kerinci Seblat National Park, characteristics of respondent households, respondents' opinions on cinnamon plantation and their perception of the Park management. The results were then compared with those of previous surveys in other protected areas around the world. The degree of population pressure on the Park (Park Pressure Index) was also investigated. The findings in this chapter serve as a fundamental data base for further analysis in the subsequent chapters on conflict resolution and decision making for sustainable park management.

4.2. Encroachment in KSNP

Encroachment of the Park lands is one of direct results of inadequate planning to integrate the sustainable park management with the regional community development. At present, encroachment for agriculture especially cinnamon cultivation is a major problem around the Kerinci valley and is spreading to other parts of the Park. Therefore, it is a major issue for the Park integrity management.

Based on the field observation as well as the discussion with the Park authority and people surrounding the Park, the historical background of encroachment, possible conflict of interest, encroachers categories and encroachment system in the Park are briefly described in the following sections. These are the contextual background assessed from informal sources. Information was collected during the group discussion with the villagers, interviews with the Park staff, informal leaders of the society (*kepala adat*) and the heads of villages as key persons in Sumurup, Plompek and Muara Hemat between May-August 1995. Field observation was carried out to ascertain the end result of encroachment in KSNP.

4.2.1. Historical background

Forest encroachment in this area was initiated a long time before the first constituent parts of KSNP were legally established in 1920s. The land belonged to a number of clans of the indigenous people. At the time of the Japanese occupation, people moved into the deep forest to escape becoming conscripted labour and developed farms and settlements in many places within the forest such as Renah Pemetik village.

The peak of the encroachment movement by surrounding communities, however, started after 1970s when the cinnamon price was high and the head of the District, as narrated by many encroachers, stimulated people to increase cinnamon production using forest land. Therefore, people perceived that encroachment for cinnamon and for subsistence needs was legally permitted. Since then, local people have been dependent on successful field cropping in the Park for their livelihood and have fulfilled many of their necessities such as timber, firewood, fruits, etc. within the Park.

4.2.2. Conflict of interest

After the Park designation, the Park administrator was committed to effective wildlife and resource conservation and restricted people's access to the Park resources. The Park boundary was established and many encroachers were displaced from their settlements in the Park. Since 1988, about 2018 households have been resettled (KSNP, 1995). Some encroachers perceived that establishing the Park has created problems because the farm expansion has been prohibited. Therefore, they lost the opportunity to extent their agricultural lands. In addition, the status of their farms are ambiguous (Section 4.3). Therefore, there is apparent conflict between local people to fulfil their subsistence needs and the Park management for biodiversity conservation.

4.2.3. Categories of encroachers

There are different types of encroachers operating in the Park. They can be differentiated according to their objectives, the social class of the people, the crops they cultivated, the location they choose, the residential time etc. Based on the encroachers' social class, encroachers operating in Kerinci Seblat National Park can be classified into six categories:

1) Wealthy people as the landlords (*induk semang*) are influential and well established people, including civil servants. Most of them are native to the area, therefore feel justified to convert the forest into farm land. They finance farm

worker/sharecroppers (*anak ladang*) to clear forest and plant it with annual crops and cinnamon. The workers receive a monthly wage, food and 50 percent of the annual crop value after harvest. For the cinnamon, they receive one third of the proceeds from cinnamon during the cultivation period and at the final harvest. Some landlords also purchase young cinnamon plantations (1-2 years).

2) Local people who live outside the Park but enter it in order to develop plantations ranging in size from 4-100 ha in multi- plots and sites. The trees are progressively felled as they mature and after one or two coppice crops, the soil is abandoned and the farmer claims ownership of the abandoned plot.

3) People who live inside the Park do not own a house or farm outside and have lived in the settlements for many years such as in Renah Pemetik. They develop settlements and rice fields in low lying areas next to the streams, while cash crops and non rice food crops are planted on upland plots. Some of these settlements have been officially registered as enclaves within the Park and have village status.

4) Newcomers from outside the Park, mainly young couples. They clear the Park forests, make temporary houses and plant cinnamon with cash crops. They came from various places, villages nearby as well as from other provinces and islands. Those from the area itself stay in the simple huts for several weeks and then return to their families. And for those who came from other provinces, they remain in the farm taking care of plantations for several years then sell the land and young cinnamon to get capital for developing new plots.

5) Farm workers who work for the landlords (*tuan tanah*) and others. They clear the Park forest for the wage of their labour. The wage is relatively low and only sufficient for the daily subsistence needs. Therefore they do not develop their own farm due to inadequate initial capital for crops and cinnamon plantation.

6) Shifting cultivators who live as nomads in the Park. They slash and burn the Park forest for cash crops. They make temporary houses on their farms and abandoned the plots after the soil is no more productive. The number of these encroacher types is now very few and they are only found in the deep of the Park.

It cannot be assumed that the same policy aimed at encroachment problems would be suitable for each of these categories. Each type of encroachment may require different solutions such as stricter enforcement against category (1) and (2), disincentives for category (4), alternative income generating opportunities for the category (3) and (5), and permanent settlement through a transmigration system for category (6).

4.2.4. Pattern of encroachment

Field observation in the Park between May - August 1995 suggested that there were three different patterns of encroachment in KSNP related to the end result of their activities as shown in Figure 4.1.

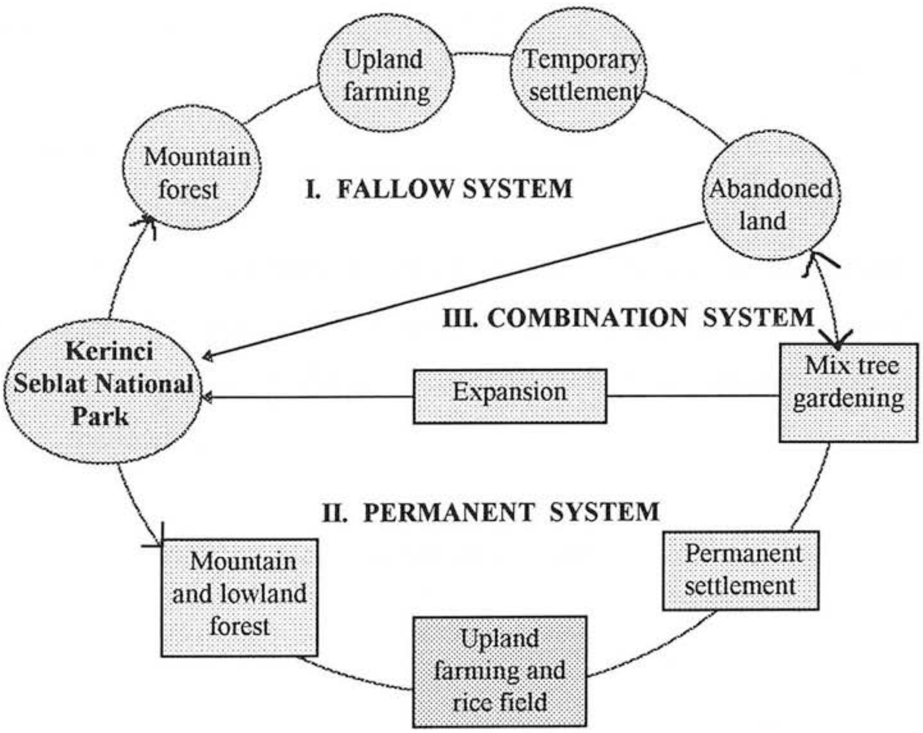


Figure 4.1. The cycle of encroachment system in Kerinci Seblat National Park

1) Fallow system

This system is operated by shifting cultivators. They open virgin forest by slash and burn. This leads to the loss of soil fertility for farming and eventually the land is abandoned as bare land. This condition is usually situated in the mountainous/hilly areas with steep slopes.

After several years of fallowing the soil fertility of abandoned land improves and encroachers return to this land for cash crops for a second period during which they grow cash crops. They then leave it again when the soil fertility has declined usually after 3 years.

2) Permanent system

The second pattern is that encroachment leads to a mix of gardening with permanent agriculture. This type is usually situated in low lying areas and is the most common type found in KSNP. While waiting for the harvesting period, encroachers expand their farms by cutting the forest in the Park.

3) Combination system

This system is the combination between the first and the second systems. Instead of fallowing, encroachers plant perennial crops in their abandoned land and claim ownership of the plot. At the same time they develop permanent settlement and rice fields in the lowland areas.

4.3. Characteristics of Respondent Households

The characteristics of respondent households were assessed based on this survey using the questionnaire in Module I (Appendix 1). It includes question on household composition, farming condition, respondent participation in the Park programme and the use of the Park resources. The survey results are described in the following sections.

4.3.1. Household composition

Table 4.1 represent respondents' composition, classified into encroachers and non encroacher households, in gender, age classification, marital status, education level, ethnic group, number of family members, occupation, understanding of the Park's management objectives and respondents annual income level. The summary of some characteristics of the respondents is also shown in Figure 4.2.

4.3.1.1. Gender, age, marital status and education

Of the total sampled households (250 respondents), 56 % were enroachers and 44 % were non encroacher households. Most respondents (88.4 %) were males and only 11.6 % were females. This was because the household selection as well as the survey interview were based on the head of the family as a decision maker. Interviews were carried out with the females when they were the head of the households (widow) or when their husbands were not around. In this case, they were considered as female respondents.

The age of respondents varied from 19 to 75 years old with an average of 43 years. More than 60.7 % of encroachers and 52.7 % of non encroacher respondents were between 30-49 years old. A majority of 229 respondents representing 91.6 % were married, and only 2 % and 6.4 % were unmarried or widowed respectively.

In terms of education level, about 30 % of both encroacher and non encroacher respondents were illiterates or had no formal schooling, and 42.8 % had received education up to primary school level. However there were huge drop outs by the time they reached high school level. Encroachers with a graduate level of education comprises 2.4 % of the sample.

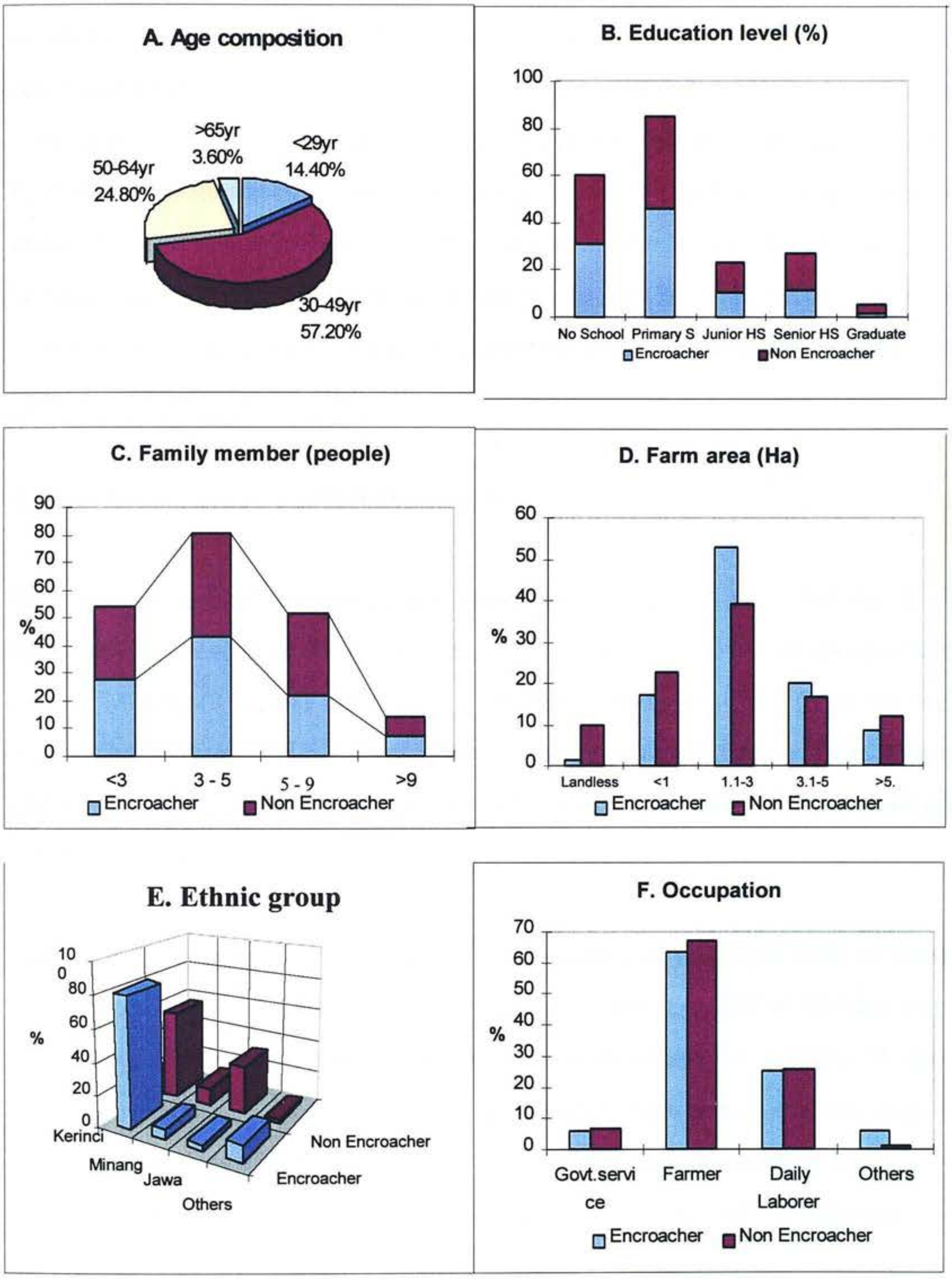


Figure 4.2. Summary of some characteristics of respondent (encroacher and non encroacher) households in KSNP (A: Age composition, B: Education level, C: Family member, D: Farm area, E: Ethnic group and F: Occupation).

There was no significant different in the education level of encroacher and non encroacher respondents (χ^2 = 2.90816; P value = 0.57331). This suggests that education level was not an important factor influencing encroachment in the Park. This finding was relevant to the test result of the respondents' understandings of the Park management objectives and issues which shows no significant different between encroacher and non encroacher (χ^2 = 0.13530; P value = 0.93459). Therefore, it can be suggested that even though some people have a high level of education as well as a good understanding on the Park's management objectives, this does not mean that they will not encroach the Park.

4.3.1.2. Ethnic group and family member

Both encroacher and non encroacher respondents come not only from the Kerinci ethnic group (more than 70 %) but also from other regions such as Java/Sunda (10 %), Minang (8 %) and others (8 %). Most of them were farmers (65.2 %), 5.2 % were daily labourers and 5.7 % of the encroachers were from government services. The extent of their experience of cinnamon farming varied from < 1 year to 40 years with the average being 14 years.

The number of family members varied from 1 (single) to 16 people with an average of five members. About 40.4 % of the total respondents consisted of families with 4-5 members. There was no significant different in family size (χ^2= 1.71924, P value = 0.78722) and occupation (χ^2 =4.1287, P=0.24790) between encroacher and non encroacher households. Therefore, each household in the surrounding Park has the same potential to encroach KSNP regardless of their number of dependant and occupation.

4.3.1.3. Income level

Table 4.1 shows that 64 % of respondents had a low income level (< Rp 750,000 per annum), however, most had an income above the national poverty line (annual income = Rp 264,324 BPS, 1994), 28 % of the respondents were in the middle income strata (Rp 750,000 to Rp 1,25,000 per annum) and only 8 % of the total respondents are at high income level (> Rp 1,250,000 per year). There was no significant different in annual income level between encroacher and non encroacher households (χ^2 = 5.94547, P value = 0.20326). Therefore, income level was not a limiting factor for people surrounding the Park to encroach KSNP.

Table 4.1. Summary of respondents' characteristics by farming status and the Chi-square P value for each factor

Variable	Encroacher	Non Encroacher	Total	
	A; (B); C	A; (B); C	A; (B)	P for χ^2
Gender :				
Male	86.4; (121); 54.8	90.9; (100); 45.2	88.4; (221)	0.27214
Female	13.6; (19); 65.5	9.1; (10); 34.5	11.6; (29)	
Age (yr):				
< 29	15.7; (22); 61.1	12.7; (14); 38.9	14.4; (36)	
30-49	60.7; (85); 59.4	52.7; (58); 40.6	57.2; (143)	0.22105
50-64	21.4; (30); 48.4	29.1; (32); 51.6	24.8; (62)	
> 65	2.2; (3); 33.3	5.5; (6); 66.7	3.6; (9)	
Marital status:				
Married	93.6; (131); 57.2	89.1; (98); 42.8	91.6; (229)	
Unmarried	2.1; (3); 60.0	1.8; (2); 40.0	2.0; (5)	0.30272
Widow	4.3; (6); 37.5	9.1; (10); 62.5	6.4; (16)	
Education level:				
No formal school	30.7; (43); 57.3	29.1; (32); 42.7	30.0; (75)	
Primary School	45.7; (64); 51.7	39.1; (43); 40.2	42.8;(107)	
Junior High School	10.8; (15); 51.7	12.7; (14); 48.3	11.6; (29)	0.57331
Senior High School	11.4; (16); 48.5	15.5; (17); 51.5	13.2; (33)	
Graduate	1.4; (2); 33.3	3.6; (4); 66.7	2.4; (6)	
Ethnic group:				
Kerinci	75.7; (106); 57.3	71.8; (79); 42.7	74.0; (185)	
Minang	8.6; (12); 60.0	7.3; (8); 40.0	8.0; (20)	0.17022
Java/Sunda	6.4; (9); 36.0	14.5; (16); 64.0	10.0; (25)	
Others	9.3; (13); 65.0	6.4; (7); 35.0	8.0; (20)	

Table 4.1. Continued

Family member:				
< 3	27.9; (39); 57.4	26.4; (29); 42.6	27.2; (68)	
4-5	42.9; (60); 59.4	37.3; (41); 40.6	40.4;(101)	0.78722
6-8	22.1; (31); 49.2	29.1; (32); 50.8	25.2; (3)	
9-10	4.3; (6); 54.5	4.5; (5); 45.5	4.4; (11)	
> 11	2.8; (4); 57.1	2.7; (3); 42.9	2.8; (7)	
Occupation:				
Govt. service	5.7; (8); 53.3	6.4; (7); 46.7	6.0; (15)	
Farmer	63.6; (89); 54.6	67.3; (74); 45.4	65.2;(163)	0.24790
Daily labourer	25.0; (35); 55.6	25.4; (28); 44.4	25.2;(63)	
Others	5.7; (8); 88.9	0.9; (1); 11.1	3.6;(9)	
Understanding on the	Park's issues:			
Good	27.6; (37); 54.4	28.4; (31); 45.6	28.0; (68)	
Fair	22.4; (30);53.6	23.9; (26); 46.4	23.0; (56)	0.93459
Poor	50.0; (67); 56.3	47.7; (52); 43.7	49.0; (119)	
Income/yr (xRp1000)				
<500	36.6; (55); 56.1	39.8; (43); 43.9	39.7; (98)	
500-750	28.8; (40); 66.7	8.5; (20); 33.3	24.3; (60)	
750-1,000	13.7; (19); 50.0	17.6; (19); 50.0	15.4; (38)	0.20326
1,000-1,250	9.3; (13); 41.9	16.7; (18); 58.1	12.6; (31)	
>1,250	8.6; (12); 60.0	37.4; (8); 40.0	8.0; (20)	

Where:
A: % respondent of total sub column
B: The number of respondent
C: % respondent of total row

Overall, there was no significant different in any household factors between encroacher and non encroacher. This suggests that the activity of encroaching the Park is not influenced by the above household factors. Therefore, each household in the surrounding Park has the same potential to encroach the Park, regardless of their social status, class and position.

4.3.2. Farming condition

Table 4.2 represents respondents' farming situations, classified into encroacher and non-encroacher households, including farm ownership, farm location related to the Park, the number and the area of farm and the area of rice field owned by respondents.

4.3.2.1. Farm ownership, area and location

A majority of both encroacher and non encroacher households had their own farms even though most of them had not been legally designated. Some 85 % of encroachers and 69.1 % of non encroachers are land owners, 16.8 % of the total respondents were sharecroppers (including farm workers to the wealthy patron who share the crop value after harvest), and only 1.4 % of encroachers and 10 % of non encroachers were landless.

The farm area possessed by individual households varied from 0.25 ha to 42 ha with an average of 3.08 ha. A majority of 117 households representing 46.8 % of the total respondents had a farm area of between 1-3 ha. The largest farm (42 ha) located in the Park was owned by an encroacher household. There were 24.28 % (34 households) of encroacher respondents who owned 76 unit of farms outside the Park covering a total area of 78.05 ha or at the average of 2.29 ha per household. In total encroacher respondents had 158 unit of farms in the Park covering a total area of 375.40 ha, at an average ownership of 2.68 ha per household. Of the total area, the average farm ownership for encroacher was 3.24 ha per household. While non encroacher respondents owned 187 unit farms outside the Park covering an area of 288.60 ha, at the average of 2.83 ha per household. There was a significant difference in farm area between encroacher and non encroacher (P value = 0.01003)

The number of farms owned by each respondent varied from one unit to 9 units. Some 39.4 % of the total respondents (98 households) owned one unit of farmland,

Table 4.2. The characteristic of respondents' farming and the Chi-square P value for each factor

Variable	Encroacher	Non Encroacher	Total	
	A; (B); C	A; (B); C	A; (B)	P for χ^2
Farm ownership:				
Owner	85.0; (119); 61.4	69.1; (76); 38.6	78.0; (195)	0.04043*
Sharecropper	13.6; (19); 45.2	20.9; (23); 54.8	16.8; (42)	
Landless	1.4; (2); 15.4	10.0; (11); 84.6	5.2; (13)	
Farm area (ha):				
0 ha	1.4; (2); 15.4	10.0; (11); 84.6	5.2; (13)	
<= 1 ha	17.1; (24); 48.9	22.7; (25); 51.1	19.6; (49)	
1.1 - 3 ha	52.9; (74); 63.2	39.1; (43); 36.8	46.8; (117)	0.01003**
3.1 - 5 ha	20.0; (28); 60.9	16.4; (18); 39.1	18.4; (46)	
> 5.1 ha	8.6; (12); 48.0	11.8; (13); 52	10.0; (25)	
Farm number:				
0	1.4; (2); 15.4	9.1; (11); 84.6	5.2; (13)	
1	41.4; (57); 58.2	37.3; (41); 41.8	39.4; (98)	
2	39.9; (55); 60.4	32.7; (36); 39.6	36.5; (91)	0.05347
3	15.2; (21); 58.3	13.6; (15); 41.7	14.5; (36)	
4	1.4; (2); 22.2	6.4; (7); 77.8	3.6; (9)	
>=5	0.7; (1); 50.5	0.9; (1); 50.0	0.8; (2)	
Rice field (ha)				
0 (No rice field)	39.6; (55); 56.1	39.1; (43); 43.9	39.4; (98)	
0.1-0.5	38.1; (53); 54.1	40.9; (45); 45.9	39.4; (98)	
0.5 - 1.0	12.2; (17); 58.6	10.9; (12); 41.4	11.6; (29)	0.98640
1.0 - 1.5	5.0; (7); 63.6	3.6; (4); 36.4	4.4; (11)	
1.5 - 2.0	2.2; (3); 60.0	1.8; (2); 40.0	2.0; (5)	
>2.0	2.9; (4); 50.0	3.7; (4); 50.0	3.2; (8)	

Note : * ,** and ***: Statistically significant at 0.05, 0.01 and 0.001 significant level respectively

A: % respondent of total sub column

B: The number of respondent

C: % respondent of total row

60 % (127 households) possessed 2-3 units and only 4.4 % (11 households) held more than 4 units. The average number of farm unit ownership for encroachers was 1.67 unit consisted of 1.14 unit in the Park and 1.7 unit outside the Park. Similarly, non encroacher respondents also had an average ownership number of farm units of 1.7. Therefore, there was no significant different in the number of farm ownership between encroacher and non encroacher (P value = 0.05347).

In summary, the total farms owned by all respondents amounted to 421 units covering an area of 742.05 ha, of which 234 units (55.6 %) comprising 453.45 ha (61.1 %) are possessed by encroacher respondents. From the total encroachers' farms, 158 units (67.5 %) covering an area of 375.40 ha (82.8 %) are located in the Park and 76 units comprising only 78.05 ha are situated outside the Park.

4.3.2.2. Farm expansion

A majority of 62.3 % encroacher respondents were planning to extend their farms, whereas only 23.3 % of non encroacher had the same plan. The reason for extension of farms varied including increasing income level (67.4 %), the existing farm is no more productive (9.5 %) and in order to save for their families (23.1 %). Those who did not have expansion plans stated that they were too old (5.3 %), it was difficult to find new farm land (25.6 %), they were satisfied with the existing farm and job (15.6 %), it was prohibited by the Park authority (34.1 %), they planned to find another job (6.2 %) and others (13.2 %).

4.3.2.3. New farm selection

Respondents stated that six factors were important when finding a new farm site. These were proximity to the settlement, proximity to road and river, proximity to the existing farm, soil fertility, crop security and site slope steepness (Figure 4.3).

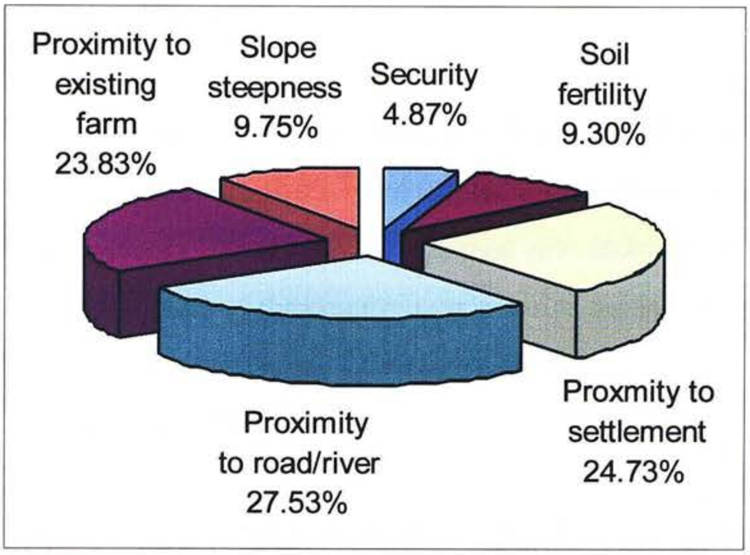


Figure 4.3. Frequency of reasons for the site selection

Figure 4.3 shows that proximity to settlement, road and river as well as the existing farm were the factors given by most respondents when choosing a new farm site. Therefore, these factors were taken into consideration for the developing model and prediction of the future encroachment in the next chapters.

4.3.2.4. Farm distance

The distance of respondents' farms from their permanent houses varied from 0 km to 80 km with an average of 8.30 km. About 50 % of the total respondents' farms were located within 5 km of their permanent houses. Farmers need to work for several consecutive weeks in their farms during the peak season of planting, weeding and harvesting. Therefore, even though prohibited by the Park authority, 28.6 % of encroachers established temporary houses on their farms for shelter in order to reduce time and cost of transportation. There was no significant difference in the need of temporary house on the farm between encroacher and non encroacher ($\chi^2 = 0.77212$; P value = 0.37956).

4.3.2.5. Rice field ownership

Besides farmlands (ladang), some respondents also had rice fields (*sawah*) inherited from their forefathers. Most rice fields were relatively small in area compared to the number of family members. Therefore, the common rule (*adat*) that applied in this area was not as in other parts of the country in which rice fields was not divided into pieces for all children. Rice fields were usually possessed by groups of family with take and turn management system.

Most of rice fields were located outside the Park. Rice field extension in this enclave area is very difficult. Therefore, most respondents had a limited area of rice field in the District. Table 4.2 shows that 39.4 % of the total respondents did not have any rice field and 39.4 % others owned between 0.1 to 0.5 ha of rice field. There was no significant different in rice field area owned by encroacher and non encroacher (P value = 0.98640). This provides an indication that encroaching the Park was independent of the availability and possession of rice fields.

It can be summarised from the overall Chi-square test analysis as shown in Table 4.2 that there were significant differences in farm ownership and farm area between encroacher and non encroacher households. Encroacher households in the surrounding park had the potential to extend their farms on the Park regardless the area of rice field possessed. The findings on characteristics of respondents' farming are of importance as a data base for the decision making and the model development of the future encroachment in the Park, as well as for buffer zones planning.

4.3.3. Respondents' participation

According to Batisse (1982) national parks cannot be managed successfully without taking into account local peoples participation. Therefore, understanding the level of their participation in the Park management programme as well as their dependency on the Park resources is of importance in devising a plan and policy for people-park conflict resolution.

There are two main programmes currently launched by the Park authority to solve encroachment problems that require peoples participation: transmigration and multi-purposes tree species (MPTS). The latter is aimed at increasing encroacher's income and gradually replacing cinnamon trees in the Park with other fruit producing species. Therefore the new species will be preventing of soil erosion, because the trees will not be cut down, as in the case for cinnamon.

Most respondents (85.6 %) stated that they were not involved in the Park management in any stages from planning, actuating to monitoring activities, 8.7 % asserted their involvement and others were either not sure or refused to answer. The willingness of respondents to participate in the transmigration programme co-ordinated by the Park authority is shown in Figure 4.4.

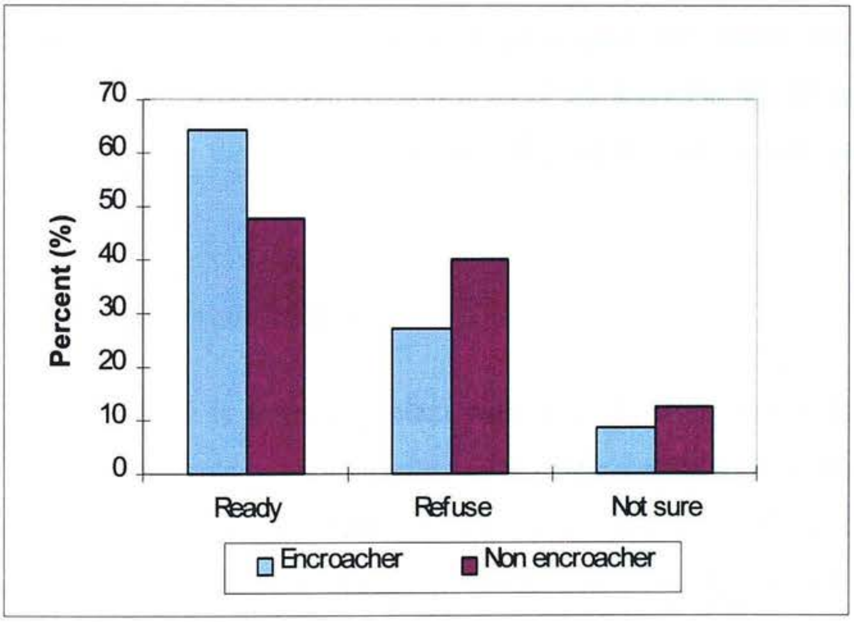


Figure 4. 4. Stated willingness of respondents to participate in transmigration program

The reasons that most of respondents stated their willingness to participate in the transmigration program varied from having farmlands for free (22.2 %), the targeted location is not too far from Kerinci (14.1 %), getting a better life (49.4 %) to just to have an experience and would be back if they were not satisfied with the new home (14.3 %). Those who refused to participate expressed that they were not sure they would have a better life in the new home (60.2 %) due to the fact that some previous transmigrated peoples left their new homes and returned to Kerinci (15.3 %), getting old (6.7 %) and they had settled in Kerinci (17.8 %). There was a significant difference in willingness to participate in the transmigration programme between encroacher and non encroacher ($\chi^2 = 18.31879$; P value = 0.00011).

A majority of 53.2 % respondent were not aware of the MPTS programme launched by the Park authority. Some respondents (35.4 %) stated that MPTS aimed to ban cinnamon cultivation in the Park, 8.9 % asserted it was to replace farmers' cinnamon and only 2.5 % respondents agree that the MPTS would be able to increase farmers' income level. Therefore, a number of respondents (44.7 %) had or would reluctantly join the programme, 25.4 % did not want to participate and others are unsure or afraid of expressing their opinions. The low level of participation on this programme might be influenced by their good perception of cinnamon cultivation (see Section 4.4.).

4.4. Attitude Towards the Cinnamon

The fact that cinnamon is the major plant cultivated in most encroachment areas indicates its important role for the people surrounding the Park. It is hypothesised that encroachment in the Park is related to the people's perception of the value of the cinnamon plantation. Therefore, based on the questionnaire in Module III, their perception on economic, socio-cultural and technical aspects of cinnamon plantation were assessed in this survey. Classification of respondent's perceptions was based on the number of positive and negative answers given in response to survey questions as shown in the categorisation of perception in Appendix 1.

4.4.1. Perceptions of economic aspects of cinnamon

It can be seen in Table 4.3. that the majority of the respondents (82.8 %) have a positive perception about the economic value of cinnamon and only 17.2 % showed neutral, negative or very negative attitudes. Most of them (81.6 %) believe that investment in cinnamon cultivation is more beneficial than that in other opportunities. This is because its maintenance cost is low (99.2 % agree), the price is relatively stable (83.6 % agree), technically viable (92.0 % agree) with low level of risk (85.6 % agree) and environmentally suitable (93.6 % agree).

Table 4. 3. Respondents attitudes towards cinnamon plantation (% each category)

Aspects of cinnamon	Respondent perception (%)						
	Very positive	Positive	Neutral	Nega-tive	Very negative	χ^2	P
A. Economic							
Encroacher	57.9	35.0	0	7.1	0	30.21157	<0.0001
Non encroacher	35.5	34.5	8.2	16.4	5.5		***
Respondents	48.0	34.8	3.6	11.2	2.4		
B. Socio-cultural							
Encroacher	59.3	27.9	1.4	4.3	7.1	20.91767	0.00033
Non encroacher	37.3	31.8	10.9	11.8	8.2		***
Respondents	49.6	29.6	5.6	7.6	7.6		
C. Technical							
Encroacher	92.9	7.1	0	0	0	14.79475	0.00012
Non encroacher	75.5	24.5	0	0	0		***
Respondents	85.2	14.8	0	0	0		

Where: *** statistically significant at 0.001 significant level

Both encroachers and non encroachers have a positive attitude on the economic value of cinnamon. The percentage of positive and very positive attitude for encroachers' respondents, however, is much higher (92.9 %) compared to that of non encroachers' (70 %). There was a significant difference in perception towards the economic value of cinnamon between encroacher and non encroacher (χ^2 =30.21157; P<0.0001). The results may explain why encroachment on the Park has been increasing for many recent years.

4.4.2. Perception on socio-cultural aspect of cinnamon

Cinnamon seems to be part of the social and cultural background of Kerinci people. Most respondents stated that cinnamon cultivation had been part of a traditional farming enterprise for decades, and it was sustainable for the future (85.6 % agree). They believed (75.8 %) that any effort to convert cinnamon plantation to other species of plants would deprive Kerinci of the trade mark of being the biggest cinnamon producers in Indonesia. They also believed that cinnamon is a symbol of wealth (86.8 % agree) and honour (57.6 % agree). In some places, ownership of a cinnamon plantation is a prerequisite for a man to gain a marriage arrangement.

Table 4.3 shows that from the social and cultural point of view, 79.2 % of the total respondents considered cinnamon plantations to be positive and very positive and only 20.8 % showed neutral, negative or very negative attitudes. As for the economic aspects of cinnamon, the percentage of positive and very positive attitude for encroachers' respondents on the socio-cultural aspects of cinnamon was also much higher (87.2 %) compared to that of non encroachers' perception (69.1 %). There was significant different in attitude towards socio-economic aspects of cinnamon between encroacher and non encroacher (χ^2 =20.91767; P<0.00033). Even though both respondent types had a positive view socio-culturally view of cinnamon, the degree of appreciation is some what different.

4.4.3. Perceptions of technical aspects of cinnamon

There are no technical problems for Kerinci people in cultivating cinnamon because the area is environmentally suitable for the cinnamon growing (Perbatakusuma *et al.*, 1993). With the relatively fertile soil in the Park areas, cinnamon can easily grow without additional fertiliser. Almost all respondents agreed that cinnamon was technically viable (92.0 % agree) for the Kerinci District with a low level of risk (85.6 % agree) and that the environment was suitable (93.6 % agree).

Other technical advantages of cinnamon plantation are that its cultivation as well as maintenance is easy, it can be mixed with other crops to meet farmer's subsistence needs and it can be sold quickly in the village level. Therefore, from the technical point of view, all respondents gave a positive and very positive perception for the cinnamon plantation. There was a significant difference in perception of the technical aspects of cinnamon between encroacher and non encroacher (χ^2 =14.79475; P<0.00012).

4.5. Cinnamon Marketing System

Based on the questionnaire data analysis as well as interviews with the traders in the village level and wholesalers in the District, cinnamon marketing system in Kerinci District can be summarised as shown in Figure 4.5.

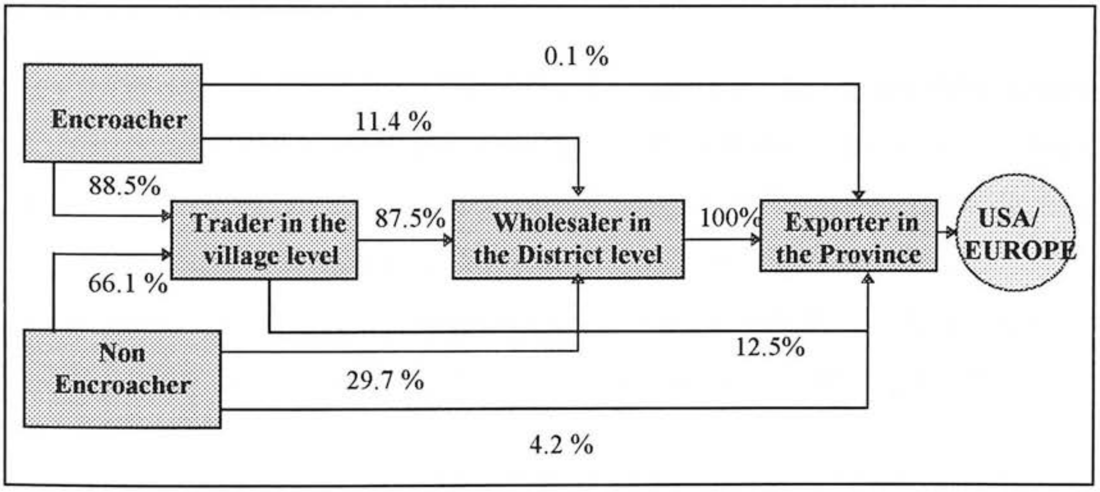


Figure 4.5. Cinnamon marketing system in Kerinci District

Figure 4.5 shows that a majority of encroachers (88.5 %) and non encroachers (66.1 %) sold their cinnamon in the traditional market to traders at the village level.

Sometimes, traders came to villages and farmers sold cinnamon from their houses or even directly from the standing stock in the field. Only a few encroacher (11.4 %) and non encroachers (29.7 %) marketed their cinnamon to wholesalers at the District level. It was very rare for encroachers or non encroachers to sell their cinnamon directly to an exporter at the province level in Padang or Jambi, with 0.1 % and 4.2 % doing this respectively. Cutting down marketing channels directly to the wholesalers or exporters would increase farmers' income level from cinnamon production. However, understanding of such a marketing system as well as transportation cost would be the main problem in carrying out this system.

Most traders in the village level (87.5 %) marketed their cinnamon to wholesalers in the District and only 12.5 % of them marketed directly to exporters in the Province. Wholesalers seem to have difficulty in exporting cinnamon due to the lack of marketing channels abroad. Therefore, all of them brought their cinnamon commodity to exporters. In addition, some wholesalers in fact belong to exporters in the Province.

4.6. Factors Influencing Intrusion to the Park

From the above analysis, it can be surmised that there were significant differences in the perception of economic, socio-cultural and technical aspects of cinnamon between encroacher and non encroacher respondents. Therefore, these findings support the hypothesis that encroachment in the Park is related to the peoples' perception of the value of the cinnamon plantation. Chi-square analyses on other respondents' factors influencing encroachment to the Park are shown in Table 4.4.

Table 4.4 shows that only two factors demonstrate significant difference between encroacher and non encroacher households: cinnamon perception and shortage of land. While other factors such as age, education, occupation, gender and level of income are not significant. Therefore, these two factors should be taken into consideration when trying to resolve people-park conflict in KSNP.

Table 4.4. The correlation between respondent factors and respondent status in relation to the Park intrusion

Factors	Encroacher (% ; No)	Non Encroacher (% ; No)	χ^2	Df	P
Age:					
< 29 yr	8.8 (22)	5.6 (14)			
30-49 yr	34.0 (85)	23.2 (58)	3.68	2	0.158
> 50 yr	13.2 (33)	15.2 (38)			
Education:					
No school	17.2 (43)	12.8 (32)			
Primary school	25.6 (64)	17.2 (43)	2.23	2	0.329
Secondary /higher	13.2 (33)	14.0 (35)			
Shortage of land:					
Yes	47.6 (118)	26.2 (65)			
No	8.9 (22)	17.3 (43)	18.31	1	<0.001***
Perception of cinnamon:					
Positive/neutral	52.0 (130)	34.4 (86)			
Negative	4.0 (10)	9.6 (24)	11.29	1	<0.001***
Occupation:					
Govt.service	3.2 (8)	2.8 (7)			
Farmer	35.6 (89)	29.6 (74)			
Daily labourer	14.0 (35)	11.2 (28)	4.12	3	0.248
Others	3.2 (8)	0.4 (1)			
Gender:					
Male	48.4 (121)	40.0 (100)			
Female	7.6 (19)	4.0 (10)	1.21	1	0.272
Income:					
Low	38.5 (95)	25.5 (63)			
Medium	13.0 (32)	15.0 (37)	3.81	2	0.149
High	4.9 (12)	3.2 (8)			

Where: *** statistically significant at 0.001 significant level

The relation between farmer's perception of cinnamon plantation and the decision for encroaching the Park can be summarised in the flow diagram of Figure 4.6.

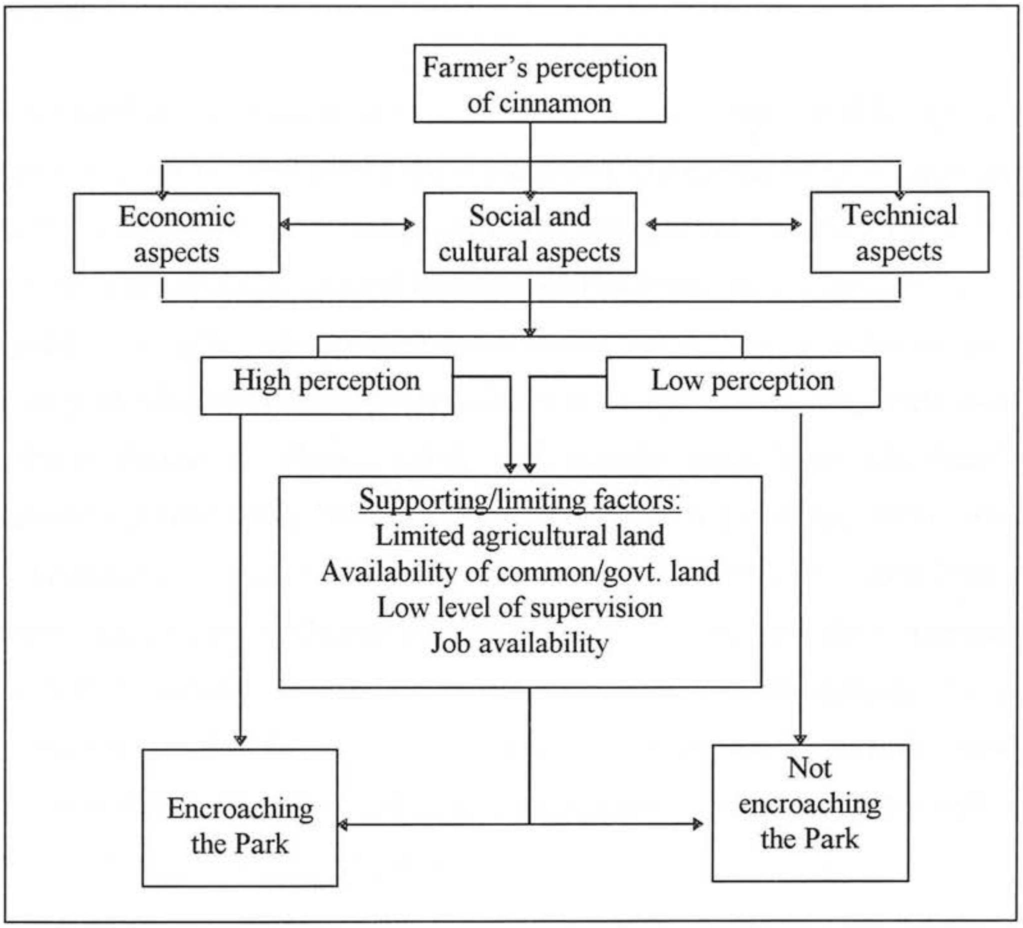


Figure 4. 6. The relation between farmers' perception of cinnamon plantation and the decision for encroaching the Park

As can be seen in Figure 4.6 the degree of farmers' perception of cinnamon is influenced by their opinions on interrelationship between economic, socio-cultural and technical aspects of cinnamon. A high perception of cinnamon supported by limited agricultural land, abundance of forest/common land with low level of supervision as well as limited job opportunity will lead to the farmer's decision to encroach the Park. While low level of perception of cinnamon with intensive supervision on the public lands by the authority, supported by the availability of alternative job opportunity in many sectors of development leads farmer's decision not to encroach the Park.

4.7. Attitude Towards the Park

4.7.1. Introduction

Since the publication of the World Conservation Strategy (Allen, 1980), approaches to park management have shifted from traditional approaches to more approaches which include local people in the planning and management of park areas to make them more acceptable to poor rural communities (Dasman, 1985). Attitudinal surveys give guidance to policy and management decisions, and act as a base line to test the effect of policy decisions. Such surveys have been incorporated in many areas such as agriculture (Reeve & Black, 1994), and recently have been introduced in conservation (Infield, 1988; Newmark *et al.* 1993; Fiallo & Jacobson, 1995). Meulen *et al.*, (1996) argued that in developing nature conservation policies at farm level not only environmental and ecological benefits and economic costs should be considered but farmers' knowledge, perceptions and preferences as well. In addition, Hooks *et al.*, (1983) stated that the process of adoption of innovative techniques, such as nature management regimes, apart from the economic aspects, behavioural and informational aspects are also important.

Therefore, if management of adjacent land use is to be approached with the same rigour as management inside park areas, then attitudes of local communities toward parks should be studied and their perceived needs and aspiration taken into account. Only in this way can people-park conflict be broken down.

Based on the questionnaire prepared in module II (Appendix 1), Respondents' attitudes toward KSNP were assessed, including their perception of the benefit of the Park (household level, community level and environmental aspects), perception of the way the Park authority managed encroachment problems as well as respondents' attitude to the Park management.

4.7.2. Perception of the benefit of the Park

Table 4.5 shows that 72.8 % respondents did not perceive any benefit of the Park on the household level as indicated by their unfavourable, negative and very negative, attitudes. This is possibly because after the Park establishment they had difficulty in expanding their farms (78.2 % agree) leading to the difficulty of their life as expressed by the statement: 'The Park has created problems in my life' with 52.3 % of the respondents agreeing. In addition, the ambiguous status and right of their farms is also one of their concerns. All of these problems have discouraged them from working hard in managing their farm, as expressed by 63.3 % respondents.

Table 4.5. Perception of the benefit of the Park by respondent status

Benefit of the park on:	Perception category (%)						
	Very Positive	Positive	Neutral	Negative	Very Negative	χ^2	P
A. Household level							
Encroacher	3.6	7.1	20.7	49.3	19.3		
Non encroacher	2.7	6.4	12.7	51.6	21.2	3.3570	0.4999*
Respondents	3.2	6.8	17.2	51.6	21.2		
B. Community level							
Encroacher	17.1	32.1	17.9	31.4	1.4		
Non encroacher	8.2	30.9	15.5	36.4	9.1	11.969	0.0175**
Respondents	13.2	31.6	16.8	33.6	4.8		
C. Environment							
Encroacher	22.9	57.9	8.6	5.7	5.0		
Non encroacher	38.2	40.9	7.3	11.8	1.8	12.992	0.0113**
Respondents	29.6	50.4	8.0	8.4	3.5		

On the community level, most respondents perceived that establishing the Park has limited agricultural land as expressed to the statements: 'The Park is too big, therefore many people lack agricultural land' with 73.6 % of the respondents agreeing. Even though the Park does not provide valuable jobs for most people (80.8 % agree), their perception of the benefit of the Park on the community level is slightly better due to the beneficial impacts of tourism development program as stated by 57.2 % respondents.

Both encroachers and non encroachers showed high positive attitudes towards the role of the Park in preserving the environment, conserving biodiversity, decreasing the level of erosion and flooding accidents in Kerinci District as summarised in the benefit of the Park on the environment (Table 4.5).

4.7.3. Perception of the management of encroachment problems

The way the Park authority deals with encroachment problems might influence the attitudes of people towards the Park. To date, there are five main programmes launched by the Park authority to handle encroachment problems: transmigration, promoting MPTS programme to replace cinnamon with other species, establishing traditional use zones as buffer zones, boundary demarcation and law enforcement by burning farmers' temporary houses in the Park.

Most people (87.6 %) stated that transmigration program is for the benefit of encroachers, however its management was not well organised (60.8 % agree). In addition, 55.6 % of respondents agreed that buffer zone development as a traditional use zone was good if it ensured their farming security. However, 62 % of respondents did not agree on banning new cinnamon planting in their farms in the Park. Perhaps not surprisingly the multi-purpose tree species (MPTS) programme launched by the Park is only supported by 44.7 % of the respondents. Most people hope that heavy handed law enforcement will be avoided.

4.7.4. Attitudes towards KSNP concept

The results of this survey are shown in Table 4.6, and they reflect a balance between positive and negative attitude towards the Park because 53.6 % respondents showed very positive and positive perception to the Park and 46.4 % have negative, very negative or neutral perceptions. Non encroacher respondents, however, showed more favourable attitude (65.4%) toward the Park than encroachers (44.3%).

Table 4.6. Encroacher's and non encroacher's attitude towards national park concept (in % and figures in parentheses indicate the number of respondent)

Respondent Status	Very Positive	Positive	Neutral	Nega- tive	Very Negative	χ^2	P
Encroacher	29.2	15.0	14.3	23.6	17.9		
	(41)	(21)	(20)	(33)	(25)		
Non encroacher	40.9	24.5	14.5	12.7	7.3	14.426	0.00605
	(45)	(27)	(16)	(14)	(8)		***
Respondents	34.4	19.2	14.4	18.8	13.2		
	(86)	(48)	(36)	(47)	(33)		

Respondents expressed a great hope that the Park should not become 'an island' in the middle of needy people as revealed by 75.9 % of the respondents agreeing to the statement: 'A park should be integrated with regional development'. Almost half of respondents did not know the benefit of conserving the Park ecosystem for future generations as expressed by 48.2 % respondents who did not agree to the statement: 'Conserving the Park ecosystem is useful for our children'.

It is surprising that half of the encroacher respondents did not realise that encroachment is against the law as stated by 49 % respondents did not agree to the statement: 'Encroachment in the Park is a law breaker'. This is probably because they feel that the Park is a communal land given by their forefathers and supported by the historical background that encroachment was stimulated by the previous highest authority of the District before establishing the Park. Results of Chi square test on factors influencing peoples' attitude towards the Park are presented in Table 4.7.

Table 4.7. Factors influencing respondents' attitudes towards the Park

Factors	Positive/ neutral attitude (%, No)	Negative attitude (%, No)	χ^2	Df	P
Age:					
< 29 yr	9.6 (24)	4.8 (12)			
30-49 yr	40.8 (102)	16.4 (41)	1.94	2	0.378
> 50 yr	17.6 (44)	10.8 (27)			
Education level:					
No school	12.8 (32)	17.2 (43)			
Primary school	30.4 (76)	12.4 (31)	39.36	2	<0.001***
Secondary /higher	24.8 (62)	2.4 (6)			
Knowledge:					
Good/fair	43.9 (107)	8.6 (21)			
Poor	5.8 (63)	21.7 (53)	24.69	1	<0.001***
Shortage of land:					
Yes	42.4 (106)	30.4 (76)			
No	25.6 (64)	1.6 (4)	29.28	1	<0.001***
Encroachment management:					
Positive/neutral	52.4 (131)	19.2 (48)			
Negative	15.6 (39)	12.8 (32)	7.78	1	0.005**
Ethnic of origin:					
Kerinci	48.4 (122)	25.2 (63)			
Minang	5.6 (14)	2.4 (6)	3.05	3	0.384
Java	6.8 (17)	3.2 (8)			
Others	6.8 (17)	1.2 (3)			
Staff relationship:					
Good	14.4 (36)	1.6 (4)			
Fair	22.8 (57)	9.2 (2)	13.87	2	<0.001***
Poor	30.8 (77)	21.2 (53)			
Status:					
Encroacher	32.8 (82)	23.2 (58)			
Non encroacher	35.2 (88)	8.8 (22)	12.99	1	<0.001***
Income level:					
Low	42.9 (106)	21.1 (52)			
Medium	18.2 (45)	9.7 (24)	2.96	2	0.227
High	6.9 (1)	1.2 (3)			
Benefit of the Park:					
Positive/neutral	22.8 (57)	3.6 (9)			
Negative	45.2 (113)	28.4 (71)	13.89	1	<0.001***

Note : ** and ***: Statistically significant at 0.01 and 0.001 significant level respectively

Chi square analyses as shown in Table 4.7 revealed that the attitude toward the Park was significantly influenced by respondents' farming status (χ^2 =12.99; P<0.001), level of education (χ^2=39.36; P<0.001), knowledge of conservation issues as well as of the Park objectives (χ^2=24.69; P<0.001), shortage of agricultural land (χ^2 =29.28; P<0.001) and people-park staff relationship (χ^2 =13.87; P< 0.001). While age, tribe and income level were not significantly different.

4.7.5. Comparison of attitude towards parks with some other countries

A study by the IUCN (1984) on forty-three of the world's most threatened protected areas and by Machlis and Tichnell (1985) on 135 parks in more than 50 countries reported that human encroachment and local attitudes are amongst the most common threats to protected areas. Although it may be argued that quantifying attitudes is as subjective as any other method, representing peoples attitudes in a quantitative way makes it possible to compare similar attitudes toward park areas in different regions.

There are wide ranges of attitudes towards conservation areas around the world as shown in Table 4.8. Researchers found that their attitudes are site specific dependent on the conditions and problems faced such as education and knowledge (Fiallo and Jacobson, 1995; Infield, 1988), benefits gained from the Park (Brown, 1991; Heinen, 1993; and Lehmkuhl, 1988), shortage of land (Parry and Campbell, 1992), the relationship with park staff and wildlife problems (Newmark *et al.*, 1993; Studsrod, 1993).

The comparison of people's attitude on KSNP based on this study results and these reported by previous researchers' results in some other countries around the world is presented in Table 4.8.

Table 4.8: Factors influencing attitudes towards conservation and protected areas around the world

Factors	Indonesia TNKS	Ecuador[1]	Costa Rica[2]	Nepal[3]	South Africa[4]	Bots-wana[5]	Tanza-nia[6]
Age	ns	*	nr	nr	nr	nr	nr
Ethnic group	ns	nr	nr	*	nr	nr	nr
Education	*	ns	nr	ns	*	nr	*
Knowledge	*	*	nr	*	*	ns	a
Relationship with park staff	*	*	a	a	nr	nr	nr
Benefits	*	*	a	ns	a	a	*
Problems with wildlife	a	ns	nr	a	*	*	nr
Shortage of land	*	a	ns	nr	nr	*	*
Residence length	nr	a	nr	nr	a	a	*
Perception of poor management	nr	nr	nr	a	nr	nr	*
Farming status	*	nr	nr	nr	nr	nr	nr
Income	ns	nr	nr	nr	nr	nr	nr

Where:
* : Statistically significant ; ns : No significant effect
a : Anecdotal support ; nr : No report
[1]Fiallo & Jacobson, 1995; [2]Brown, 1991; [3]Heinen, 1993; [4]Infield,1988; [5]Parray & Campbell, 1992; [6]Newmark *et al.*,1993.

Table 4.8. shows that there are a great variety of factors influencing people attitude towards national park and protected areas. It is site specific depending on the conditions and problems faced by the surrounding people. However, some factors such as level of education, level of understanding on the Park's objective, perceived benefit from the Park, problems with wildlife and shortage of land seem to be general factors influencing people attitude to the Park in many countries.

4.8. Park Pressure Index

The Park Pressure Index (PPI) is an instrument to measure the people-park relationship especially the degree of people pressure on the Park, using equation (3.1) as presented in Chapter Three.

$$PPI = \frac{a\ Po\ Pt\ (1 + r)^{t}}{Lt} \qquad (3.1)$$

According to the Schneider's (1992) study result, the value of 'a' (minimum area of farming needed for one person to support a perceived adequate level of living) for Kerinci District is 2.1 hectare. The values of 'Po' (percentage of farmers in the total population) is 74 percent, 'Pt' (the total population in 1994) is 287,406 people and the value of 'r' (population growth rate) is 2.25 percent/year (BPS Kerinci, 1995). Based on the GIS analysis (Perbatakusuma *et al.*, 1993) the value of 'Lt' (total of productive land in 1994) is equal to 153,700 ha.

Therefore, the value of PPI (Park Pressure Index, the degree of population pressure on the Park) in 1995 is 2.97. It means that Kerinci Seblat National Park is now under pressure by the surrounding people. To lessen the people pressure back to the pressure limit, PPI = 1, if no management intervention is undertaken, an extension of 302,978 hectares of productive farm land is needed.

Using t value = 10, with the assumption that all factors are stable, the value of PPI is equal to 3.63. It means that without any management intervention an additional area of 404,230 hectares of productive land is needed up to the year of 2005 to maintain the people pressure on the Park in the normal situation. Therefore, in order to conserve both the Park biological diversity and KSNP integrity, promoting integrated management policy with the regional development as well as the policy to set aside suitable lands in the form of traditional use zones or buffer zones which can be utilised for the surrounding people are inevitable.

The expansion of agricultural farm in Kerinci District seems difficult to carry out, since the enclave directly abuts the KSNP boundary. Therefore, there are five choices to be considered in an attempt to raise income level of the local people and lessen the population pressure to the Park. They include intensification of the existing agricultural farms, reviving abandoned lands into productive lands, establishing buffer zones and traditional use zones across the Park boundary, income generating in a non agricultural basis and decreasing the population growth both through family planning and people displacement programmes out of the enclave areas.

4.9. Summary

Understanding patterns of encroachment system in KSNP, the socio-economic characteristics of respondent households and their attitude towards the Park and cinnamon is an important step in designing the Park management policies that aim at resolving people-park conflict.

Encroachment in KSNP is a complex system involving many parties, not only the local poor people but also those who are wealthy and who are coming from many other regions. This study results indicated that intrusion to the Park was influenced by the shortage of farm lands and people perception of cinnamon regardless of their income level, social status, class and position. Six factors have been considered by encroachers in selecting the new encroachment area. They included proximity to the existing farm, road, river and settlement, slope steepness and soil fertility. The study results showed that peoples' attitudes towards the Park were influenced not only by their internal factors such as level of education, knowledge of the Park's objectives, and farming status, but also by the external factors such as their past contacts with the Park staff and the benefits they personally received from the Park. Analysis on the degree of population pressure using PPI as a yard stick revealed that KSNP is now under a serious population pressure. The impacts of this pressure on the land use change of Kerinci are presented on the following chapter.

CHAPTER FIVE
LAND USE DYNAMICS

Land use dynamics in Kerinci District over the last 20 years have been dominated by the twin processes of encroachment and forest degradation. Encroachment expansion coupled with forest depletion are particularly controversial due to the great impacts on fragmentation in the Park leading towards the complexity of land-use dynamics in Kerinci District. These problems have been addressed by many researchers and organisations e.g. Perbatakusuma *et al.*, 1993; The World Bank, 1993; DHV, 1993; Ramdhani, 1997, unfortunately, though quantitative evaluation and documentation of land-use dynamics in this area has not been carried out.

This chapter presents quantitative analysis of land-use dynamics of the Kerinci District based on a GIS spatial analysis. It comprises of four main sections: (1) analysis of land-use dynamics between different land-use categories; (2) analysis of land-use dynamics in relation to slope and elevation; (3) analysis of land-use changes based on the land status both in the Park and in the enclave areas; and (4) analysis of impacts of boundary alteration on land-use compositions. Each of these is discussed in turn below.

5.1. Land-use Dynamics between different Land-use Types

5.1.1. Methods

IDRISI GIS software is capable of analysing land-use dynamics between different land-use types. In this study Pairwise comparison techniques were utilised to express the dynamics and changes between two dates of land use. While, overlay techniques, spatial crosstabulation and crossclassification modules were undertaken to discern quantitative information on possible combinations of land use changes in Kerinci District. The georeferenced land-use image (scale 1: 50,000) of 1982 as shown in

Figure 2.10 served as a starting point for this analysis since the Park was designated at that time, and the land use image of 1991 (scale 1: 25,000) shown in Figure 2.11 (Chapter Two) was utilised for the end period of analysis. This 10 year period is assumed to be sufficient to gauge the general trends of land use dynamics in the area.

Kerinci land-use was classified into 10 categories. These were sand stone, shrub, lake, forest, tea plantation, encroachment (*perladangan*), settlement, swamp, rice field and abandoned land. Maps of the main types of land use changes were produced based on the analysis procedure shown in Figure 5.1. To test the degree of association of each spatial land use for two different dates, a pairwise comparison analysis of Kappa Index Association (KIA) was carried out.

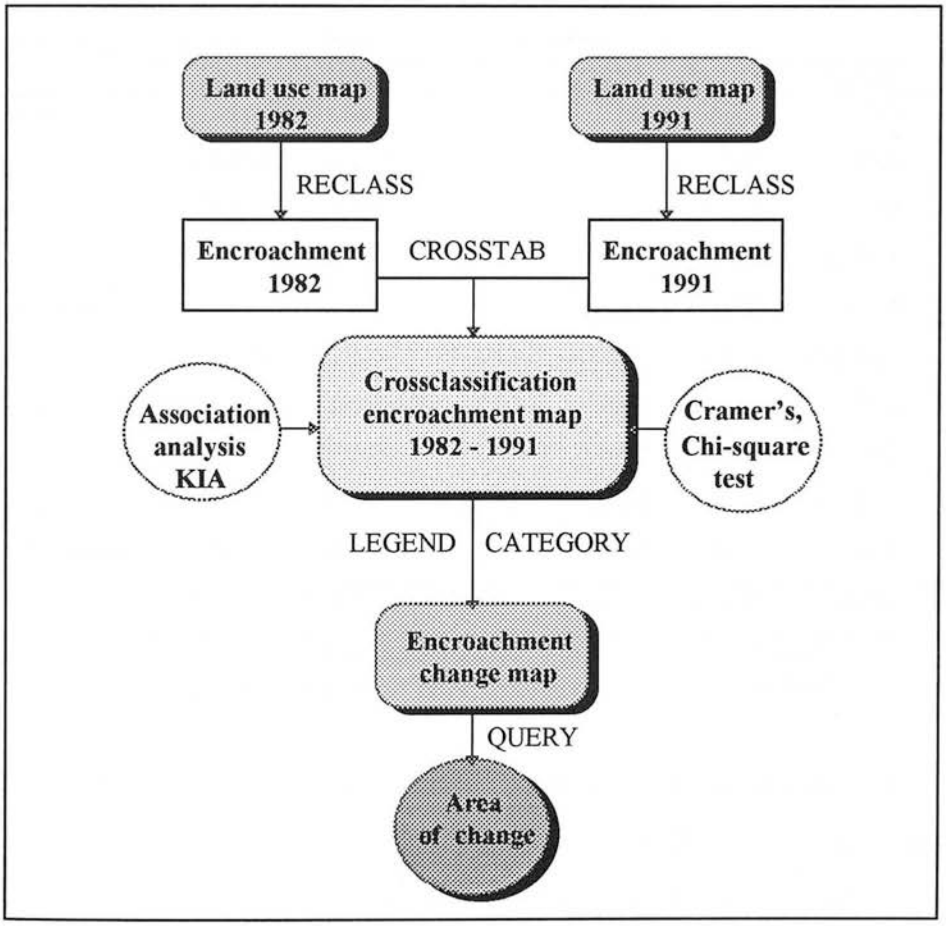


Figure 5.1. Analysis of Pairwise Comparison process for producing each type of land use change map 1982-1991 (e.g. encroachment change map).

5.1.2. Results

5.1.2.1. The rate of land use change

During the decade since the Park was designed in 1982, a total of 42,986 hectares (11.52 %) of Kerinci land has been converted from the original land use type in 1982 into other land uses in 1991 with the average conversion rate being equal to 4,299 hectares per year (1.15 % per year, Table 5.1). Both forest depletion and encroachment expansion have jointly been the greatest contributors (87.24 %) to the overall Kerinci land use dynamics.

Table 5.1. The rate of land use change in Kerinci District 1982-1991 based on images crosstabulation analysis

Land-use type	Area 1982	Area 1991	Land-use change (1982-1991)			Rate of change	
	(Ha)	(Ha)	(Ha)	(% LU)*	(%T)**	(Ha/yr)	(%/yr)
Sandstone	147	144	- 3	- 2.04	- 0.003	- 0.3	- 0.21
Shrub	12,394	6,348	- 6,046	- 48.78	- 7.03	- 604.6	- 4.87
Lake	5,179	5,186	+ 7	+ 0.14	+ 0.01	+ 0.7	+ 0.01
Forest	268,468	232,727	- 35,741	- 13.31	- 41.58	- 3,574.1	- 1.33
Tea plantation	3,250	3,325	+ 75	+ 2.31	0.08	+ 7.5	0.23
Encroachment	51,678	90,931	+ 39,253	+ 75.96	45.66	+3,925.3	7.59
Settlement	2,175	1,660	- 515	- 23.69	- 0.60	- 51.5	- 2.36
Swamp	3,270	3,273	- 3	- 0.09	- 0.003	- 0.3	- 0.09
Rice field	16,842	20,487	+ 3,645	+ 21.64	4.74	+ 364.5	2.16
Abandoned land	9,648	8,970	- 678	- 7.03	- 0.79	- 67.8	- 0.70
Total	373,051	373,051	42,986	11.52	100.00	4,299	1.15

Note: * : % change of the area of each land use type — - : decrease
** : % contribution of the total area of land use change — +: increase

Between 1982-1991 forest area decreased sharply by 35,741 hectares (13.31 %) at an average degradation rate of 3,574 hectares or 1.33 % per year. The forest depletion rate in Kerinci is 1.66 times greater than that of the National figure (0.8 % per year, WRI, 1990). It contributes about 0.4 % to the total annual national forest degradation (WRI, 1990 = 900,000 hectares/year; Whitmore and Sayer, 1994 = 1000,000 ha).

During this period, shrub land decreased by 6,046 hectares (47.78 %) contributing 7.03 % of the total change of Kerinci area with an annual average loss of 606.4 hectares (4.78 %) . On the contrary, the encroachment area expanded by 39,253 hectares (75.96 %) contributing 45.66 % of the total land use in Kerinci District with the average expansion of 3,925 hectares (7.59 %) per year. Amongst other land use types, there was a 23.69 % decrease in settlement, a 21.64 % increase in rice fields, a 0.09 % decrease in swamp and a 7.03 % decrease in abandoned land.

These findings show that forest deterioration and encroachment expansion in Kerinci District were significant, and these are in agreement with descriptive analyses addressed by other researchers (Perbatakusumah *et al.*, 1993; Bappeda and IPB, 1994; Idham, 1995).

5.1.2.2. The complexity of land-use dynamics

The GIS crossclassification analysis of the two different land-use maps revealed the dynamic historical background of each land-use type within a decade between 1982-1991. Table 5.2 shows the correlation between Kerinci land-use 1982 in the table column and land-use 1991 in table row.

The shaded numbers on the diagonal of rows and columns are the area of related land-use which were unchanged during 10 years period since 1982 until 1991. Numbers to the left and the right of a shadow are the expansion of a 'row' land use in 1991 originated from the different related 'columns' of land uses 1982. While numbers above and below the shadow are land use area in 1982 that have been converted into different related 'rows' of land uses in 1991.

These results show that the actual land-use changes are very dynamic in that there are gains and losses in all land-use categories. Shrub land, for example, has lost 11.056 hectares to lake (5 ha), forest (771 ha), tea plantation (5 ha), encroachment (8,489 ha), settlement (11 ha), rice field (678 ha) and abandoned land 1,097 ha). At the same time, however, it also gained 5,011 hectares from sand stone (3 ha) through the succession process, forest (3,803 ha), encroachment (948 ha), settlement (24 ha), rice field (21 ha) and abandoned land (212 ha). The change of lake, even though it is relatively small, seems to be unrealistic. It could be due to the technical error during the production of land use maps utilised in this study as mentioned in Chapter three. The dynamics and changes of other land-use types can be traced from Table 5.2 in the similar manner.

Table 5.2. The dynamic of land use (LU) changes (Ha) in Kerinci District (1982-1991) based on the images cross-classification analysis of land use 1982 (columns) and land use 1991 (rows).

LU	Land Use 1982 (Ha)										Total
1991	I	II	III	IV	V	VI	VII	VIII	IX	X	(Ha)
I	144	0	0	0	0	0	0	0	0	0	144
II	3	1,338	0	3,803	0	948	24	0	21	212	6,348
III	0	5	5,167	14	0	0	0	0	0	0	5,186
IV	0	771	4	229,711	0	1,594	7	6	5	629	232,727
V	0	5	0	0	3,193	29	94	4	0	0	3,325
VI	0	8,489	0	31,888	2	43,720	436	20	1,599	4,777	90,931
VII	0	11	0	27	50	321	753	0	430	68	1,660
VIII	0	0	0	689	2	163	0	2,387	32	0	3,273
IX	0	678	0	686	3	2,958	860	339	14,674	289	20,487
X	0	1,097	8	1,651	0	1,945	1	514	81	3,673	8,970
Total	147	12,394	5,179	268,468	3,250	51,678	2,175	3,270	16,842	9,648	373,051

Key labels:

I	: Sand stone	VI	: Encroachment
II	: Shrub	VII	: Settlement
III	: Lake	VIII	: Swamp
IV	: Forest	IX	: Rice field
V	: Tea plantation	X	: Abandoned land

753 : The shadowed numbers are related land-use area which were unchanged between 1982 - 1991.

Based on Table 5.1 and Table 5.2 above, the dynamics of five main land-uses in Kerinci District: forest, encroachment, abandoned land, shrub and rice field can be illustrated more clearly using the diagram in Figure 5.2. The figure shows the gains and losses area of each land use type. The gain, loss and net conversion areas for some Kerinci land use types are summarised in Table 5.3. Whereas the percentage conversion of some land-use types in 1982 into other land-uses in 1991 and the percentage of origin of some land-use types of 1991 are illustrated in Figure 5.3 and Figure 5.4 respectively.

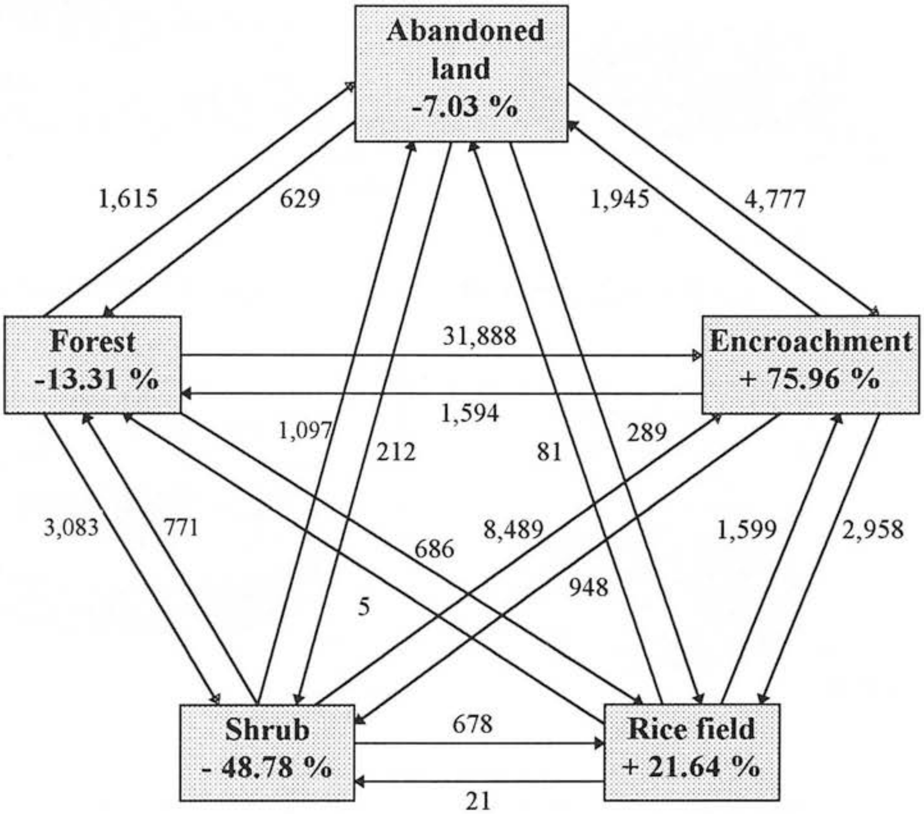
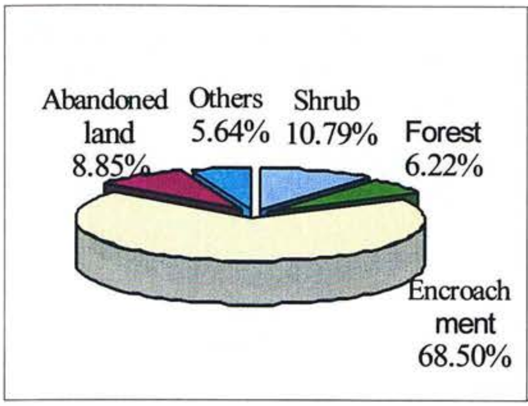


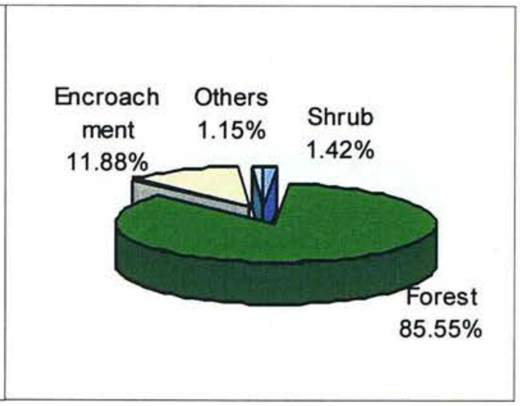
Figure 5.2. The dynamics and changes of five main land uses from 1982 to 1991 in Kerinci District (numbers represent total hectares converted into or out of stated land use).

Table 5.3. The summary of some land use 1982 changes showing the unchanged area, converted area and land use expansion in 1991 (Ha)

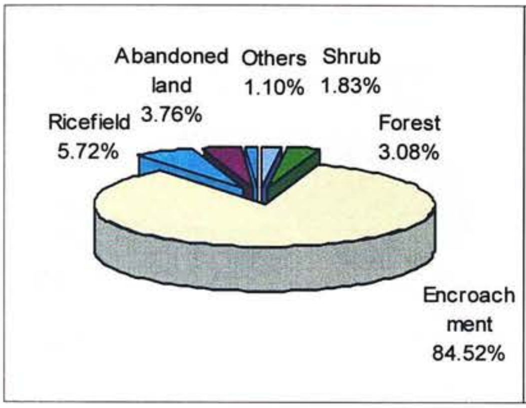
Land-use (LU) Type	Total LU in 1982	LU 1982 remained unchanged		LU 1982 converted into others in 1991		LU expansion in 1991		Net conver-sion
	(Ha)	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)	(Ha)
Forest	268,468	229,711	85.56	-38,758	14.44	3.016	1.12	- 35,742
Encroachment	51,678	43,720	84.60	- 7,958	15.40	47,211	91.36	39,253
Shrub	12,394	1,338	10.79	- 11,056	89.20	5,011	40.43	- 6,045
Rice field	16,842	14,674	87.13	- 2,168	12.87	5,813	34.51	3,645
Swamp	3,270	2,387	73.00	- 883	27.00	886	27.09	3
Abandoned land	9,648	3,673	38.07	- 5,975	61.93	5,297	54.90	- 678



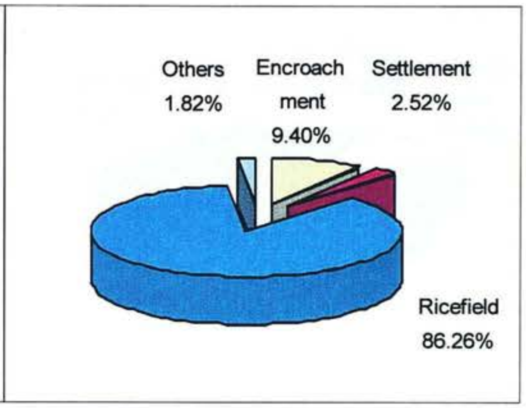
A. Shrub (12,394 ha)



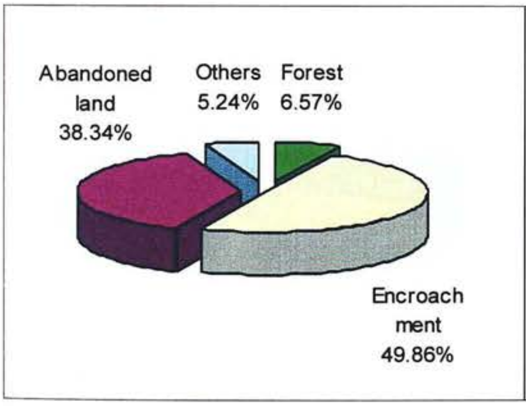
B. Forest (268,468 ha)



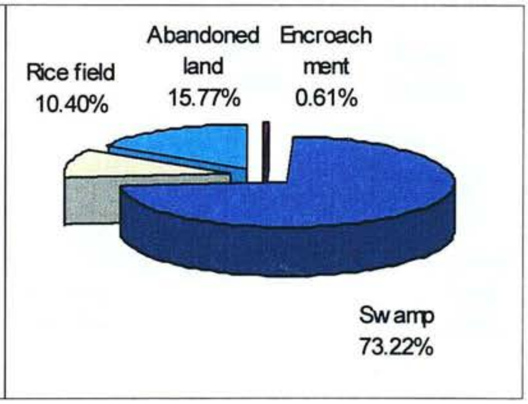
C. Encroachment (51,678 ha)



D. Rice field (16,842 ha)

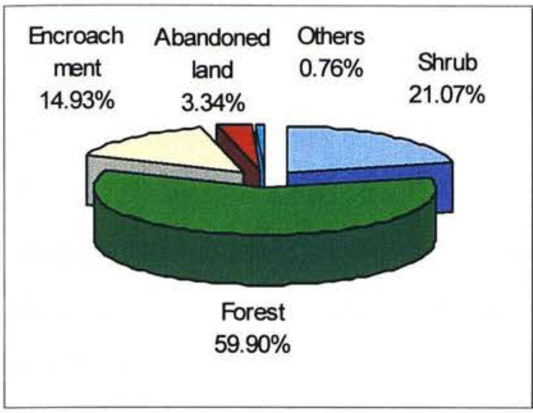


E. Abandoned land (9,648 ha)

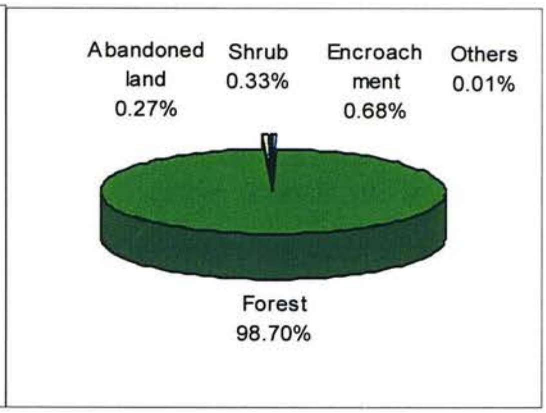


F. Swamp (3,270 ha)

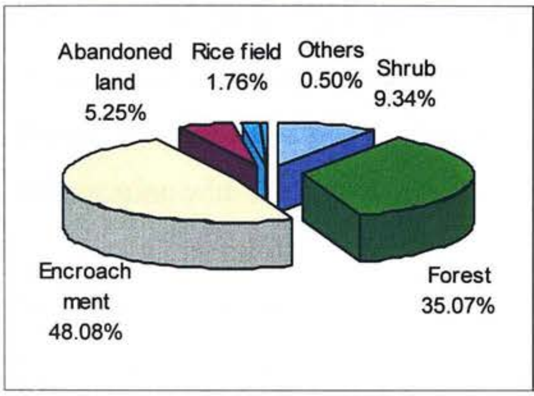
Figure 5.3. Some land use types of 1982 (A to F) in Kerinci District and their conversions into other land uses of 1991 (numbers in the boxes represent the percentage of conversion of the land use total area '82).



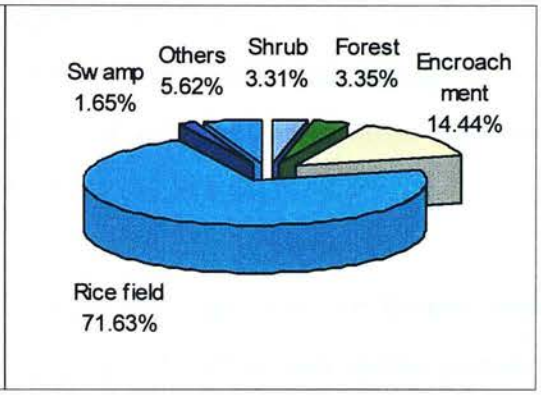
A. Shrub (6,348 ha)



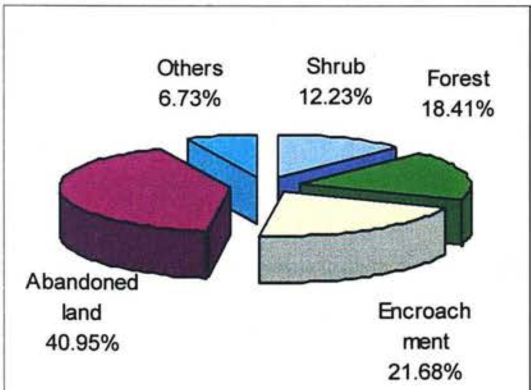
B. Forest (232,727 ha)



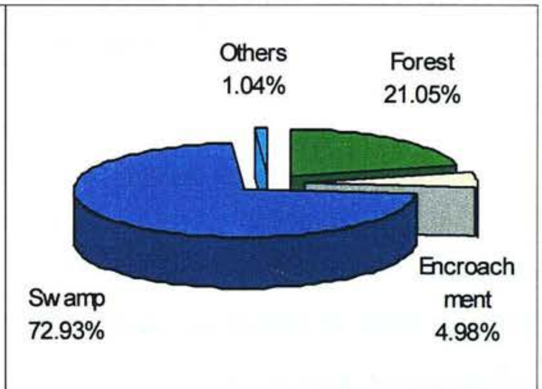
C. Encroachment (90,931 ha)



D. Rice field (20,487 ha)



E. Abandoned land (8,970 ha)



F. Swamp (3,273 ha)

Figure 5.4. Some land-use types of 1991 (A to F) in Kerinci District and their land uses of origin (numbers in the boxes represent the percentage land use origin of the total area of land use 1991).

5.1.2.3. Forest dynamics

Over the 10-year period (1982 - 1991) as indicated by Table 5.2, Table 5.3, Figure 5.3 B and Figure 5.4 B, 85.56 % (229.711 ha) of the total forest area remained unchanged, 14.44 % (38,758 ha) changed into other land uses such as encroachment (31,888 ha, 11.88 %), shrub (3,083 ha, 1.42 %), abandoned land (1,615 ha, 0.60 %) and others (1,416 ha, 0.53 %).

Over the same time period, however, through afforestation activities, forest gained only 3,016 ha (1.12 %) from encroachment (1,594 ha, 52.85 %), shrub (771 ha, 25.56 %), abandoned land (629 ha, 20.86 %) and other land uses (22 ha, 0.74 %). Therefore, during this period, the rate of deforestation was much faster than that of afforestation with the total depletion of 13.31 % (35,741 ha).

Encroachment is the biggest factor influencing forest degradation in Kerinci because 82.27 % (31,888 ha) of the total converted forest (38,758 ha) during this period was lost to encroachment. This observation is supported by the fact that forest changes were mainly concentrated around the settlement areas as resulted from the GIS pairwise comparison analysis and presented in Figure 5.5.

5.1.2.4. Encroachment dynamics

The dynamics of encroachment between 1982-1991 was remarkable. During this period, 84.52 % (43,720 ha) of the total area of encroachment in 1982 (51,678 ha) remained unchanged. 15.40 % (7,958 ha) was lost to various land uses including to shrub (948 ha, 1.83 %), abandoned land (1,945 ha, 3.76 %), rice field (2,958 ha, 5,72 %), forest area due to the afforestation (1,594 ha, 3.08 %) and others (1.10 %). Such a large area of encroachment changes to shrub and abandoned lands suggests management inefficiency of the encroachment area by the surrounding people.

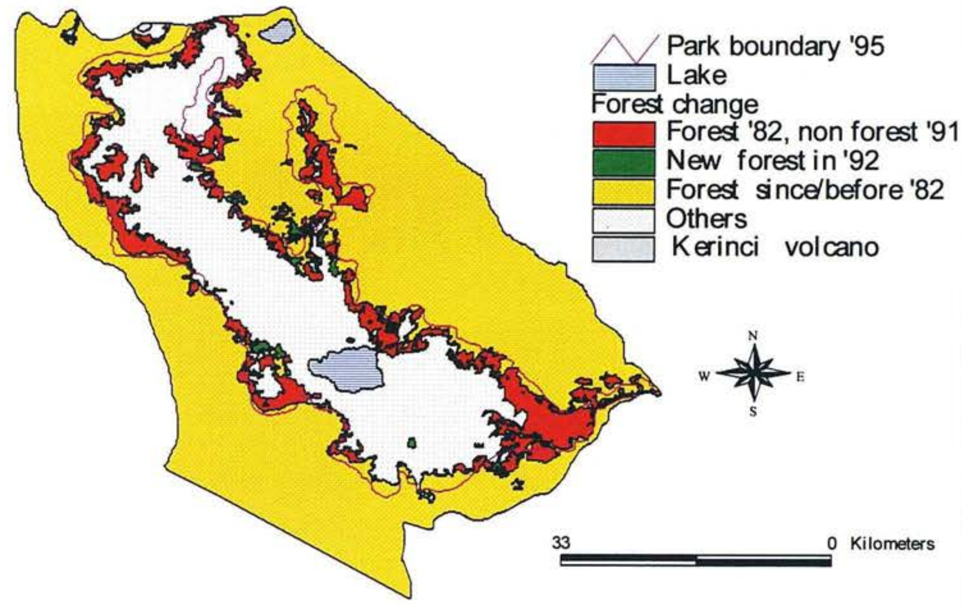


Figure 5.5. Forest change in Kerinci District (1982-1991)

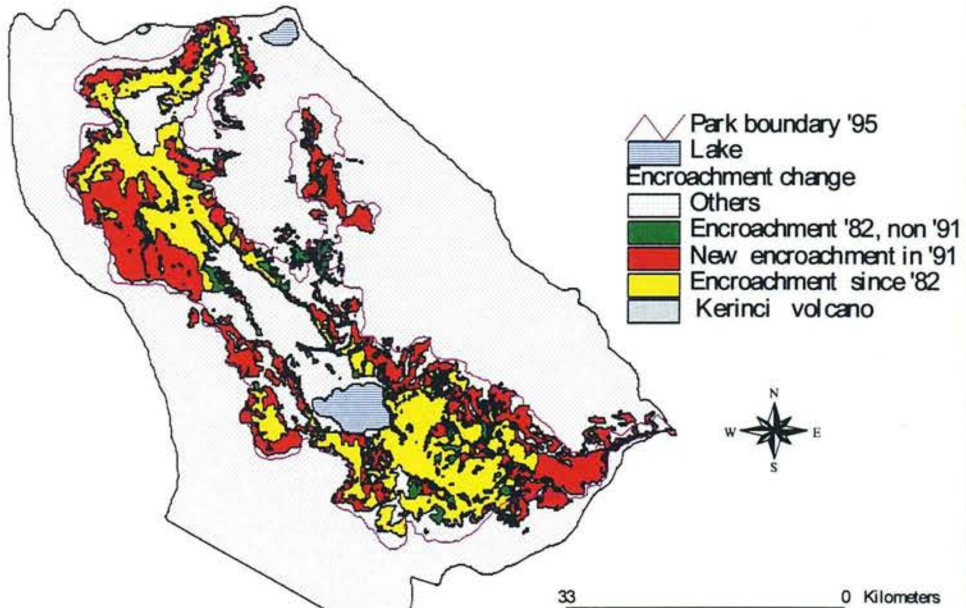


Figure 5.6. Encroachment change in Kerinci District (1982-1991)

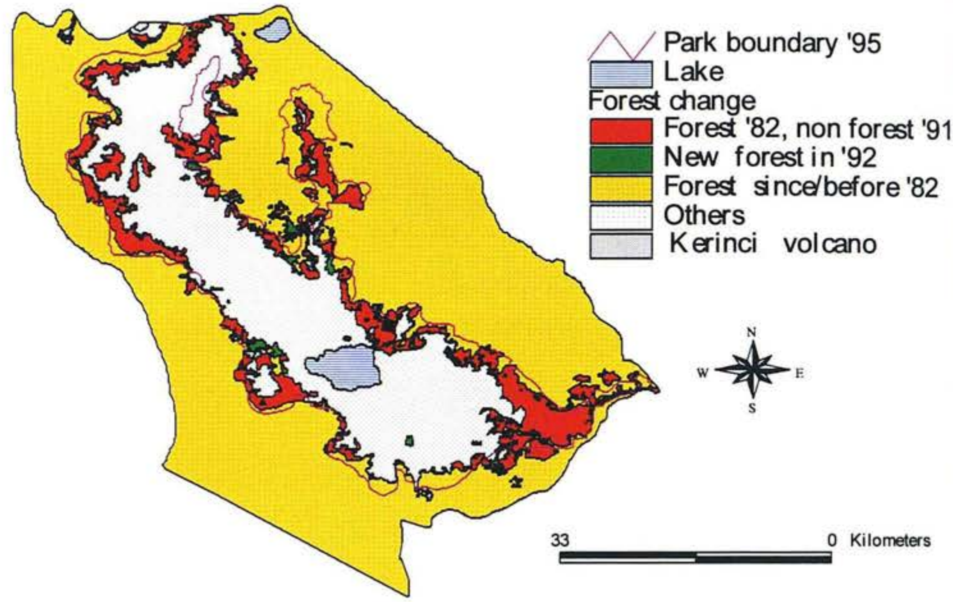


Figure 5.5. Forest change in Kerinci District (1982-1991)

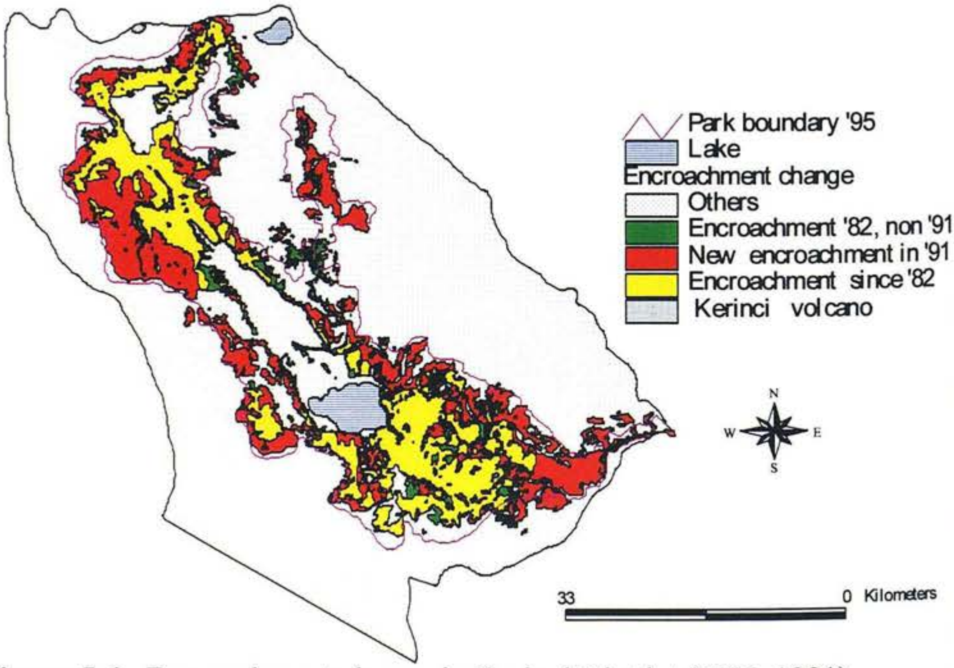


Figure 5.6. Encroachment change in Kerinci District (1982-1991)

Over the same period, encroachment expansion was about six times greater (47,211 ha, 91.36 %) than the lost area and mostly at the expense of forest (31, 888 ha, 67.54 %). The rest was at the expense of shrub (8,489 ha, 17.98 %), abandoned land (4,777 ha, 10.12 %), rice field (1,599 ha, 3.39 %) and others (0.97 %). Figure 5.2 shows that the gains of encroachment from the shrub exceed the losses by approximately nine times, and its gains from abandoned land was 2.5 times greater than it losses. These findings support the questionnaire results that farm expansion to the forest was more difficult after the Park establishment. Therefore, people started using the available less productive lands such as abandoned land and shrub. The location map of encroachment changes based on the GIS pairwise comparison analysis is illustrated in Figure 5.6.

5.1.2.5. Shrub dynamics

Table 5.3 and Figure 5.3 A show that 89.21 % (11,056 ha) of the shrub area in 1982 was converted into variety of land uses and only 10.79 % (1,338 ha) remained unchanged until 1991. The most significant shrub change was due to encroachment activities (68.50 %, 8,489 ha). The rest was changed into abandoned land (8.85 %), afforestation (6.22 %) and other land uses (5.64 %).

During the decade 82-91 the shrub area expanded by 40.43 % (5,011 ha) at the expense of forest (3,083 ha, 61.52 %), encroachment area (948 ha, 18.92 %), abandoned land (212 ha, 4.23 %) and others (15.33 %). The changes in shrub area based on the GIS pairwise comparison analysis is presented in Figure 5.7.

5.1.2.6. Abandoned land dynamics

Abandoned land is concentrated in the mountainous sites around the densely populated area near the central administrative of Sungai Penuh as a result of poor farming management over many decades. Of the total abandoned land in 1982 (9,648 ha), 61.93 % (5,975 ha) was converted into other land uses such as encroachment

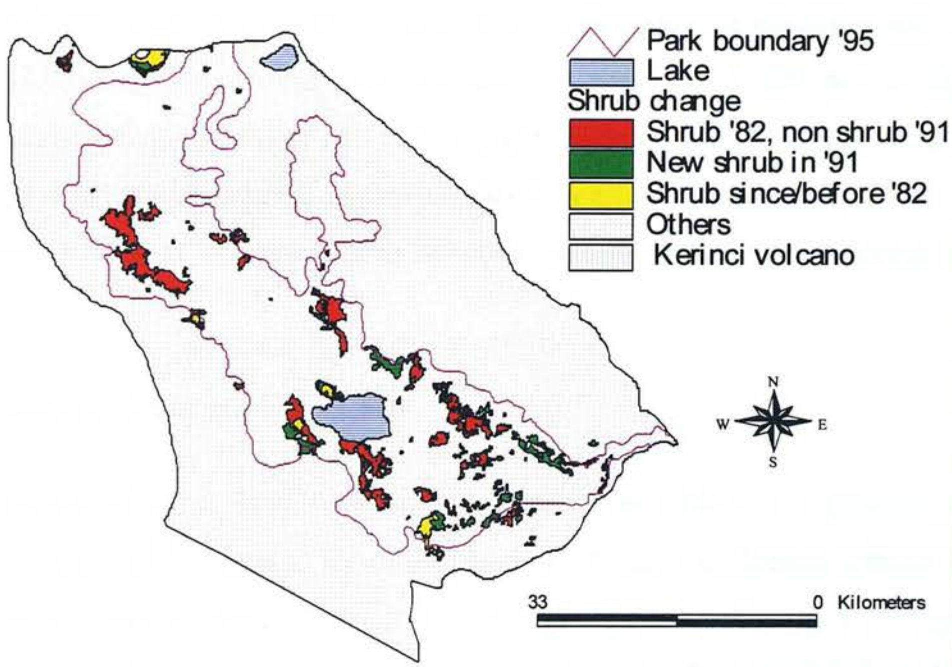


Figure 5.7. Shrub change in Kerinci District (1982-1991)

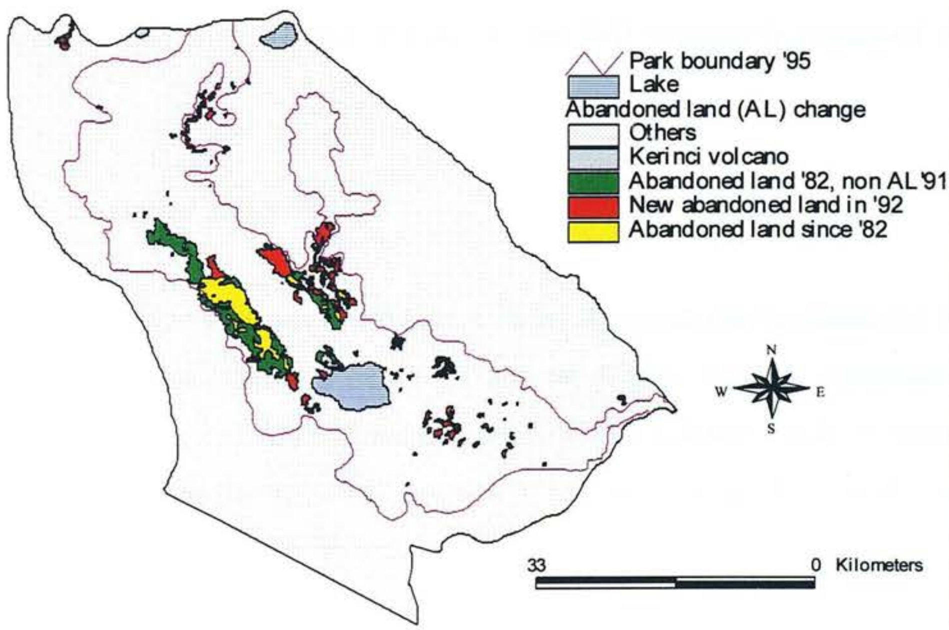


Figure 5.8. Abandoned land change in Kerinci (1982-1991)

(4,777 ha, 49.86 %), afforestation (629 ha, 6.57 %), shrub (212 ha, 2.19 %) and others (5.24 %). While 38.34 % of the area (3,673 ha) remained unchanged till 1991. Conversion of these areas into productive farming is a challenging task for both the District and the Park authorities in the future and its success could lessen the pressure on the Park. In 1991, abandoned land expanded by 54.90 % (5,297 ha) at the expense of shrub (20.71%), forest (31.17 %), encroachment (36.72 %), and other land uses (11.4 %). Of the overall dynamics, abandoned land decreased by 7.03 % (678 ha). The changes of abandoned land based on the GIS analysis are illustrated in Figure 5.8.

5.1.2.7. The dynamics of other land uses

The contribution of other land uses such as sand stone, lake, tea plantation, settlement, swamp and rice field to the overall land use dynamic in Kerinci District is only 5.43 %, of which 4.74 % is due to the rice field expansion. During a 10 year period, the area of rice field increased considerably by 21.64 % (3,645 ha) at the expense of shrub (1,097 ha, 30.1 %), forest (1,651 ha), encroachment (1,945 ha, 45.29 %), swamp (514 ha, 14.10 %), abandoned land (289 %, 7.9 %) and others (90 ha, 2.47 %). At the same time, however, rice field also lost 2,168 ha (12.87 %) to shrub (21 ha), forest (5 ha), encroachment (1,599 ha), settlement (430 ha), swamp (32 ha) and abandoned land (81 ha). A map of rice field changes is presented in Figure 5.9.

5.1.3. Images correlation analysis

The degree of association between two different dates of images can be measured in three ways: A Chi-square statistic, Cramer's V and the Kappa Index of Agreement (Eastman and McKendry, 1991). Fung and LeDrew (1988) found that the latter index is the most accurate to test the degree of association and can distinguish between the change and no-change areas of the images.

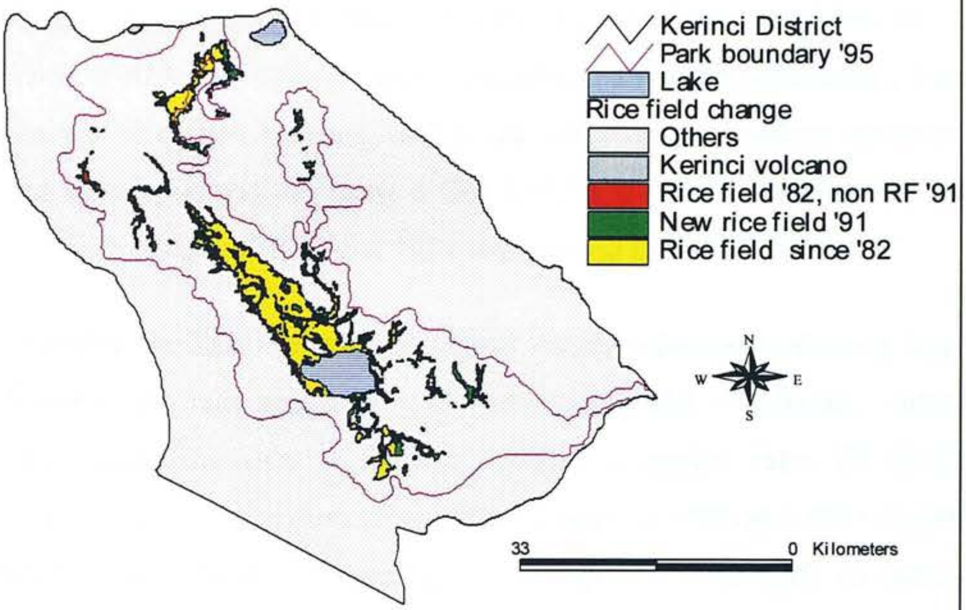


Figure 5.9. Ricefield change in Kerinci District (1982-1991)

Table 5.4. Kappa Index of Agreement (KIA) of Kerinci land uses in 1982 and 1991 based on land use 1991 as the reference image.

Land use code	Land use type	KIA 1982	KIA 1991	Overall test results
I	Sandstone	1.0000	0.9796	
II	Shrub	0.1963	0.0996	KIA:
III	Lake	0.9963	0.9977	0.8458
IV	Forest	0.9786	0.7809	
V	Tea plantation	0.9601	0.9824	Cramer's V:
VI	Encroachment	0.4391	0.8223	0.7665
VII	Settlement	0.4519	0.3448	
VIII	Swamp	0.7280	0.7287	Chi Square:
IX	Rice field	0.7091	0.8673	4010594
X	Abandoned land	0.4010	0.3725	

The Kappa Index of Agreement (KIA) is simply a measure of the proportion of test sites that are correctly classified as change and no-change areas, corrected for chance agreement (Rosenfield and Fitzpatrick-Lins, 1986). Therefore, it can be utilised to describe both the degree of agreement of two maps in different dates as a whole and the correlation of each land use type between the two dates (Eastman and McKendry, 1991). The value of KIA is between 0 (no agreement) and 1 (perfect agreement). The association test can be carried out using each of the images as the standard reference image. Images association analysis using a GIS IDRISI Crosstab module revealed KIA values for both images of 1982 and 1991 as presented in Table 5.4.

Table 5.4 shows that the KIA test result on overall images indicated a relatively high agreement between the two images of 1982 and 1991 (KIA = 0.8458). Image association test using Cramer's V method revealed a similar value (0.7665). Association analysis for each land-use type on both images of 1982 and 1991 shows slightly different results. Some land-use types of image for 1982 such as shrub, encroachment, settlement, and abandoned land show the KIA values less than 0.5. This indicates that those land-use types experienced a greater change between 1982-1991 compared with other land use categories. Therefore, these findings support the previous land-use dynamics analysis as presented in Table 5.1 and Figure 5.3 and Figure 5.4.

5.2. Land-use Dynamics in relation to Slope and Elevation

Land use dynamics in mountainous ecosystems such as Kerinci Seblat often have a vertical as well as horizontal component. Some land use changes are often concentrated in areas of particular slope and elevation. Therefore, in order to fully understand the character of change in the study area, it is necessary to incorporate topographic data such as slope and elevation into the land use dynamic analysis. This section aims to identify such land use change in areas of critical high slope and elevation both as separate and combined factors.

5.2.1. Methods

Use of GIS allowed further examination of the resource situation by comparing the land-use dynamics in relation to topographic variables, particularly slope and elevation (Schreier *et al.*, 1994). Slope is an important aspect of resource management because of its substantial role on the governing surface water behaviour. Therefore, it is one of the determining factors for the degree of soil erosion (Boodt, 1991).

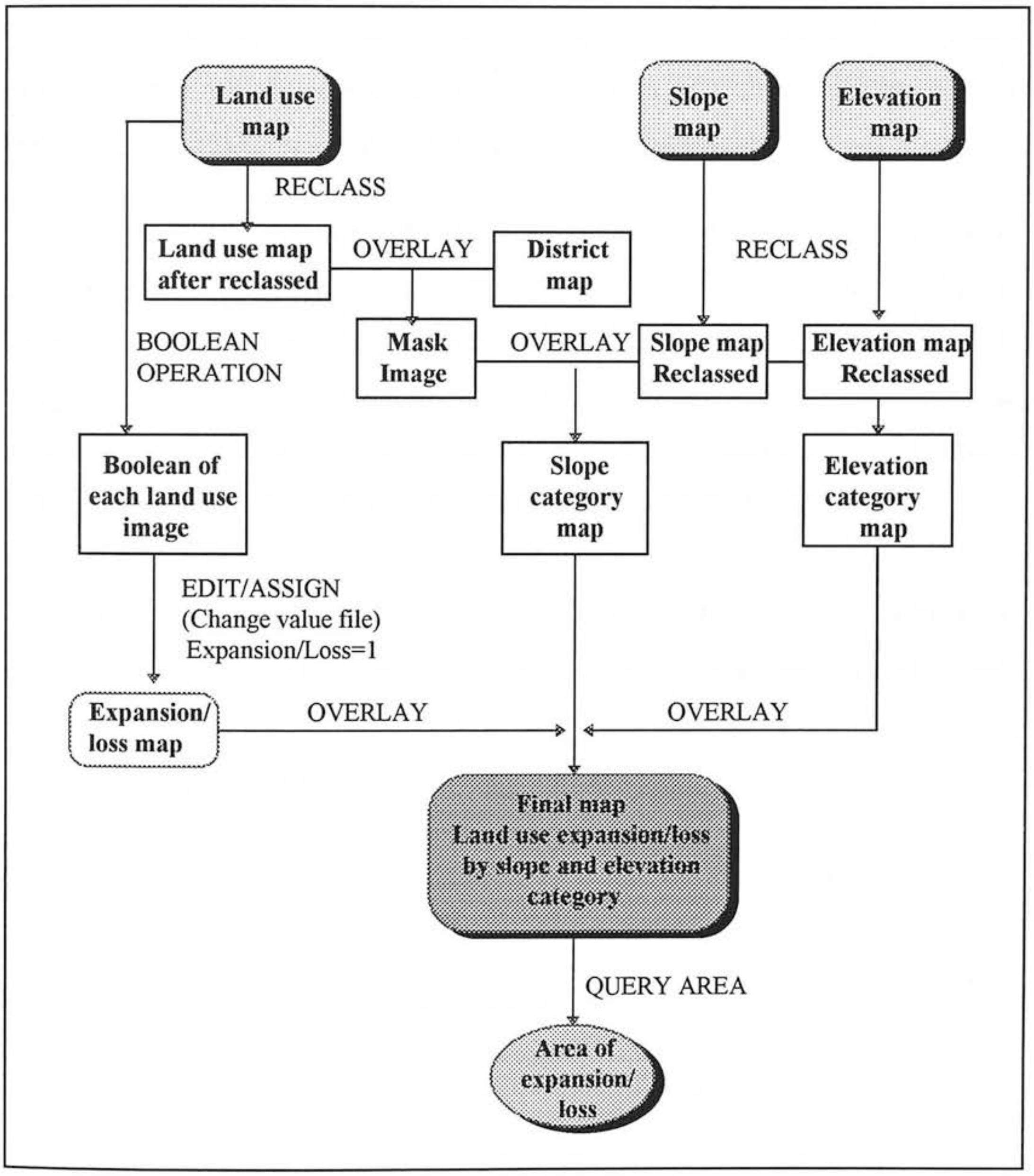


Figure 5.10. The analysis procedure for the creation of tables and maps of land use change by slope and elevation categories.

Elevation in association with the temperature is a natural limiting factor for the growth of plant species, including cinnamon. As indicated by results presented in the previous chapter, farmers instinctively consider these factors (slope and elevation) when deciding on sites for their new farms because in the long term they might influence the cinnamon growth as well as the soil fertility. Therefore, these two physical factors are of importance for the Park planning and sustainable management.

Three georeferenced images included land use, slope and elevation were utilised in this study. For the purpose of the analysis, slope factor of the research site was classified into three groups: 0 - 15 %, 15 - 40 % and more than 40 %. Whereas elevation factor was categorised into six levels :100 - 500 m, 500 - 1000 m, 1000 - 1500 m, 1500 - 2000 m, 2000 - 2500 m and more than 2500 m.

A number of IDRISI GIS software modules were involved in this analysis to produce both quantitative data and images of land use dynamics in relation to slope and elevation. These included reclass, overlay, Boolean operation, edit and assign, and query modules. To create an image of a particular land use change, a Boolean image showing only the desired land use was produced. The procedure of GIS analysis of land use dynamics in relation to slope and elevation is shown in Figure 5.10.

More than 99 % of the total area change in Kerinci was due to the contribution of five main land uses (encroachment, forest, rice field, shrub and abandoned land). Therefore, the analysis was limited to considering changes in these land use types in relation to slope and elevation categories.

5.2.2. Results

5.2.2.1. Land use dynamic by slope category

Within the 10-year period (1982-1991), 13.31 % (6,279 ha) of the encroachment expansion occurred on relatively flat area with 0-15% slope range, 51.01 % (24,066 ha) on moderately sloping terrain (15 - 40 %) and 35.68 % (16,833 ha) on steeply sloping more than 40 % (Table 5.6). There were two reasons provided by farmers why encroachment expansion was moving upslope. Firstly was the limited suitable area of the gently or moderately sloping land after the Park establishment, and secondly, as stated by 4.87 % respondents as the reason for the new site selection, was for their farm security because the steeply sloped areas are hidden both from the theft and the authority supervisions (Chapter 4).

Table 5.5. Land use change in relation to slope in Kerinci District (1982-1991)

Slope class	Encroachment Expansion		Forest loss		Rice field Expansion		Shrub land loss		Abandoned land loss	
	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)
0 - 15 %	6,279	13.31	5,340	13.78	3,160	54.38	1,532	13.86	574	9.61
15 - 40 %	24,066	51.01	19,499	50.31	1,925	33.13	5,189	46.93	2,331	39.01
> 40 %	16,833	35.68	13,919	35.91	726	12.49	4,335	39.21	3,070	51.38
Total	47,178	100	38,758	100	5,811	100	11,056	100	5,975	100

Table 5.5 shows that the percentage distribution of forest loss by slope category is proportional to that of encroachment expansion figures. This supports the previous analysis that most of encroachment expansion is at the expense of forest as can be seen in Figure 5.2, Figure 5.3 and Figure 5.4. The distribution of encroachment expansion as well as forest lost is presented in Figure 5.11 and Figure 5.12 respectively.

The results in Table 5.5 indicate that 54.38 % of sites converted to rice fields occurred on the flat area with the slope range between 0 - 15 %, 33.13 % on a moderately sloping (15 - 40 %) and 12.49 % on steeply sloping more than 40 %. While the loss of shrub and abandoned land lost to encroachment, rice field and others occurred mostly on the steeper slopes between 15 % to more than 40 %, with the percentage distribution of 86.14 % and 90.39 % respectively.

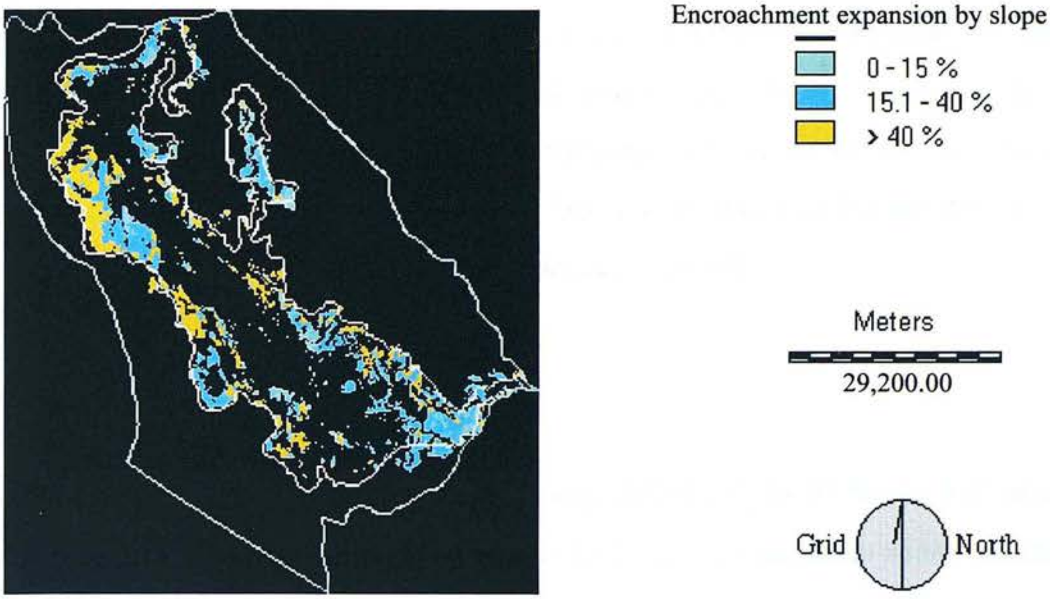


Figure 5.11. The distribution of encroachment expansion across a range of slopes in Kerinci District between 1982-1991

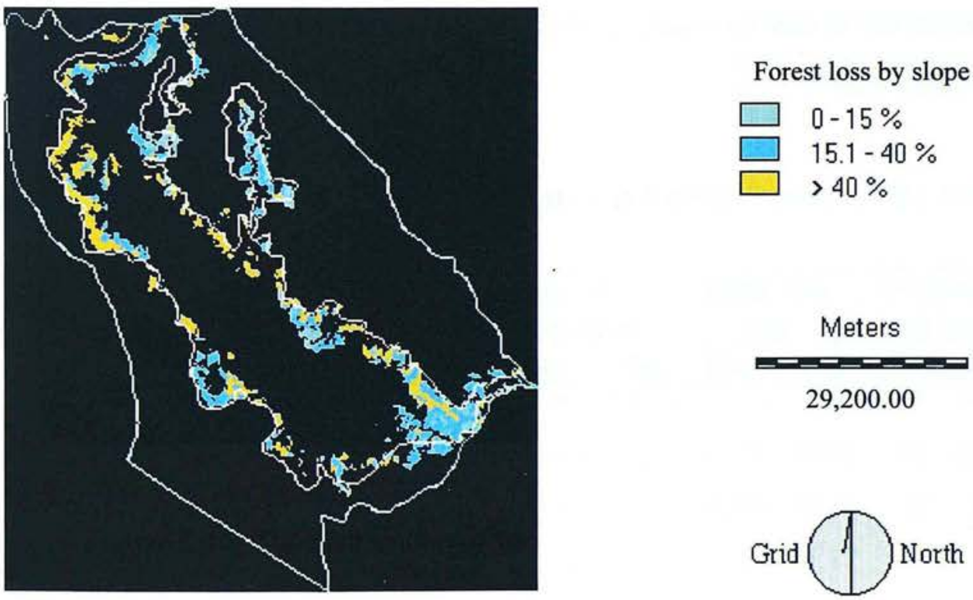


Figure 5.12. The distribution of forest loss across a range of slopes in Kerinci District between 1982-1991

Slope stability and soil erosion are of critical concern in Kerinci with the tropical climate and high rain fall especially on steeply sloped areas and upper elevation, yet conversion into encroachment rather than afforestation is the dominant trend on these sites. This trend is consistent in most land uses (forest, shrub, abandoned land, encroachment) converted into agricultural farming and encroachment. Therefore, these findings clearly points to the fact that land use dynamics in Kerinci District is moving towards more marginalization of agriculture activities.

5.2.2.2. Land-use dynamic by elevation

Table 5.6 shows that during the decade between 1982-1991, 88.82 % (41,852 ha) of the total encroachment expansion (47,121 ha) took place on elevation zones between 500-1500 m. Encroachers seemed well informed about the technical aspects of cinnamon growing, because a majority of the encroachment area was cultivated with cinnamon, and this slope range is best suited to the growth of cinnamon plantation (Perbatakusuma *et al.*, 1993). On a proportional basis, a similar amount of forest loss was in the same elevation class. These data, in addition to previous findings, also provide an indication that most of the encroachment expansion was at the expense of forest.

Table 5.6. Land use change in relation to elevation in Kerinci District (1982-1991).

Elevation	Encroachment expansion		Forest loss		Rice field expansion		Shrub land loss		Abandoned land loss	
(m)	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)
100 - 500	1,260	2.67	1,330	3.43	3,767	64.82	22	0.20	2,045	34.23
500 - 1000	16,210	34.40	12,138	31.32	2,005	34.5	4,755	43.01	3,863	64.65
1000 - 1500	25,642	54.42	20,705	53.42	41	0.71	5,904	53.40	67	1.12
1500 - 2000	4,009	8.51	4,209	10.86	0	0	129	1.17	0	0
2000 - 2500	0	0	148	0.38	0	0	238	2.15	0	0
> 2500	0	0	228	0.59	0	0	8	0.07	0	0
Total	47,121	100	38,758	100	5,813	100	11,056	100	5,975	100

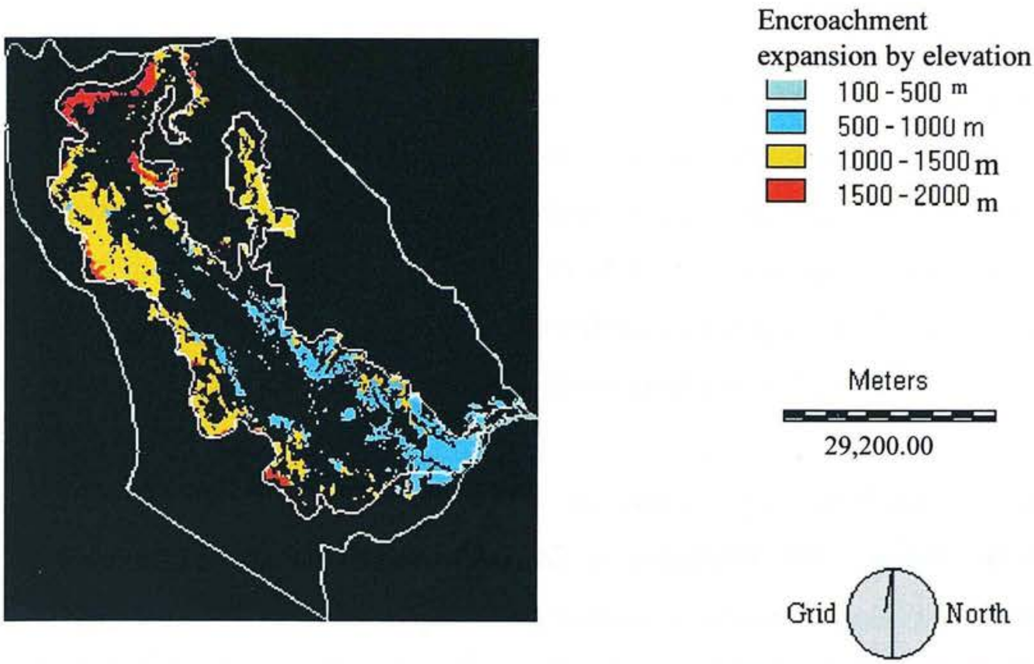


Figure 5.13. The distribution of encroachment expansion across a range of elevations in Kerinci District between 1982-1991

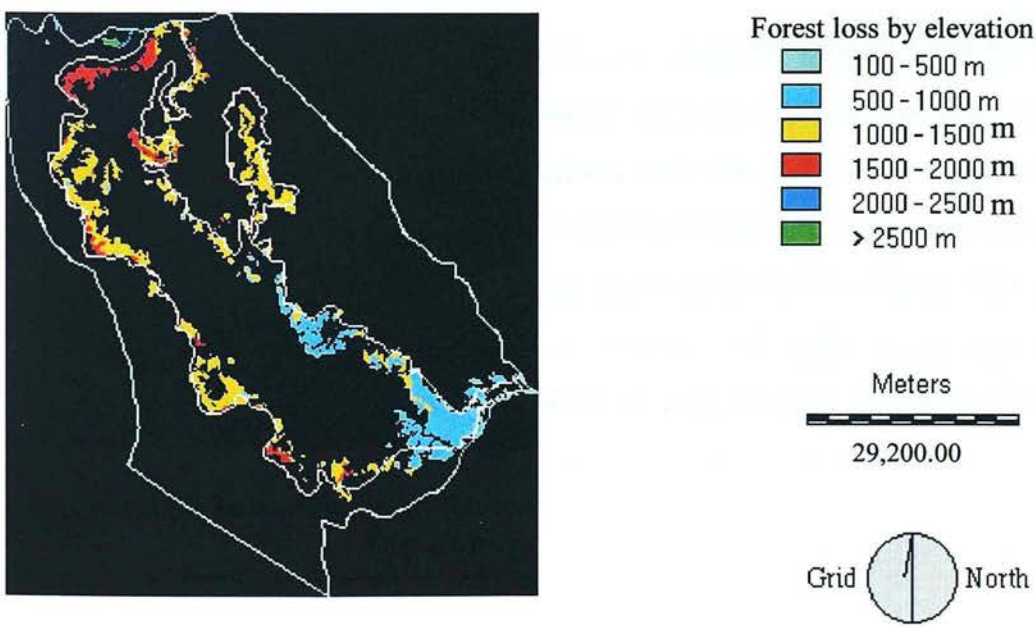


Figure 5.14. The distribution of forest loss across a range of elevations in Kerinci District between 1982-1991

As can be seen from Table 5.6, the majority of shrub land lost (96.41 %) and of abandoned land (65.77 %) occurred in the 500 to 1500 m elevation zone. Only rice fields showed an expansion occurring in the elevation range between 100 - 500 m and 500 - 1000 m containing 64.82 % and 34.5 % of the total change respectively. This is possibly due to the fact that most farmers cultivate local species of slow-growing rice which are not suitable for growth at elevations greater than 1000 m.

Given the interdependence of the resources, the overall expansion in encroachment and the loss of forest shrub land, as well as abandoned land, it will become increasingly difficult to sustain the prevailing land use system in Kerinci in the future. This is evident by the very dynamic nature of land use changes and the loss of upper elevation and steeper lands to encroachment.

5.2.2.3. Land use dynamic by combination of slope and elevation

The analysis of land use dynamic in relation to combined factors of slope and elevation was limited to forest and encroachment, as these two land use types make up the bulk of Kerinci District and their changes were the most predominant of all land use dynamics in the District with a great impact on the Park. The results of this analysis are presented in Table 5.7 and summarised in Table 5.8, Figure 5.15 and Figure 5.16. The findings indicated that a majority of both forest loss and encroachment expansion took place in the elevation zone between 500 m to 1500 m across a variety of slopes, ranging from 15 % to more than 40 % (Table 5.8).

Table 5.7. Land use dynamics of forest area and encroachment area by slope and elevation classes

Slope :	0 - 15 %				15 - 40 %				> 40 %				Total	Total Change	
Elevation	1982	1991	Change '82-'91		1982	1991	Change '82-'91		1982	1991	Change '82-'91		LU '82	1982 - 1991	
(m)	(ha)	(ha)	(ha)	(%)	(ha)	(ha)	(ha)	(%)	(ha)	(ha)	(ha)	(%)	(ha)	(ha)	(%)
Forest lost															
100 - 500	155	73	-82	-52.9	3,228	2,154	-1,074	-33.3	4,650	4,492	-158	-3.4	8,033	-1,314	-16.4
500 - 1000	2,398	825	-1,573	-65.6	23,312	16,313	-6,999	-30.0	35,162	32,208	-2,954	-8.4	60,872	-11,526	-18.9
1000 - 1500	8,687	5,897	-2,790	-32.1	46,501	38,927	-7,574	-19.5	71,168	63,725	-7,443	-10.5	126,356	-17,807	-14.1
1500 - 2000	1,863	1,450	-413	-22.2	20,403	18,233	-2,170	-10.6	39,805	38,526	-1,279	-3.2	62,071	-3,862	-6.2
2000 - 2500	344	351	7	2.0	2,830	2,833	3	0.1	6,623	6,528	-95	-1.4	9,797	-85	-0.9
> 2500	0	0	0	0	2	2	0	0	406	182	-224	-55.2	406	-224	-54.9
Total	13,447	8,596	-4,851	-36.1	96,276	78,462	-17,814	-18.5	157,814	145,661	-12,153	-7.7	267,535	-34,818	-13.0
Encroachment expansion															
100 - 500	0	81	81	100.0	39	1,033	994	2,548	44	206	162	368.2	83	1,237	1,490
500 - 1000	4,749	6,489	1,740	36.6	13,830	20,953	7,123	51.5	3,873	7,221	3,348	86.4	22,452	12,211	54.4
1000 - 1500	5,091	6,637	1,546	30.4	11,984	22,402	10,418	86.9	8,365	18,357	9,992	119.5	25,440	21,956	86.3
1500 - 2000	1,440	1,846	406	28.2	2,185	4,202	2,017	48.0	226	1,573	1,347	85.6	3,851	3,770	97.9
2000 - 2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
> 2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	11,280	15,053	3,773	33.4	28,038	48,590	20,552	73.3	12,508	27,357	14,849	118.7	51,826	39,174	75.6

Note : % is calculated as the area of change for each elevation class divided by the area of land use 1982 for the same elevation class

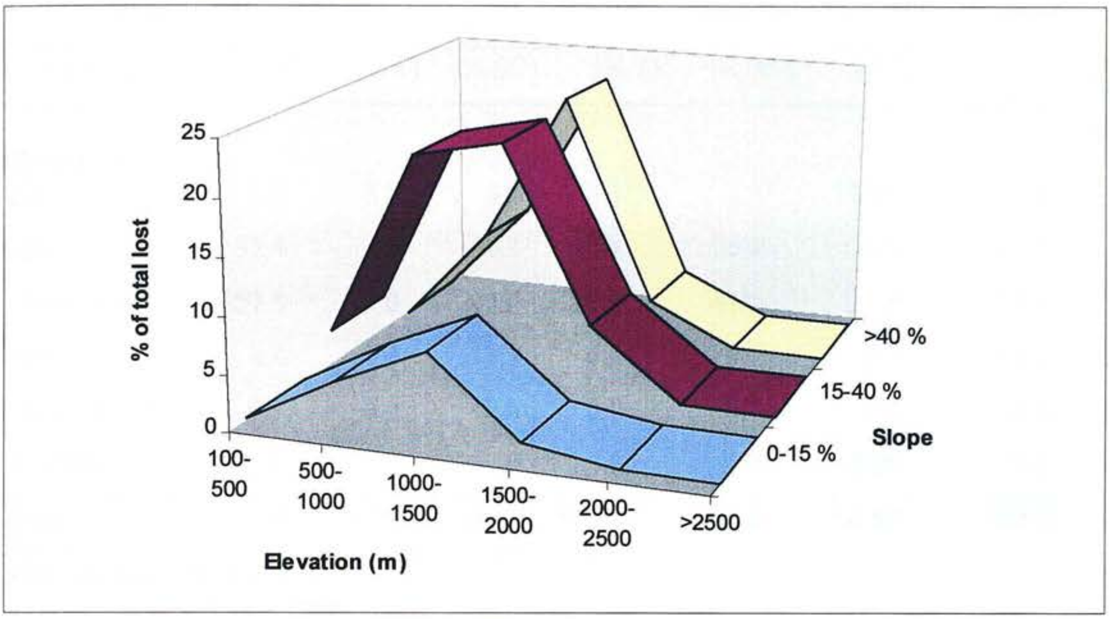


Figure 5.15. The distribution of forest loss across a range of slopes and elevations in Kerinci District (1982-1991)

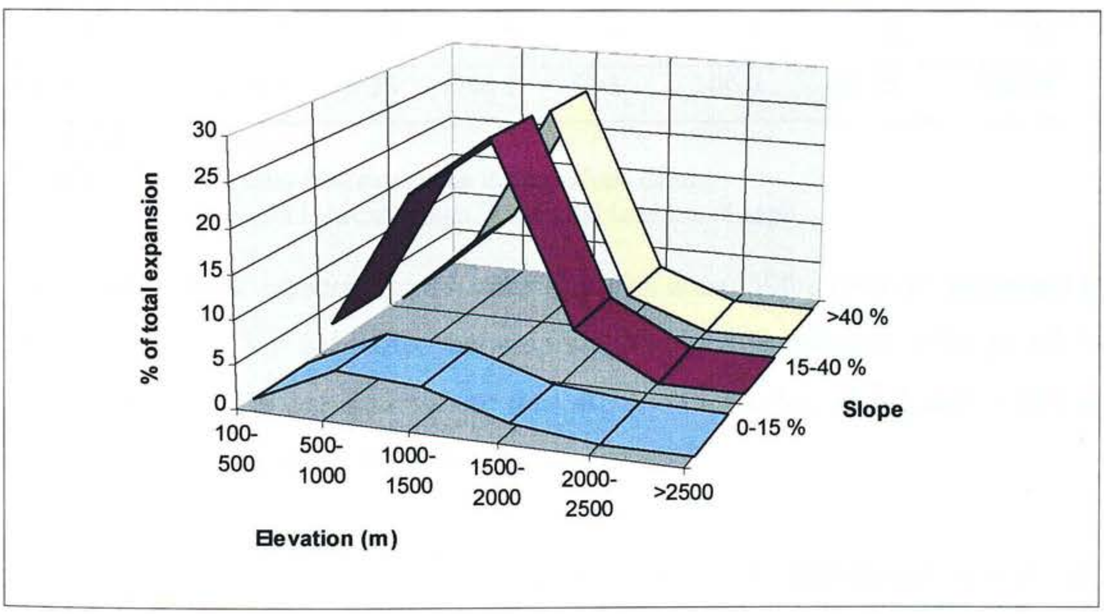


Figure 5.16. The distribution of encroachment expansion across a range of slopes and elevations in Kerinci District (1982-1991)

Table 5. 8. The percentage distribution of forest loss and encroachment expansion across varying slopes and elevations.

Slope:	0 - 15 %		15 - 40 %		> 40 %		Total
Elevation	(% SC)	(% T)	(% SC)	(% T)	(% SC)	(% T)	
Forest lost							
100 - 500	1.6	0.2	6.0	3.1	1.3	0.05	3.8
500 - 1000	32.4	4.5	39.3	20.1	24.4	8.5	33.4
1000 - 1500	57.5	8.0	42.5	21.8	61.3	22.5	51.5
1500 - 2000	8.4	1.2	12.2	6.2	10.5	3.7	11.2
2000 - 2500	0.1	0.0	0.0	0.0	0.7	0.0	0.0
> 2500	0	0	0	0	1.8	0.06	0.1
Total	100.0	13.93	100.0	51.20	100.0	34.84	100.0
Encroachment expansion							
100 - 500	2.1	0.0	4.8	2.5	1.1	0.1	3.1
500 - 1000	46.1	4.4	34.7	19.2	22.5	8.5	31.0
1000 - 1500	41.0	3.9	50.7	26.4	67.3	25.5	55.7
1500 - 2000	10.8	1.0	9.8	5.2	9.1	3.5	10.2
2000 - 2500	0	0	0	0	0	0	0
> 2500	0	0	0	0	0	0	0
Total	100.0	9.33	100.0	53.3	100.0	37.35	100.0

Key labels:
(% SC) : % of the total loss/expansion in each slope class,
(% T) : % of the total loss/expansion in the total land use change

The encroachment expansion in the same elevation zone (500 - 1500 m) amounted to 34,167 ha (86.7 %) distributed between slope ranges as follows: 15% to 40 % (17.541 ha; 45.6 %), at slopes more than 40 % (13,340 ha; 34 %) and 3,286 ha (8.1 %) in the gentle slope between 0-15 %.

On the upper elevation between 1500 m to 2000 m, the percentage of the total change for both forest and encroachment was almost equal being 11.2 % (3,862 ha) and 10.2 % (3,770 ha) respectively. Most of these changes occurred on steeper slopes from 15 % to more than 40 %.

The above land use changes in relation to slope and elevation category reveals that the most critical zone for both encroachment and forest degradation was in the elevation between 500 m to 1500 m with the slope range from 15 % to 40 %. These findings provide evidence of the close relation between the depletion of forest resources and the encroachment activities. Therefore, these zones should be carefully observed since encroachment activities in these zones may further jeopardise of the Park forest resources.

5.3. Land-use Changes with Land Status

Many of the factors that affect the management of Kerinci Seblat National Park were located outside the Park boundaries and are largely beyond the control of the Park authority. One of these factors is land use changes in the enclave which is likely to have negative impacts on the integrity and the sustainability of the Park resources. The enclave area is under the responsibility of the local government of Kerinci District. It is important to incorporate both areas, the Park and the enclave, within analysis of land use dynamics. The following sections aim to investigate the character of land use changes in the Park and in the enclave. Understanding these characters is of importance for both the Park authority and the local Government in order to take necessary actions for the conservation of the Park's biodiversity.

5.3.1. Procedure of the analysis

Analysis of land use changes in the Park area and in the enclave based on IDRISI was carried using two different land use images in 1982 and in 1991. The analysis was performed in two steps based on the old boundary when the Park was established in 1982 and the new boundary established in 1995. Enclave map data based on these Park boundaries was not available. Therefore, a number of modules in IDRISI such as Lineras, Digitise Group, Reclass and Overlay were performed to produce Boolean enclaves as well as land use maps in the enclave in 1982 and in 1991 from the District land use map. By creating two enclave images for different dates, comparative analysis of land use dynamics for the enclave as well as analysis of the impacts of boundary alteration was possible. Query area and Subtract modules then were applied to produce information of land use changes in the enclave and in the Park area respectively. The procedure of the GIS analysis is shown in Figure 5.17.

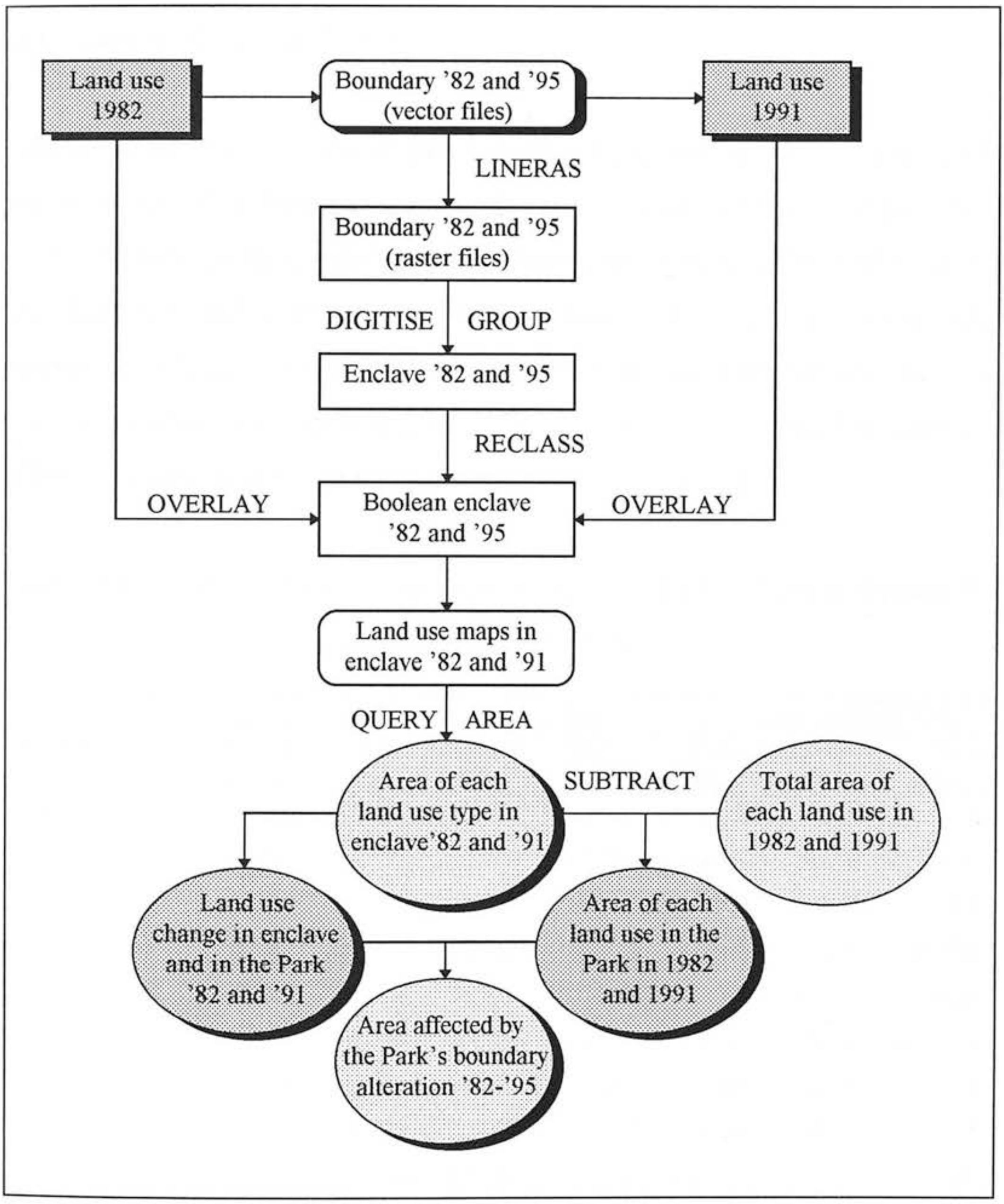


Figure 5.17. Procedures for building table of land use changes in the enclave and in the Park, as well as the table of the area affected by the boundary alteration in KSNP.

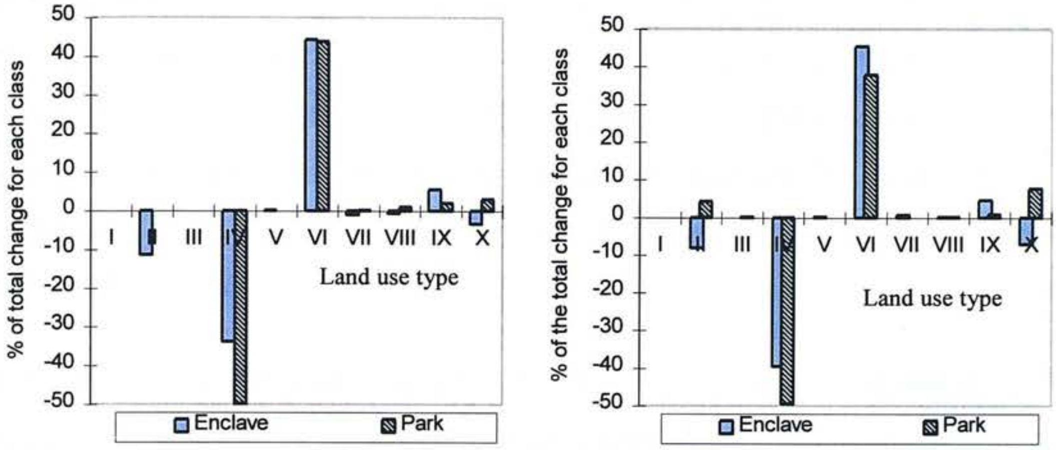
5.3.2. Land use dynamics in the enclave and the Park based on the Park boundary 1982

It can be seen in Table 5.9 and Figure 5.18 A that based on the old boundary of 1982, when the Park was initially established the total area of change in the enclave is 26,672 ha (21.17 %). This is three times greater than that in the Park which amounted to 17,971 ha (7.11 %).

Within the enclave zone, forest area and shrub decreased sharply by 50.30 % (17,965 ha) and 61.59 % (6,3034 ha) respectively. While abandoned land decreased by 18.40 % (1,775 ha). On the contrary, encroachment expanded by 54.78 % (23,618 ha) and rice field increased by 20.23 % (2,950 ha). Of the total area changed in the enclave as presented in Figure 5.18 A, 33.70 % was due to the forest degradation, 44.30 % due to the encroachment expansion, 11.32 % was due to shrub loss(17,965 ha) and less than 10 % caused by changes of other land uses (Figure 5.18 B).

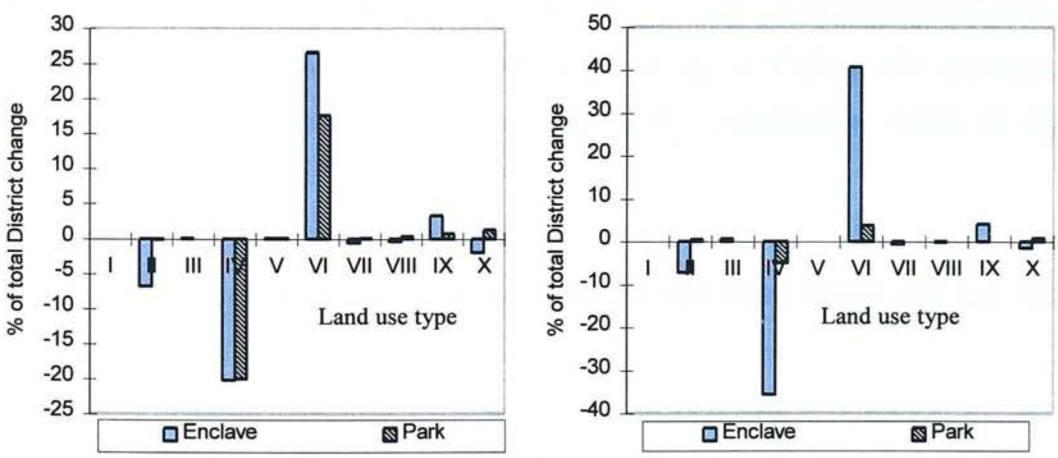
Table 5.9. Land use change in the enclave and in the Park of Kerinci district (1982 - 1991) based on the Park boundary 1982.

Land use types	Land use 1982		Land use 1991		Land use change 1982 - 1991			
	Enclave	Park	Enclave	Park	In the enclave		In the Park	
	(Ha)	(Ha)	(Ha)	(Ha)	(Ha)	(%)	(Ha)	(%)
Sandstone	0	147	0	144	0	0	- 3	- 8.84
Shrub	9,797	2,597	3,763	2,585	- 6,034	- 61.59	- 12	- 0.46
Lake	4,205	974	4,211	975	+ 6	+ 0.14	+ 1	+ 0.10
Forest	35,717	232,751	17,752	214,975	-17,965	- 50.30	-17,776	- 7.64
Tea Plantation	3,250	0	3,313	12	+ 63	+ 1.94	+ 12	0.00
Encroachment	43,111	8,567	66,729	24,202	+23,618	+ 54.78	+15,635	+185.50
Settlement	2,117	58	1,548	112	- 569	-26.88	+ 54	+ 93.10
Swamp	537	2,733	208	3,065	- 329	- 61.27	+ 332	+ 12.15
Rice field	14,581	2,261	17,531	2,956	+ 2,950	+ 20.23	+ 695	+ 30.74
Abandoned land	9,646	2	7,871	1,099	- 1,775	18.40	+1,097	+548.50
Total	122,961	250,090	122,926	250,125	26,672	21.17	17,971	7.11



(A) (B)

Figure 5.18. The contribution of each land use type on the total change of enclave and the Park (1982-1991) based on the boundary (A) 1982 and (B) 1995. (I : Sandstone; II : Shrub; III: Lake; IV : Forest; V: Tea Plantation; VI : Encroachment; VII : Settlement; VIII : Swamp; IX : Rice field; X : Abandoned land).



(A) (B)

Figure 5.19. The contribution of each land use type of enclave and the Park on the total change of Kerinci District (1982-1991) based on the boundary (A) 1982 and (B) 1995. (I : Sandstone; II : Shrub; III: Lake; IV : Forest; V: Tea Plantation; VI : Encroachment; VII : Settlement; VIII : Swamp; IX : Rice field; X : Abandoned land).

Within the Park, more than 93.8 % of the total area change was due to the dynamic of forest and encroachment (Figure 5.18 A). Even though the percentage of forest loss was only 7.64 %, it contributed 98.91 % (17,776 ha) of the total area change of the Park. In the decade between 1982-1991, the area of encroachment in the Park increased 2.8 times by 185.50 % (15,635 ha). Some encroachment areas were poorly managed and then abandoned by the farmers as indicated by a growth in of abandoned land by 548.50 % (1,097 ha) contributing about 3.08 % of the total area change of the Park.

In short, based on the Park boundary 1982, the enclave zone contributed 60.33 % , of the total area change of Kerinci District mostly through forest depletion (20.20 %), encroachment expansion (26.56 %), shrub loss (6.78 %), rice field expansion (3.32 %) and loss of abandoned land (1.99 %). While the Park's contribution was approximately 39.67 % due to forest deterioration (19.99 %), encroachment expansion (17.28 %) as well as abandoned land enlargement (1.23 %).

The Park's boundary rationalisation in 1995 was inspired by the numerous land use changes in the Park as well as in the enclave zone. Therefore, it was aimed both to accommodate the aspiration of the people surrounding the Park as the shortage of farming land and the need for the Park biodiversity conservation. Some of these issues are discussed below.

5.3.3. Land use dynamics in the enclave and the Park based on the Park boundary 1995

Boundary rationalisation in 1995 had great impacts on the composition of land use change between the enclave and the Park. As shown in Table 5.10, the total area of change in the enclave was nine times greater than that of the Park, being 39,636 ha (21.17%) and 4,378 ha (1.99 %) respectively. Compared to the land use change based on the boundary in 1982, the change in the enclave zone based on the boundary 1995 is 1.5 times greater, while the change in the Park is 0.25 times smaller.

Boundary alteration, therefore, transferred a big number of converted areas such as forest degradation and encroachment from the Park into the enclave.

Within the enclave zone, forest depletion was 1.75 times greater than that of 1982 by 31,368 ha (57.77 %), while the loss of shrub and abandoned land were almost the same as for the 1982 boundary by 58.21 % (6,398 ha) and 14.17 % (1,352 ha) respectively. On the other hand, compared to 1982, the rate of encroachment was 1.5 times faster and the area under rice fields increased by 1.2 times. Of the total area of change in the enclave as presented in Figure 5.18 B, 39.60 % was due to the degradation of forest, 45.34 % contributed by the expansion of encroachment, 8.08 % was due to shrub loss, 7.11 % was because of abandoned land loss and less than 10 % caused by other land uses.

Table 5.10. Land use change in the enclave and the Park of Kerinci district (1982-1991) based on the Park boundary 1995.

Land use type	Land use 1982		Land use 1991		Land use change 1982 - 1991			
	Enclave (Ha)	Park (Ha)	Enclave (Ha)	Park (Ha)	In the enclave (Ha)	In the enclave (%)	In the Park (Ha)	In the Park (%)
Sandstone	0	147	0	144	0	0	-3	-2.04
Shrub	10,991	1,403	4,593	1,755	- 6,398	-58.21	+ 372	+ 26.51
Lake	4,205	974	4,211	975	+ 6	+ 0.14	+ 1	+ 0.10
Forest	54,297	214,171	22,929	209,798	- 31,368	- 57.77	- 4,373	- 2.04
Tea Plantation	3,250	0	3,325	0	+ 75	+ 2.31	0	0
Encroachment	50,346	1,332	86,260	4,671	+35,914	+71.33	+3,339	+ 250.68
Settlement	2,165	10	1,651	9	- 514	- 23.74	- 1	- 0.10
Swamp	1,600	1,670	1,596	1,677	- 4	- 0.25	+ 7	+ 0.42
Rice field	16,189	653	19,762	725	+ 3,573	+22.07	+ 72	+ 11.03
Abandoned land	9,539	109	8,187	783	- 1,352	- 14.17	+ 674	+ 618.35
Total	152,582	220,469	152,514	220,537	39,636	21,17	4,378	1.99

Within the Park, forest degradation was 0.25 times less compared to that for the boundary 1982. Even though encroachment expansion was 0.21 times smaller than in 1982 (3,339 ha), the percentage of expansion was 1.4 times greater than that of

1982 by 250.68 %. This indicates that the tendency for encroaching in the Park by surrounding people was still high though the Park boundary was adjusted.

In summary, based on the Park boundary 1995 as shown in Figure 5.19 B, the majority of land use change in Kerinci District which occurred in the enclave (90.05 %) was mostly due to forest depletion (35.63 %), encroachment expansion (40.79 %), shrub loss (7.26 %), and others (5.6 %). While the Park's contribution to the total land use change of Kerinci District was approximately only 9.95 % or 0.25 times smaller than that of boundary 1982 contribution.

All the above analyses indicate that there is interdependency of the Park conservation and the local economic development. Therefore, involvement of related parties such as the local Government, Forest Service (Dinas Kehutanan), Sub Regional Office of Land Rehabilitation and Soil Conservation (SBRLKT) and the Park authority is needed in order to maintain the Park integrity. Furthermore, an integrated programme between the Park management and the regional development is inevitable for the sustainable Park management.

5.4. Impacts of Boundary Alteration on Land-use Composition

The rationalisation of the Park boundary regarding disputed land between villagers and or encroachers and the Park management in Kerinci District was carried out in 1995. This was critical for the successful development and sustainability of the Park as buffer zone land was being subjected to serious disturbance from encroachers' activities. The new rationalised Park boundary was targeted to represent a compromise boundary between social and biological pressures (The World Bank, 1996). Areas with important Park assets such as lowland habitat were included and areas that had no biodiversity values or were impossible to manage such as villages in the Park, some encroachment area and rice field, were excluded (TNKS, 1995).

Impacts of the Park boundary rationalisation from 1982 to 1995 on the composition of land use change was analysed using images crossclassification method. The procedure of the analysis is described in Figure 5.17 and the result is presented in Table 5.11.

Table 5.11. Impact of the Park's boundary alteration on land use composition in Kerinci district based on the images crossclassification of land use 1991

Land use types	Boundary 1982		Boundary 1995		Differences			
	Enclave (Ha)	Park (Ha)	Enclave (Ha)	Park (Ha)	In the enclave (Ha)	(%)	In the Park (Ha)	(%)
Sandstone	0	144	0	144	0	0	0	0
Shrub	3,763	2,585	4,593	1,755	+ 830	+22.06	- 830	-32.11
Lake	4,211	975	4,211	975	0	0	0	0
Forest	17,752	214,975	22,929	209,798	+5,177	+ 29.13	-5,177	-2.41
Tea Plantation	3,313	12	3,325	0	+ 12	+ 0.36	- 12	-100.0
Encroachment	66,729	24,202	86,260	4,671	+19,531	+29.27	-19,531	- 80.70
Settlement	1,548	112	1,651	9	+ 103	+ 6.72	- 103	- 91.96
Swamp	208	3,065	1,596	1,677	+ 1,388	+667.31	-1,388	- 45.29
Rice field	17,531	2,956	19,762	725	+2,231	+12.73	-2,231	-75.47
Abandoned land	7,871	1,099	8,187	783	+ 316	+ 4.01	- 316	- 28.75
Total	122,926	250,125	152,514	220,537	+29,588	+ 24.07	- 29,588	- 11.83

As can be seen from Table 5.11, the Park's boundary rationalisation increased the area of enclave by 24.07 % (29,588 ha) from 122,926 ha to 152,514 ha. However, the Park lost 11.83 % of the area (29,588 ha) going from 250,125 ha to 220,537 ha. The objective of the Park rationalisation, to exclude areas with limited biodversity values, is shown in Table 5.11 by the exclusion of 80.70 % of previous encroachment , 91.96 % of settlement, 75.47 % of rice field, 100 % of tea plantation and 28.75 % of abandoned land from the Park.

Of the total area of land use change (29,588 ha) due to the Park boundary alteration, 66 % was contributed by encroachment, 17.49 % by forest area, 7.5 % by rice field, 4.69 % by swamp, 2.8 % by shrub, 0.3 % by settlement and 1.06 % by abandoned land.

5.5. Summary

In this chapter land use dynamics in relation to land use types, slope and elevation, land status and the Park boundary alteration were presented. Land use dynamics in Kerinci were very complex in that there were gains and losses in all land-use categories. During a decade since 1982 a total of 85,966 ha (23.04 %) of Kerinci land has been converted to other land uses in 1991 with the average conversion rate of 2.30 % a year.

This GIS-based analysis showed that encroachment was the main factor inducing land use change in Kerinci. Encroachment area expanded by 75.96 % from 51,678 ha to 90,931 ha during a decade since 1982 to 1991. This expansion was mainly at the expense of forest (67.55 %), shrub (17.99 %) and abandoned lands (10.11 %). The most critical areas for both forest degradation and encroachment expansion were those in the elevation between 500 and 1500 m above sea level with the slope range from 15 % to 40 %. Land use change happened in both the Park and in the enclave. However, the change in the enclave was three times greater than that of in the Park. A boundary alteration in 1995 aimed to maintain the integrity of the Park has excluded most encroachment areas. Consequently, the Park lost 11.83 % in area. In the next chapter further impacts of encroachment on some soil chemical components and vegetation composition change is presented.

The GIS-based method to analyse land use dynamics was very useful. However two key problems associated with the analysis should be noted. First, within the 10 year time periods, there were internal land use dynamics which can not be detected with the available data. Therefore, the results only show the overall trend during this period.

CHAPTER SIX

IMPACTS OF ENCROACHMENT

6.1. Introduction

The general impacts of agricultural activities on natural resource degradation in many developing countries have been reported by many researchers (e.g. Greenland, 1974; Myers, 1988; Mortimore, 1989; Magrath and Arens, 1989; Beets, 1990; Aiken and Leigh, 1992). Some of the depletion of certain components of the natural resource base are due to the practices of unsustainable agricultural systems such as encroachment and shifting cultivation (Beets, 1990). However, the precise character and extent of depletion are poorly understood. This chapter presents impacts of human encroachment on the bio-physical factors of the Park especially on soil chemical properties and the vegetation change in Kerinci Seblat National Park.

6.2. Impacts on soil properties

Soil is a matter-thick layer of debris that serves to support all terrestrial ecosystems and food chains. Top soil, the sub layer with usually rich organic content and hence of particular interest, is often no more than one-quarter of a meter deep. This layer is a critical factor in most agricultural activities, since, it is susceptible to erosion and degradation. The rate of soil erosion in developing and developed countries is 50 tons and 10 tons per hectare per year respectively (Myers, 1988). However, under normal conditions, the rate of soil formation is only 0.01-0.5 mm per year . This means that hundreds of years are required to renew 25 mm or the equivalent of 400 tons per hectare of soil (Hudson, 1981). Consequently, soil fertility, the plant nutrients available in the soil and one of the soil properties important to growth of plants is affected by soil erosion.

6.2.1. The declining of soil fertility

Soil fertility was defined by Cooke (1967) as the ability of soil to supply enough nutrients and water to allow the crop to make the most of the site. It is distinguished from soil productivity because the latter integrates both the climatic potential of the site and the fertility of the soil. At present, 16 chemical elements are known to be essential for the growth of crop plants (Miller and Donahue, 1990; Appendix 3).

Soil is not primarily a physical and geological phenomenon. It is the combined result of atmospheric and biological processes acting on geological materials over a period of time. Jenny (1961) quoted by Kimmins (1997), therefore, noted that soil formation is influenced by a number of factors. These include parent materials, climate, biota, topography and time.

Human encroachment in Kerinci Seblat National Park was found across the boundary of many slopes and elevations, but at present it is largely confined to hilly upland areas (Chapter 5). Soil in such areas tends to be highly erodable. Therefore, soil exhaustion leading to the declining yield of the existing land is usually the main problem faced by most encroachers and shifting cultivators (Nye and Greenland, 1960; Beets, 1990).

Greenland (1974) reported that soil fertility under shifting cultivation in Ghana, Nigeria and Peru declined rapidly after as little as three years of continuous cultivation. This was because no external energy in the form of fertilisers is utilised in this agricultural system. In order to improve soil fertility, therefore, Lanly (1985) argues that the balance between fallowing period and the length of the crop is an important factor leading to the sustainability of shifting cultivation system. This balance is influenced by the degree of population pressure on the natural resources. The relation between the length of fallow and soil productivity in shifting cultivation is illustrated by Guillemin in Ruthenberg (1980) as shown in Figure 6.1.

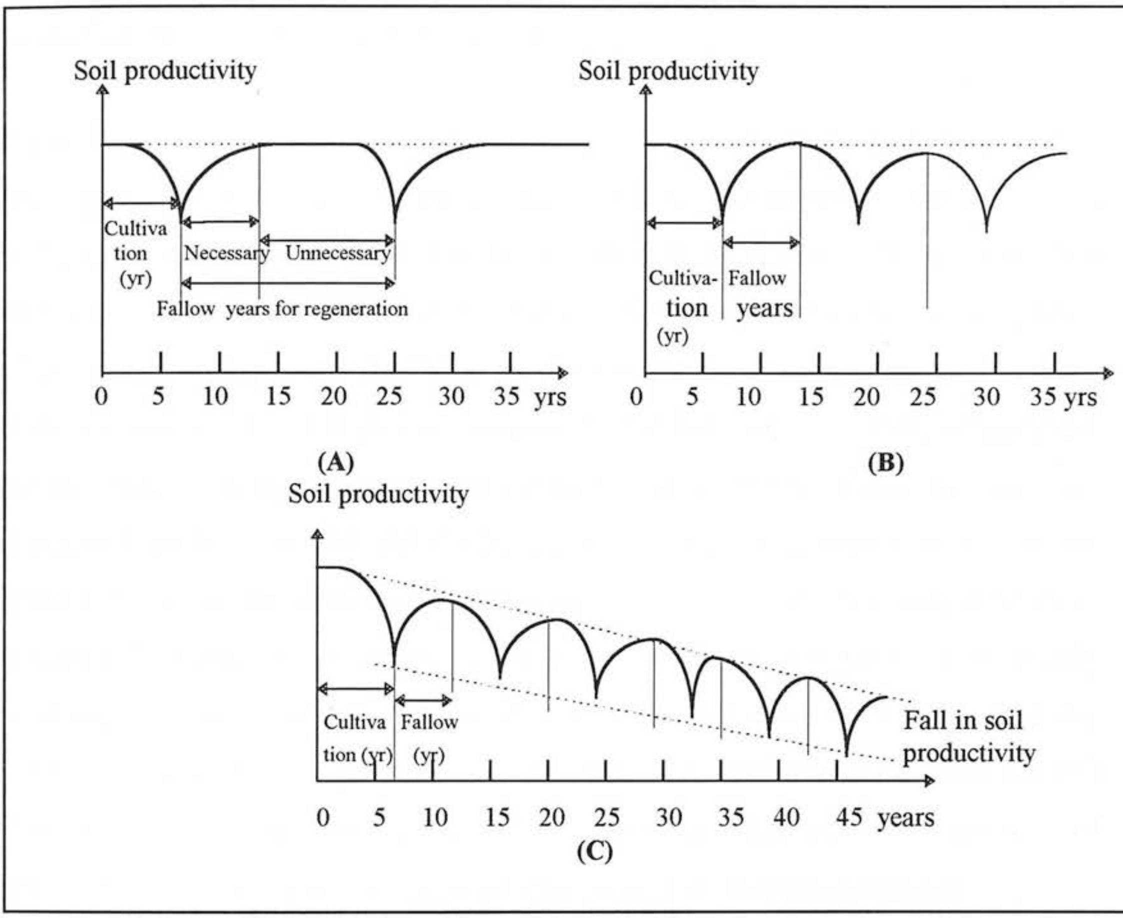


Figure 6.1. The relation between length of fallow and soil productivity in shifting cultivation. Interval of fallowing period is: (A) Too long, (B) Exactly in the time limit for soil recovery, and (C) Too short for soil recovery (Adapted from Guillemin in Ruthenberg *et al.*, 1980).

It can be seen from Figure 6.1 that too long an interval of fallowing as shown in Figure 6.1. (A) results in non exhausted production potential of the soil. The correct interval of the fallowing period is exactly the time limit for soil recovery as shown in Figure 6.1 (B), and will result in fully exhausted production potential of the soil. Whereas if the interval of fallowing period is too short for soil recovery as shown in Figure 6.1 (C) it may lead to a loss of soil productivity. This analysis suggests that shifting cultivation will attain its optimum function if there is an appropriate balance between fallowing period and the length of cropping. This situation, however, is only possible when the availability of areas for agricultural lands is not a limiting factor.

6.2.2. Change in soil chemical properties

From a chemical point of view soils are composed of a large number of constituents, ranging from simple salts to highly complex inorganic and organic compounds (Lutz and Chandler, 1946; Syers and Rimmer, 1994). Soil is the source of essential plant nutrients. At present, 16 chemical elements are known to be essential for the growth of crop plants (Appendix 3). These plant nutrients are hydrogen, carbon, oxygen from air and water, phosphorus, potassium, sulphur, calcium, iron, magnesium, boron, copper, manganese, zinc, molybdenum, and chlorine from the soil, and nitrogen from both air and soil (Miller and Donahue, 1990). However, a standard analysis on the six elements most essential for the growth of plants (Organic Carbon, Nitrogen, Phosphorus, Potassium, Calcium and Magnesium) is the most frequently carried out in studies of soil chemical nutrients (e.g. Jones and Wild, 1975; Watson, 1994). The soil analyses in this study, therefore, were performed on those six soil elements in two different soil types: Andosol and Latosol. The impacts of encroachment on these soil nutrients are described in the following sections.

6.2.3. Impacts of the length of encroachment

Under shifting cultivation systems, soil nutrients may be lost from the topsoil by erosion and in runoff water, by leaching, through volatization on burning vegetation and by crop removals during harvest period (Mortimore, 1989). In theory, any changes in soil chemical properties can be corrected by appropriate fertiliser management (Jones and Wild, 1975; Mortimore, 1989). However, fertiliser was not utilised under encroachment in KSNP. Therefore, any change in soil chemical properties might be addressed in terms of the impact of agricultural practices. Unfortunately, no reports on the impact of encroachment on the soil properties of KSNP were available.

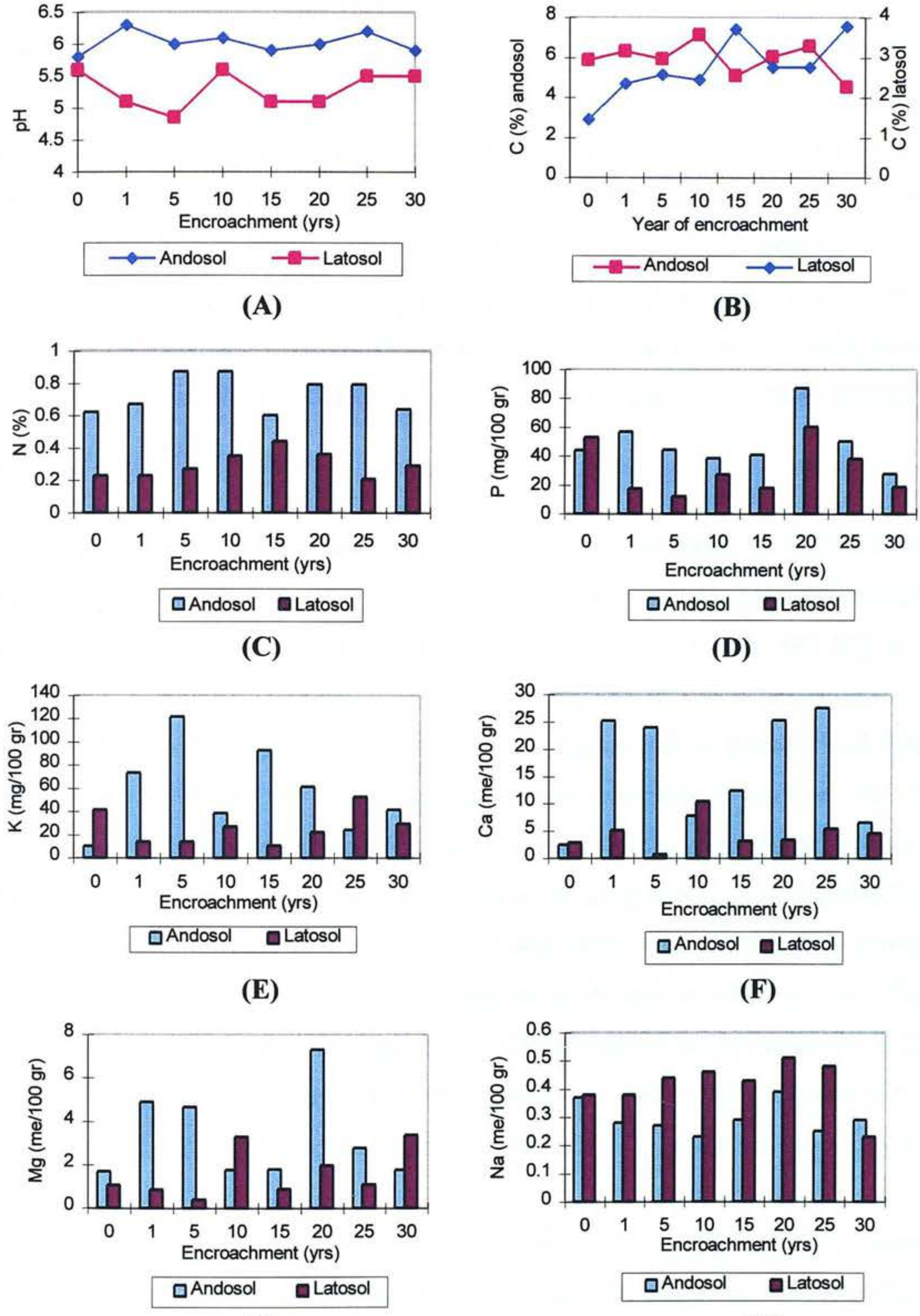


Figure 6.2. Chemical components of soil samples in KSNP based on the length of encroachment (A = pH; B = Organic carbon (C); C = Nitrogen (N); D = Phosphorus (P); E = Potassium (K); F = Calcium (Ca); G = Magnesium (Mg); H = Sodium (Na).

The soil sampling regimes utilised here were presented in Chapter three. While the data of soil chemical properties based on the soil chemical analysis are displayed in Figure 6.2 and Appendix 4. Analysis of Covariance (orthogonal designs) was undertaken to ascertain the effects of the length of encroachment (1- 30 years) with the covariates (i.e. soil types and soil depths) on the soil chemical contents (i.e. pH, N, P, K, Ca, Mg and organic matter). The results of this analysis are presented in Table 6.1. A General Linear Model (Anova GLM) was used to test the influences of land cover types and soil depths on the same soil properties and these results are presented in Table 6.2.

The data show a tendency for some soil chemical components to decrease with increasing the length of encroachment (Figure 6.7). However, analysis of Covariance (Table 6.1) reveals that the decreasing rate of pH, C, N, K, Ca, and Mg is not statistically significant. This was possibly due to any loss of soil nutrients during the first three years of cropping being made up by organic debris (grasses and shrub) decomposition during the remaining years under cinnamon plantation. As only cinnamon plants are maintained for the rest of the years after the third year of plantation then there could be functioning as a fallowing period as in the traditional shifting cultivation. This is because grasses and shrub were continuously growing under cinnamon plantations and were decomposed through weeding process. These findings are in accordance to Endredy and Montgomery's study results in a wide range of forest soils in Ghana (Nye and Greenland, 1960), which indicate that the change of pH and soil nutrients over cropping periods of several years were very low.

All covariates (soil factors) showed significant effects on all soil chemical properties of KSNP. Further analysis indicated that these effects are caused by soil type and not by the depth of the soil (Table 6.1). There was a significant effect of increasing years of cropping on the soil chemical contents for phosphorus (Table 6.1.4). Phosphorus deficiency is almost universal in upland tropical soils (Jones and Wild, 1975; Willett, 1994).

Table 6. 1. Analysis of Covariance (Orthogonal Designs) of soil properties (pH, C, N, P, K, Ca, Mg and Na) by length of encroachment, soil type and soil depth in KSNP

6.1.1. Analysis of Covariance for pH

Source	DF	Adj SS	MS	F	P
Covariates	2	4.38871	2.19436	27.34	0.000***
Year	7	0.62800	0.08971	1.12	0.387
Error	22	1.76549	0.08025		
Total	31	6.78220			

Covariate	Coef	StDev	T	P
Soil	-0.7200	0.100	-7.189	0.000***
Depth	-0.1738	0.100	-1.735	0.097

6.1.2. Analysis of Covariance for C

Source	DF	Adj SS	MS	F	P
Covariates	2	100.065	50.032	95.61	0.000***
Year	7	3.465	0.495	0.95	0.493
Error	22	11.512	0.523		
Total	31	115.042			

Covariate	Coef	StDev	T	P
Soil	-3.536	0.256	-13.83	0.000***
Depth	-0.055	0.256	-0.22	0.832

6.1.3. Analysis of Covariance for N

Source	DF	Adj SS	MS	F	P
Covariates	2	1.48861	0.74431	68.66	0.000***
Year	7	0.12309	0.01758	1.62	0.181
Error	22	0.23849	0.01084		
Total	31	1.85019			

Covariate	Coef	StDev	T	P
Soil	-0.4313	0.0368	-11.72	0.000***
Depth	-0.0100	0.0368	-0.27	0.788

6.1.4. Analysis of Covariance for P

Source	DF	Adj SS	MS	F	P
Covariates	2	3190.5	595.2	18.58	0.000***
Year	7	8026.2	146.6	13.35	0.000***
Error	22	1889.1	85.9		
Total	31	13105.8			

Covariate	Coef	StDev	T	P
Soil	-19.94	3.28	-6.087	0.000***
Depth	-1.07	3.28	-0.328	0.746

6.1.5. Analysis of Covariance for K

Source	DF	Adj SS	MS	F	P
Covariates	2	4214.9	2107.5	2.61	0.096
Year	7	2447.6	349.7	0.43	0.871
Error	22	17794.9	808.9		
Total	31	24457.4			
Covariate	Coef	StDev	T	P	
Soil	-22.48	10.1	-2.236	0.036*	
Depth	4.62	10.1	0.460	0.650	

6.1.6. Analysis of Covariance for Ca

Source	DF	Adj SS	MS	F	P
Covariates	2	1143.33	571.66	12.99	0.000***
Year	7	682.41	97.49	2.22	0.073
Error	22	967.90	44.00		
Total	31	2793.64			
Covariate	Coef	StDev	T	P	
Soil	-11.93	2.35	-5.088	0.000***	
Depth	0.73	2.35	0.311	0.759	

6.1.7. Analysis of Covariance for Mg

Source	DF	Adj SS	MS	F	P
Covariates	2	11.534	5.767	3.65	0.043**
Year	7	11.050	1.579	1.00	0.458
Error	22	34.775	1.581		
Total	31	57.359			
Covariate	Coef	StDev	T	P	
Soil	-1.178	0.445	-2.650	0.015*	
Depth	-0.232	0.445	-0.522	0.607	

6.1.8. Analysis of Covariance for Na

Source	DF	Adj SS	MS	F	P
Covariates	2	0.108706	0.054353	11.73	0.000***
Year	7	0.173597	0.024800	5.35	0.061
Error	22	0.101919	0.004633		
Total	31	0.384222			
Covariate	Coef	StDev	T	P	
Soil	0.11312	0.0241	4.701	0.000***	
Depth	-0.02812	0.0241	-1.169	0.255	

Note:
***: Statistically significant at 0.1 % level
** : Statistically significant at 1 % level
* : Statistically significant at 5 % level

This finding is relevant to Nye and Greenland's report (1960) on the change of soil chemical study under continuous cropping in Senegal and Guatemala. He pointed out that crop removal makes a significant contribution to the loss of phosphorus. Crop removal is pertinent to encroachment in KSNP as crops such as maize, tobacco, potato, coffee are planted between cinnamon trees and frequently harvested in the first three years of encroachment. The cinnamon trees are then cut down every 5-10 year period.

A regression analysis was carried out to test the effect of the length of encroachment on soil phosphorus in both andosol and Latosol soils. The results indicate that there was a significant relationship for andosol soil ($r^2 = 0.8786$, p-value = 0.001), and no significant relationship for Latosol soil ($r^2 = 0.023$, p-value = 0.7452). The regression analysis for andosol soil indicates a negative relationship between variables in which longer encroachment leads to decreased soil phosphorus content of KSNP as shown in Figure 6.3.

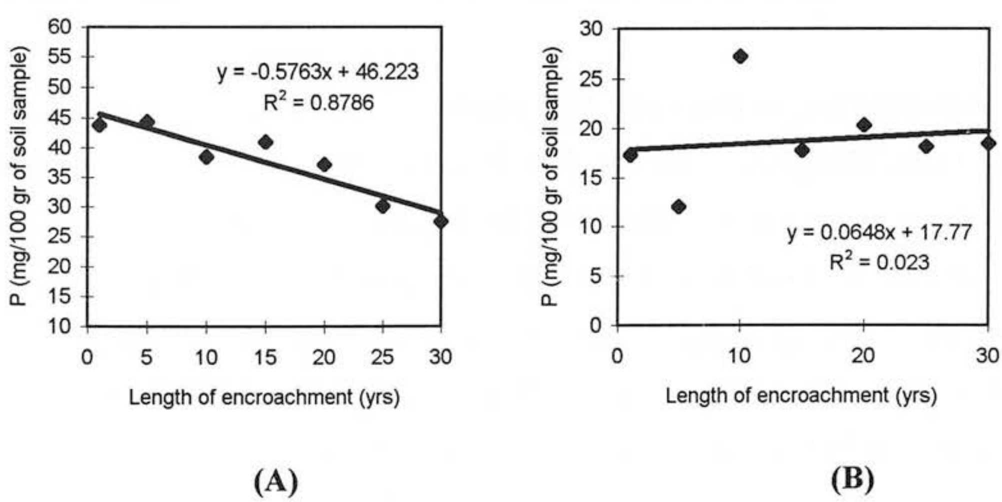


Figure 6.3. Regression analysis between the length of encroachment and soil phosphorus content of (A) Andosol soil and (B) Latosol soil in KSNP

6.2.4. Relation to land cover types

The abandonment of encroachment areas in KSNP has resulted in the change of land cover type from a virgin forest to a secondary forest and shrub. Land cover type may influence the soil properties through leaching and soil erosion processes, since vegetation is effective in preventing accelerated soil erosion in any region. Several researchers have reported that the loss of soil in a densely virgin forest is much smaller than the losses from the secondary forest and grassland (Lutz and Chandler, 1946; Syers and Rimmer, 1994).

It was reported that the canopy of an undisturbed depterocarp forest has been found to intercept at least 35 percent of rainfall in South East Asia. Whilst the canopy of heavily logged forest intercepts less than 20 percent, and that of a tree plantation, such as rubber or oilpalm, only about 12 percent (Low and Goh, 1972 and Ba, 1997 in Myers, 1988). However, the transfer of land from forest land to farmland does not automatically indicate degradation in the sense of loss of productivity, since, such degradation depends on the type of management (Mortimore, 1989).

Furthermore, the change of land cover type from forest land to secondary forest and shrub land might influence the change of soil nutrients through the effect of the soil pH, because it affects the solubility of soil minerals. Vegetation exerts a strong influence on soil acidity through the litter which it supplies. In general soils supporting conifers tend to be more acidic than those supporting hardwoods. This is because most conifer leaves contain relatively high acidity and low basic buffer compared with most hardwood leaves (Lutz and Chandler, 1946; Miller and Donahue, 1990).

In this study, the relation of land cover types (primary forest, secondary forest and shrub) to some soil chemical contents were assessed. Analysis of Variance of General Linear Model (Anova GLM) was carried out to test influences of land cover types and soil depths on the soil properties as presented in Table 6.2.

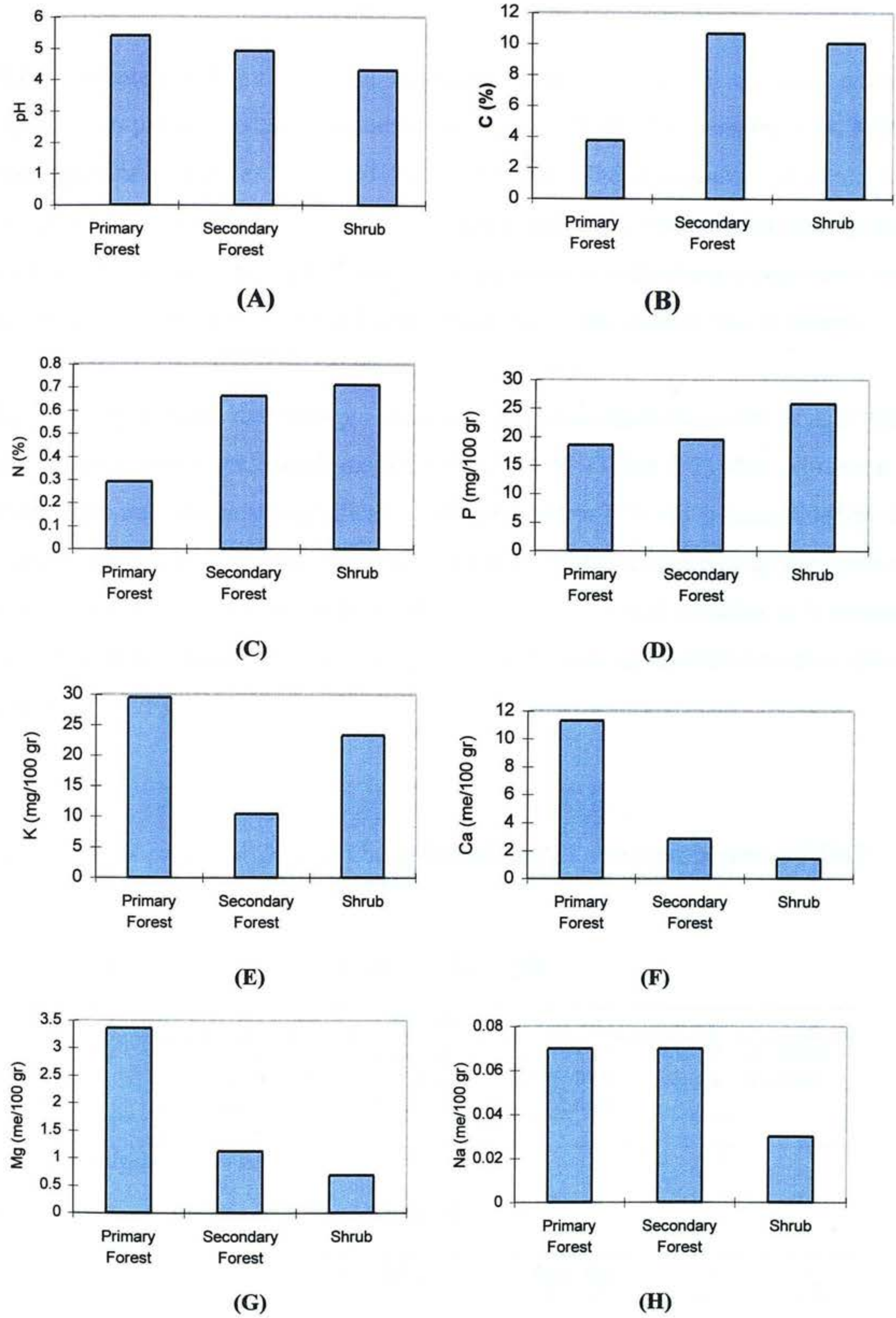


Figure 6. 4. Chemical components of soil samples based on land cover types in KSNP (A = pH; B = Organic carbon (C); C = Nitrogen (N); D = Phosphorus (P); E = Potassium (K); F = Calcium (Ca); G = Magnesium (Mg); H = Sodium (Na).

Data presented in Figure 6.4 and Appendix 4 suggest that soil chemical content varied from primary forest to secondary forest and shrub. Soil samples from KSNP were generally acid as indicated by a low pH. The availability of some soil components such as K, Ca, and Mg in the soil samples of primary forest were greater than in other land cover types. On the contrary some soil chemical components such as organic carbon, nitrogen and phosphorus in shrub were greater than in others.

Figure 6.4 (C) shows that nitrogen content in soil under shrub is greater than in other land covers. However, based on the test of GLM (Table 6.2) this difference is statistically not statistically significant. Nitrogen content of a soil is determined by the relative rate of gain and loss (Miller and Donahue, 1990). Loses usually predominate under cultivation, and gains under bush fallow, but the actual situation is a dynamic one and under stable conditions nitrogen tends towards an equilibrium value (Jones and Wild, 1975).

Table 6.2. Analysis of General Linear Model (GLM) of soil properties in KSNP by forest type and soil depth

6.2.1. Analysis of Variance for pH

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Veg. Type	2	1.48853	1.48853	0.74427	28.77	0.034*
Depth	1	0.06827	0.06827	0.06827	2.64	0.246
Error	2	0.05173	0.05173	0.02587		
Total	5	1.60853				

*: Statistically significant at 0.05 level

6.2.2. Analysis of Variance for C

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Veg. Type	2	58.364	58.364	29.182	52.96	0.019*
Depth	1	10.881	10.881	10.881	19.75	0.047*
Error	2	1.102	1.102	0.551		
Total	5	70.347				

6.2.3. Analysis of Variance for N

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Veg. Type	2	0.205300	0.205300	0.102650	17.65	0.054
Depth	1	0.056067	0.056067	0.056067	9.64	0.090
Error	2	0.011633	0.011633	0.005817		
Total	5	0.273000				

6.2.4. Analysis of Variance for P

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Veg. Type	2	63.29	63.29	31.64	1.53	0.395
Depth	1	37.45	37.45	37.45	1.82	0.310
Error	2	41.26	41.26	20.63		
Total	5	142.00				

6.2.5. Analysis of Variance for K

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Veg. Type	2	380.22	380.22	190.11	12.45	0.074
Depth	1	6.32	6.32	6.32	0.41	0.586
Error	2	30.54	30.54	15.27		
Total	5	417.09				

6.2.6. Analysis of Variance for Ca

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Veg. Type	2	114.09	114.09	57.04	2.66	0.273
Depth	1	19.91	19.91	19.91	0.93	0.437
Error	2	42.90	42.90	21.45		
Total	5	176.90				

6.2.7. Analysis of Variance for Mg

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Veg. Type	2	8.2832	8.2832	4.1416	4.84	0.171
Depth	1	0.8438	0.8438	0.8438	0.99	0.425
Error	2	1.7113	1.7113	0.8557		
Total	5	10.8383				

6.2.8. Analysis of Variance for Na

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Veg. Type	2	0.00270000	0.00270000	0.00135000	81.00	0.012
Depth	1	0.00001667	0.00001667	0.00001667	1.00	0.423
Error	2	0.00003333	0.00003333	0.00001667		
Total	5	0.00275000				

Analysis of General Linear Model (Table 6.2) of soil chemical properties in relation to land cover types and soil depth reveals that there was a significant correlation between land cover types and the soil chemical constituents of pH (P-value = 0.034) and organic carbon (P-value = 0.019). However, there was no significant correlation with only other soil chemical properties.

The result also indicates that the factor of soil depth provides a significant correlation with soil organic carbon (P-value = 0.047) but there was no significant correlation with other soil chemical components. Greater amount of organic matter were found in the topsoil than that in the subsoil layer for all land cover types. This is reasonable because organic matter is firstly stored in the topsoil before it goes to the sub soil layer or underneath. The production of organic matter is influenced by climatic conditions. As Jones and Wild (1975) noted, the amount of organic matter in the wet season is greater than in the dry season because plants grow faster to produce plant residues returned to the soil. Organic matter also provides the major soil aggregate-forming cements and is therefore important in reducing soil erosion (Miller and Donahue, 1990).

In short, the results suggest that even though there were slight changes in the soil chemical constituents due to the alteration of land cover from primary forest to secondary forest and shrub, in general their changes are not statistically significant, except for pH and organic carbon. This might because those plots remain covered by vegetation for a long period which leads to the internal mineral turn over through organic matter decomposition.

6.3. Vegetation change

Encroachment by the surrounding people in KSNP started with forest clearance through slash and burn and has resulted in some abandoned lands scattered across the park. Some abandoned areas are becoming shrub lands and some others have changed into secondary forest. In order to investigate whether forest succession is possible or not in such areas, therefore, this section is aimed at assessing the vegetation change in those areas compared to the virgin primary forest.

6.3.1. Forest succession

Forest succession has been discussed by many researchers (West *et al.*, 1981; Loucks, 1981; McIntosh, 1981; Shugart, 1984; Spurr and Barnes, 1992). It is usually defined as a continuous change in species composition of natural communities that result from many processes, particularly the growth and mortality of organisms under environmental conditions that are continuously changing as a result of the actions of organisms themselves and/or externally imposed processes (Drury and Nisbett, 1973 cited from Zedler, 1981; Huston, 1994), or in short as a replacement of the biota of an area by one of a different nature (Spurr and Barnes, 1992). Therefore, succession is a continuing process with the passage of time. In indefinite time without any disturbance from any external factors such as fire and human activities, the plant succession will attain its climax stage in which all species will be in an equilibrium condition (Spurr and Barnes, 1992).

6.3.2. Species composition

The methodological approach for the data collection to analyse vegetation change was described in Chapter three. The data recorded from the sample plots are presented in Appendix 5 and summarised in Table 6.3. The average number of species per plot recorded from primary forest, secondary forest and shrub for pole, sapling and seedling is shown in Figure 6.3.

The results indicate that there were 31 families recorded from the sample plots, consisting of 45 species and 174 individual plants. The vegetation composition in the sample plots was very heterogeneous. It was dominated by the families of Sapindaceae, Lauraceae, Aspleniaceae, Euphorbiaceae and Fagaceae. Among species most frequently recorded more than others in the sample plots were *Cinnamomum* *subavenium, Mischocarpus sundaicus, Asplenium, Lithocarpus, Cryptocarya densiflora, Eugenia lineata and Macaranga triloba* (Appendix 5).

Table 6.3 shows that within the plot of primary forest, there were 13 families consisting a total of 35 species recorded as poles 7 species, saplings 12 species and seedlings 16 species. About 53.8 % of the total families or 28.6 % of total species recorded were found both in the form of poles, saplings and seedlings. This indicates that some 46.4 % of poles or saplings were not producing seedlings in that sample plot.

Table 6.3. Average number of family, species and individual plants recorded in the primary forest, secondary forest and shrub sample plots in KSNP.

Sub Sample Plot	Land Cover Type						Total
	Primary Forest		Secondary Forest		Shrub		
	No.	%	No.	%	No.	%	No.
Pole:							
Family	5	35.7	9	64.3	-		11 (3)
Species	7	43.8	9	56.2	-		13 (3)
Individual	18	51.4	17	48.6	-		35
Sapling:							
Family	9	50.0	13	72.2	3	16.7	12 (6)
Species	12	37.5	16	50.0	4	12.5	24 (8)
Individual	24	43.6	27	49.1	4	7.3	55
Seedling:							
Family	13	39.4	17	51.5	14	42.4	23 (10)
Species	16	34.8	23	50.0	14	30.4	35 (11)
Individual	21	25.0	39	46.4	24	28.6	84
Total:							
Family	13	27.7	22	46.8	17	36.1	31 (16)
	(7)	(53.8)	(10)	(45.5)	(1)	(14.3)	
Species	35	56.5	48	77.4	18	29.0	45 (17)
	(10)	(28.6)	(12)	25.0	(1)	(5.5)	
Individual	63	36.2	83	47.7	28	16.1	174

Note: Numbers in brackets are the number of the same family/ species (out of the number in the left or above bracket) present in all primary forest, secondary forest and shrub plots.

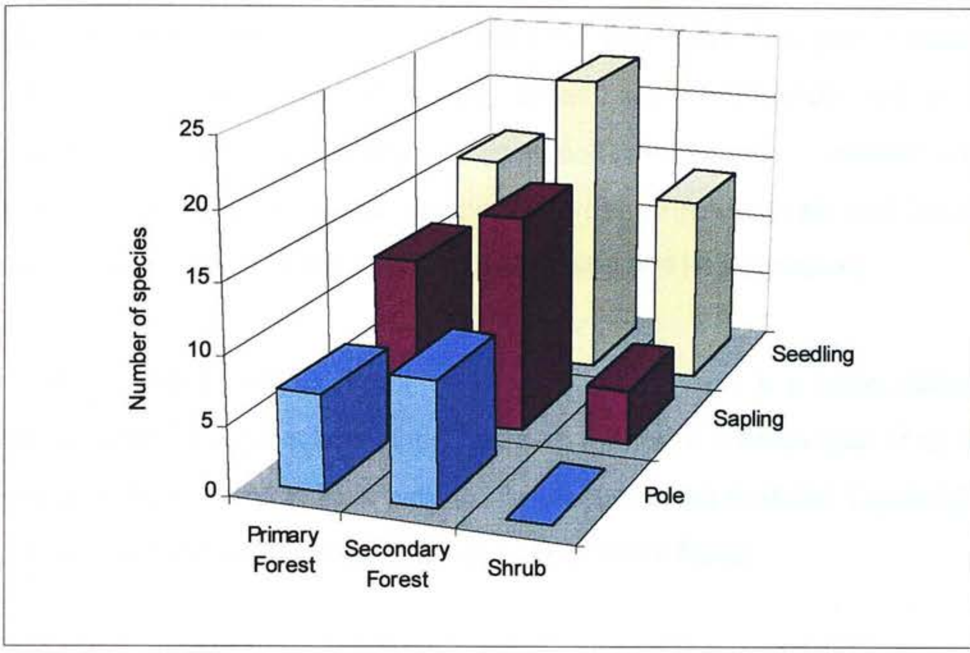


Figure 6.5. Average number of species of woody plants per plot in KSNP

In the secondary forest, 22 families consisted of 48 species were recorded. These species were distributed as 9 species of pole, 16 species of sapling and 23 species of seedling. This indicates that the secondary forest produces more diversity and number of sapling and seedling than the primary forest. This is because pole, sapling and seedling which were found as the same species comprised only 25 % of the total species recorded.

There were 17 families found in the shrub sample plots consisted of 18 species. With 4 species as sapling, 14 species as seedlings, and no pole was recorded. Vegetation in the shrub sample plots seems more heterogeneous because only 5.5 % of the total species recorded has the same species for sapling and seedling.

Comparison across the sample plots revealed that 17 species (37.8 %) of the total species recorded were found in all primary forest, secondary forest and shrub plots.

About 23 % of the total pole species were found in the primary and the secondary forest. And 33.3 % of the total sapling species was recorded under primary forest, secondary forest and shrub. Whereas the number of species of seedling found in all sample plots was about 31.4 %. This indicates that there is a poor similarity in vegetation composition between primary forest, secondary forest and shrub. A Pearson correlation test on family of vegetation composition revealed that the correlation between primary and secondary forest, primary forest and shrub and secondary forest and shrub are 0.6633, 0.2675 and 0.09919 respectively.

Based on the above analysis, it can be concluded that there is a large chance that abandoned lands by encroachers might return to a form of a forest land if no further external disturbances occur. However, the forest succession in Bukit Tapan KSNP is unlikely to attain the same climax as the existing primary forest.

6.3.3. Species similarity index

The similarity between species occurrence in the sample plots (primary forest, secondary forest and shrub) was approached by the coefficient of association. This coefficient was calculated based on the abundance of woody plants recorded in the plots using three different formula: Sorensen's Coefficient, Simple Matching Coefficient and Baroni-Urbani and Buser's Coefficient (Krebs, 1989). The range of all similarity index for binary data is supposed to be 0 (no similarity) to 1.0 (complete similarity). The results of the calculation of the similarity index are presented in Table 6.4. The formula utilised to calculate the similarity index are as follows:

Sorensen Coefficient :

$$S_S = \frac{2a}{2a + b + c} \tag{6.1}$$

Simple Matching Coefficient :

$$S_{Sm} = \frac{a + d}{a + b + c + d} \tag{6.2}$$

Baroni-Urbani and Buser Coefficient: $S_B = \frac{\sqrt{ad} + a}{a + b + c + \sqrt{ad}}$ (6.3)

Where :

a = Number of species in sample plot A and B (joint occurrence)
b = Number of species in sample plot B but not in sample plot A
c = Number of species in sample plot A but not in sample plot B
d = Number of species absent in both samples (zero-zero matches)

Table 6.4. Similarity indexes of vegetation species in three different land cover types (LCT) of the primary forest (PF), the secondary forest (SF) and shrub (SH) in KSNP.

	Species Similarity Index								
	Sorensen			Simple Matching			Baroni-Urbani and Buser		
LCT	PF	SF	SH	PF	SF	SH	PF	SF	SH
PF	1			1			1		
SF	0.51	1		0.40	1		0.44	1	
SH	0.51	0.37	1	0.53	0.31	1	0.52	0.34	1

Table 6.4 shows that there is no high pair of similarity in the community of vegetation species between primary forest, secondary forest and shrub. The results are in accordance with the previous analysis, therefore, it is unlikely that the vegetation succession in KSNP after encroachment will attain the same species composition with the existing primary forest. The table also shows that three different calculation methods produce the similar value of the similarity index.

6.4. Summary

Encroachment in KSNP has influenced the soil chemical constituents and the vegetation composition of the abandoned lands. There was a tendency for some soil chemical components to decrease as the length of encroachment increased and also with alteration of land cover. However, the change of most soil components was not statistically significant. Abandoned lands by encroachers both in the secondary forest and in the shrub land have a relatively high vegetation diversity. These areas might return to a form of a forest land if no further external disturbances occur. However, since the secondary forest and the abandoned lands have a different vegetation composition from that of the primary forest and a low level of similarity index, it is unlikely that they will attain the same climax as the existing virgin forest. The next chapter presents buffer zone development in order to increase the Park's ability to protect its biological resources and provide income generating opportunities for the local people.

CHAPTER SEVEN

BUFFER ZONE DEVELOPMENT

7.1. Introduction

National parks throughout the world, including KSNP, are being threatened as population growth and expansion results in the conversion of forest on surrounding lands to human-dominated land uses such as agriculture (Schelhas, 1992; Ghimire, 1994). This human activity is in response to the legitimate necessities of people who have no other land available from which to meet their subsistence needs. In response to this situation, increasing attention is being focused on meeting development needs outside Parks whilst at the same time promoting land uses compatible with biological conservation adjacent to the park (Wells *et al.*, 1990; West and Brechin, 1991). Buffer zones surrounding national parks with land uses that can both increase a park's ability to protect biological resources and provide subsistence and income generating opportunities for local people have been proposed to resolving people-park conflict (MacKinnon, 1982; Wind, 1991; Sayer, 1991; Schelhas, 1992).

This chapter is concerned with the development of buffer zones in KSNP and presents three main sections: the theoretical background of buffer zones, Indonesia's policy for buffer zone establishment and the application of GIS-based method for designing suitable areas for buffer zones in KSNP.

7.2. Theoretical Background

There is a general consensus that the traditional concept of parks management which is largely based upon patrolling and law-enforcement policy is not effective in handling people-park conflict (Wind, 1991). To minimise the inevitable people-park conflicts that occur when human settlements directly abut national parks, such as in

Kerinci Seblat, buffer zone development is one way to relieve direct contact of these mutually conflicting land uses (MacKinnon, 1982; Poore and Sayer, 1991). The definitions, objectives and types of buffer zones as well as factors considered in establishing buffer zones are presented in the following sections.

7.2.1. Definition

There are many different versions of the definition of buffer zone, two of which are presented here. MacKinnon (1982) and Poore and Sayer (1991) stressed the function of buffer zones in their definition:

> *'Areas peripheral to national parks or reserves which have use restrictions to give added protection to the reserve, and to compensate local people for the loss of access to the resources of strict reserve areas'.*

Whilst the Act No. 5 of 1990 of The Republic of Indonesia, concerning Conservation of Living Resources and Their Ecosystem (Ministry of Forestry, 1992), emphasised the physical aspects of buffer zones, and define them as:

> *'Areas outside nature reserves, in the form of other forestlands, government lands or whose rights have been assigned, which are needed and able to support the reserves integrity (Article 16, Paragraph 2).*

Buffer zones according to MacKinnon (1986) may serve two main function:

(1) *Extension buffering*

It is an extension area of the habitats contained within the park allowing total breeding populations of both wildlife and plant species to exceed those limits provided by the park boundaries. Protection forests, recreation forest and selectively logged production forests are examples of such buffering.

(2) *Socio-economic buffering*

Where the management objective is for the benefit of the local people such as to provide firewood and other forest products which were formerly collected inside the park, as well as to produce cash crops, medicinal plants animal fodder and meet other subsistence needs.

7.2.2. Objectives

Based on the above definitions and the functions of buffer zones, there are two sets of objectives of buffer zones development: to maintain the integrity of the conservation area and at the same time to improve the livelihoods of local people. However, Wells, Brandon and Hannah (1992) suggested that the integrity of the park and protected areas is the principle objective of buffer zone development as also mentioned in the Indonesian Law No. 5 of 1990. Therefore, any management of buffer zones should be directed primarily to attain its principle objective. Buffer zone development in many developing countries has failed so far because the relative priority of objectives have not been stated clearly (Wind, 1991).

7.2.3. Types of buffer zone

There are many types of buffer zone (MacKinnon and MacKinnon, 1986; Wind, 1991) which can possibly be established around parks and protected areas. There can be categorised into three different groups:

1). Physical buffers

If there is no available land for buffer zone development, the park boundary itself must serve as a buffer. It can be in the form of canals, ditches, walls, fences or spiny hedges. This aims to discourage wildlife from leaving the park and prevent people and domestic livestock from entering the park.

2). Socio-economic buffers

In order to reduce the needs of local peoples to take resources from the park and to limit encroachment expansion, a socio-economic buffering is some time needed. This buffer is designed to restrict access to the park and to enhance support for the integrity of the park. This could take the form of special agriculture such as cash tree plantation, social or communication assistance or provision of productive buffer lands. In a situation where indigenous people still live within the parks and when no suitable land exist outside the parks, traditional use zones could be developed in the parks using some parts of the parks' area.

3). Alternative resource buffers

These buffers aim to withhold people from entering the parks by offering alternative supply, such as fuel wood, fodder, or timber forest to relieve villagers who are directly dependent on these resources for their daily use but for which no alternative resources are available in their present state of development. These could take the form of natural forest, enriched secondary forest or even plantation where the emphasis is on maximising sustained yield for local village use.

Every park has specific problems related to the sosio-economic condition of the surrounding communities, the potential resources and the unique scenic area of the park. Therefore, the needs of buffer zones varies from one to another park. Given the present encroachment problems in KSNP largely caused by the limited agricultural land available to meet people's subsistence needs, it is the combination of the second and the third buffering category which will most likely be suitable for KSNP it is here that were therefore considered in this study.

7.2.4. Factor consideration

A buffer zone will have an increased probability of achieving its functions if the relevant factors are carefully taken into consideration in the planning stage of the establishment. These factors are of importance in determining the type of buffer zones needed for a protected area. MacKinnon and MacKinnon (1986) suggested the following factors be considered in establishing a buffer zone:

(1) The needs of threatened wildlife species for use of additional habitat outside the park boundaries. The closer the buffer zone to the park boundary the better;
(2) The need for buffer zone to serve other protective functions, such as soil and water conservation. In this case the degree of slope is an important factor to be considered;
(3) The reasonable needs of local people for land and forest products and the suitability of possible buffer crops for the particular land type and climatic conditions. In this case site altitude should be taken into consideration;
(4) The amount of land available for buffer use, whether it is currently under natural vegetation or under other land uses. This factor will serve as a constraint in buffer zone establishment.

7.3. Indonesia's Policy for Buffer Zone Establishment

Some of Indonesia's protected areas including national parks are now facing problems of population pressure. As populations grow and expand, the threat of encroachment expansion, resulting in the conversion of protected areas to human-dominated land uses such as agriculture and settlements, is intensifying. The Government has set up policies and programmes to resolving these people-park disputes. These include the promulgation of an Act on the Conservation of Natural Resources and Ecosystems (Act No. 5 of 1990), the political will to set clear policies for future buffer zone development, and promotion of ICDPs system (Integrated

Conservation Development Programmes) for managing protected areas integrated with the socio-economics and regional development.

7.3.1. Legal basis

There are few countries where national legislation allows national park and reserve agencies to manage land as a buffer around protected areas (Sayer, 1991). In Indonesia, the development of national parks and buffer zones is based on the Indonesian Act No. 5 of 1990, concerning Conservation of Living Resources and Their Ecosystem (Ministry of Forestry, 1992). Based on this Act, a National Park should be managed through a zoning system which may consist of a core zone, a utilisation zone and other zones such as wilderness zone, traditional use zone, rehabilitation zone and so on depending on the necessity (Article 32). Buffer zones are suggested by the Act (Article 16) to be established in adjacent areas of sanctuary reserves including national parks. This Act states that buffer zones are to be placed outside the protected areas and are needed for safeguarding of the integrity of the protected areas. This makes clear that the buffer zone is not a part of the protected area, but it supports the protected area's objectives.

7.3.2. Policy for buffer zone planning

The buffer zones development programme in Indonesia is rather complex, involving many different parties and organisations. Using conventional methods, defining the links between conservation factors and development aspects to establish buffer zones in a national park can take several years. Several steps have to be undertaken before buffer zones can be developed, and as Wind (1991) noted (Figure 7.1), the planning of buffer zones in Indonesia take place at three levels: national level, national park level and resort level.

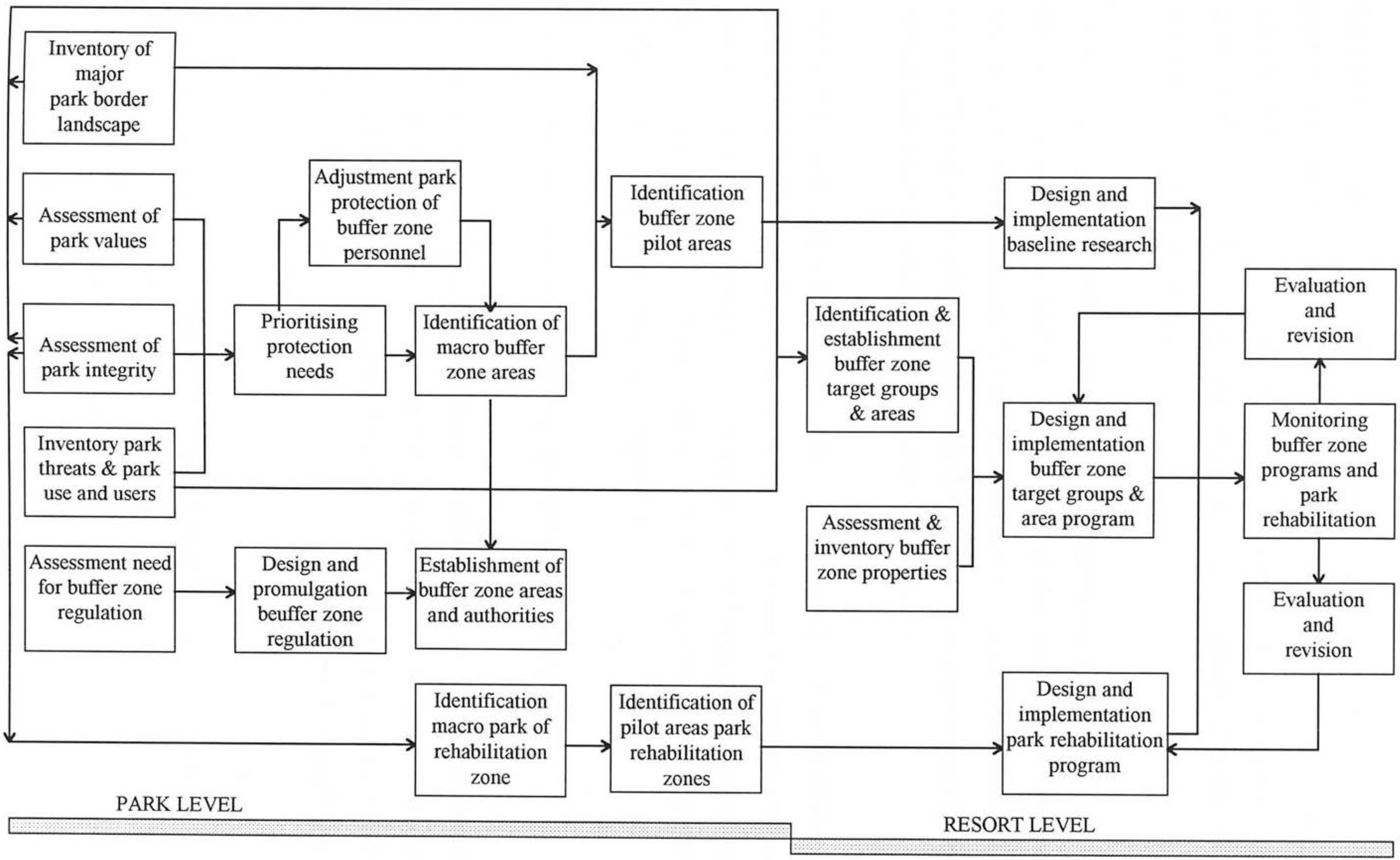


Figure 7.1. National park buffer zone planning scheme in Indonesia (Wind, 1991)

Buffer zones planning at National level is co-ordinated by the Directorate General of PHPA. It is mainly focused on the assessment of the need for buffer zones for prioritised protected areas, review for buffer zone regulation, co-ordination with related authorities at the national level, monitoring and evaluation of buffer zone implemented by the park authorities.

At national park level, buffer zone planning is co-ordinated by the head of the Regional Forestry and the head of a national park in close co-operation with the relevant government agencies. The activities are focused on the identification of major ecological landscape units across the park boundary, assessment of park values and integrity, inventory of park threats and park uses and users.

All the above data will then be utilised in the final step 'resort level' to establish the most suitable areas for buffer zones, identifying target groups and designing buffer zone implementation programmes. This final step is co-ordinated by the head of the park in close relation with the head of the sub district. The general overview of the buffer zones planning scheme is shown in Figure 7.1.

7.4. The GIS Application for Buffer Zone Establishment in KSNP

Buffer zone establishment in most of Indonesia's national parks so far has been based on subjective judgement of the actors involved. Factors and constraints for the buffer zone development were poorly measured and then visually delineated in a map. With such a designation system, the ability of a buffer zone to attain its objectives is questionable.

The application of GIS-based methods provides an alternative system for buffer zone designation. These were based on more accurate consideration of factors and constraints. The target group in the designation of buffer zone is villagers residing across the Park boundary, especially the encroachers' households. Therefore, it is intended to negate both the expansion of encroachment areas in the Park, whilst at the same time to providing alternative sources for people's subsistence needs. To meet these objectives, the criteria of locations best suited for buffer zones should be identified. Based on the consideration of the relative importance of the economic and ecological factors, four scenarios were applied to provide alternative choices of the most suitable buffer zones in KSNP.

7.4.1. Methods

The Multi-Criteria Evaluation tool (MCE) running within IDRISI-GIS was utilised in this study for land suitability analysis of buffer zones in KSNP. This module has the capability of combining the information from several criteria and constraints to form a single index of evaluation through a series of standardisation, weighing and pairwise comparison procedures in order to achieve a specific objective. Some fundamental methodological approaches of the buffer zone development in this study, including the reasoning for criteria selection, were presented in the Overview of Research Methods (Chapter three). Whilst the detailed analysis procedure for buffer zones establishment in this study is shown in Figure 7.2.

7.4.2. Establishing the criteria: factors and constraint

Criteria are defined as some basis for a decision that can be measured and evaluated, and upon which a decision is based. Criteria can be of two kinds: factors and constraints. A factor is a criterion that enhances or detracts from the suitability of a specific alternative for the activity under consideration, while a constraint serves to limit the alternatives under consideration. There are therefore measured on a continuous scale (Eastman, 1995). The procedure by which criteria are combined to arrive at a particular evaluation and then compared and acted upon is known as a decision rule.

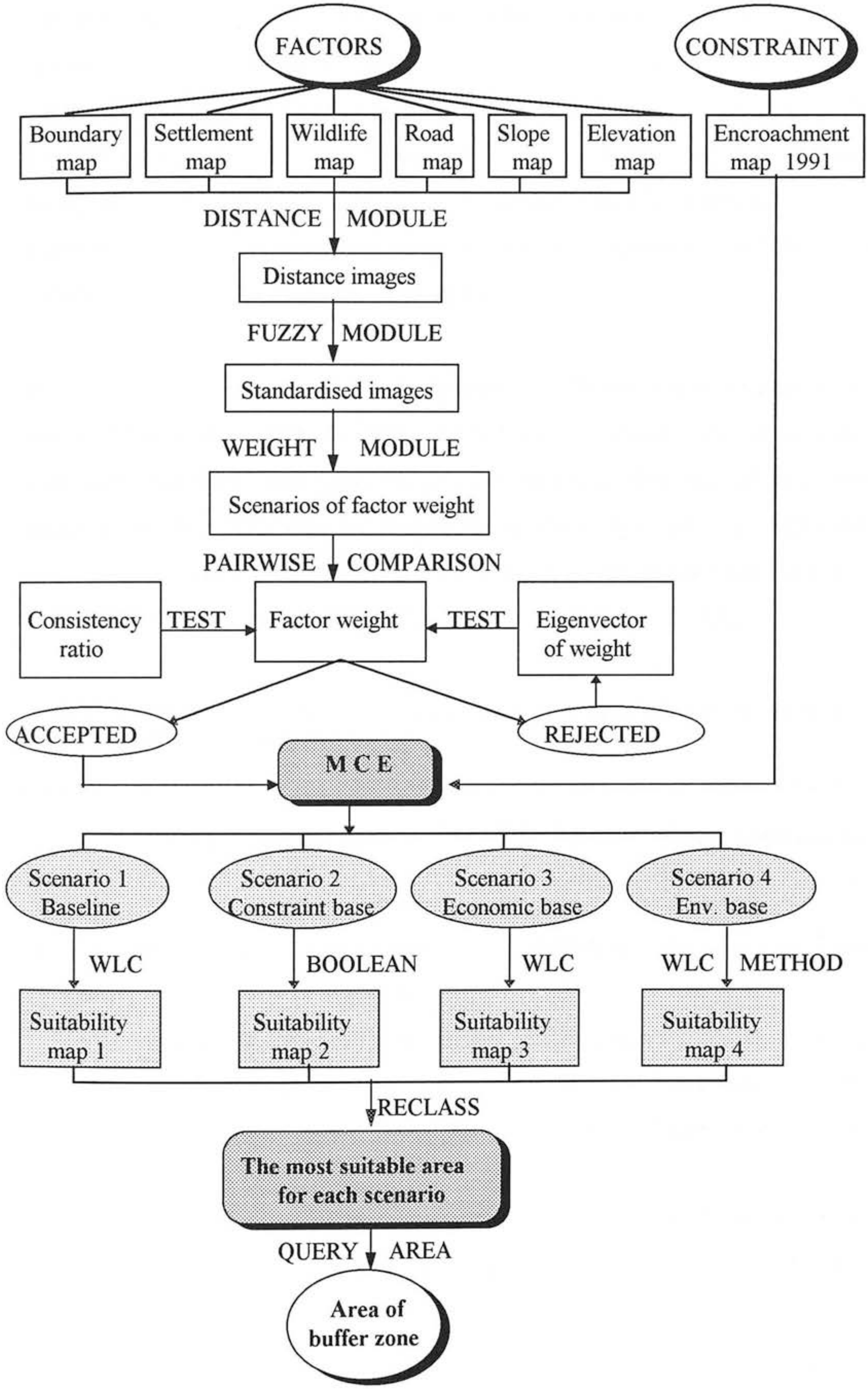


Figure 7.2. The GIS process of building suitability map for buffer zones in KSNP

The rules and criteria for establishing the buffer zone in KSNP were derived from interviews with the people surrounding the Park, questionnaires and from the GIS analysis of existing encroachment data deducted from the land use map of KSNP as presented in Chapter three. Based on these analyses, seven factors were identified as being relevant to the development of buffer zones in KSNP: proximity to the Park boundary, proximity to settlement, proximity to road, proximity to wildlife corridor, suitability of slope and suitability of elevation.

In order to encourage peoples' participation in buffer zones management, the designed buffer zones were defined to be in the encroachment area out of the 1995 boundary. Therefore, encroachment areas in land use 1991 served as a Boolean image coded as 1 and were involved in the spatial analysis process, while the non encroachment areas were coded as 0 and were excluded from the analysis. The criteria and rules for establishing buffer zones are summarised in Table 7.1.

Table 7.1. The rule of each factor and constraint for establishing buffer zone in KSNP using MCE module

Classification of MCE		Rules	Requirements of criteria
Group of factor:	Factor and constraint:		
A. Management factor	1. Proximity to the park boundary	< 2000 m	The nearer, the better
B. Economic/cost related factors	2. Proximity to settlement	< 5000 m	The nearer, the better
	3. Proximity to road	< 5000 m	The nearer, the better
C. Ecological factors	4. Proximity to wildlife corridor	> 2000 m	The farther, the better
	5. Suitability to slope	< 40 %	The flatter, the better
	6. Suitability to elevation	< 1500 m	The lower, the better
Constraint	7. Encroachment area in 1991	Boolean image	Should be in the existing encroachment area 1991

7.4.3. Standardising the factors

A Multi Criteria Evaluation within IDRISI is possible for further processing if the input maps are in the standard form. Therefore, all the six factor maps were standardised to a consistent range of 0 - 255, while the constraint was developed as a Boolean map. Standardisation was achieved by application of Distance module and Fuzzy set module within IDRISI on each factor using suitable types of membership function curve and control points as presented in Table 7.2.

Table 7.2 . The type of membership function curves and their inflection control points to standardise factor maps in fuzzy set module application

Classification of MCE		Type of membership	Control
Group of Factor	Factor	function curve	points
A. Management factor	1. Proximity to the park boundary	J-Shaped, monotonically decreasing	0 ; 2000
B. Economic/ cost related factor	2. Proximity to settlement	J-Shaped , monotonically decreasing	1000 ; 5000
	3. Proximity to road	J-Shaped , monotonically decreasing	2000 ; 5000
	4. Proximity to wildlife corridor	Sigmoidal, monotonically increasing	2000 ; 5000
C. Ecological factors	5. Suitability to slope	Sigmoidal, monotonically decreasing	0 ; 40
	6. Suitability to elevation	Linear, monotonically decreasing	0 ; 1500

7.4.4. Establishing the factor weights and scenarios

Once the standardised maps were created, the Multi Criteria Evaluation (MCE) procedure requires a set of weightings be defined in order to reflect importance of each of the seven factors to meet the defined objective. This was accomplished using the IDRISI pairwise comparison matrix based on Saaty's (1977) technique known as Analytical Hierarchy Process (AHP). The comparison concerns the relative importance of the two criteria (row factor to column factor) involved in the determining suitability area for buffer zones. The rating was based on Saaty's AHP technique (1977) which is available in an IDRISI module of 'nine-point continuous scale' as shown in Table 7.3.

Table 7.3. A pairwise comparison 'nine-point continuous scale' as a reference basis to assign the relative importance of map factors

1/9	1/7	1/5	1/3	1	3	5	7	9
Extremely	Strongly	Moderately		Equally		Moderately	Strongly	Extremely
Less importance						More importance		
Relative importance of factor row to factor column								

Based on the relative importance of management factor (proximity to the Park boundary), economic cost related factors (proximity to settlement and road) and ecological factors (proximity to wildlife corridor, suitability of slope and elevation), four scenarios of land allocation best suited for buffer zones were envisaged: baseline scenario, economic base scenario, ecological base scenario and constraint base scenario. The baseline scenario considered each factor with equal priority. Whilst, the three other scenarios were developed putting economic/cost related factor as the top priority for economic base scenario, ecological factors as the top priority for ecological based scenario and constraint image as the top priority for the constraint base scenario.

An IDRISI Weight module was utilised to assign a set of weights totalled to one for each factor in each scenario as required by the weighted linear combination procedure. The construction of the pairwise comparison matrix, indicating the relative importance of factor row to factor column, was a subjective process. Therefore, an investigation of the consistency of the ranking factors in the matrixes is required. To produce a best fit set of weights, the principal eigenvector of the pairwise comparison matrix was calculated. The consistency ratio of the ranking factors in the matrixes was computed using the Weight module in IDRISI to test the reliability of the assigned weights. Matrices with consistency ratio (CR) of 0 are excellent, and a CR of 1 is poor, while CR of 0.10 should be re-evaluated (Saaty, 1977). All consistency ratios obtained for the four scenarios were less than 0.05 which is an acceptable result (Table 7.4 for the baseline scenario; Table 7.5 for the economic base scenario and Table 7.6 for the ecological base scenario).

Table 7.4. Pairwise comparison matrix of the relative importance factors, weighting factors and consistency ratio for the baseline scenario

Factors	F1	F2	F3	F4	F5	F6	The eigenvector of weight	Consistency Ratio (CR)
Boundary	1						0.1667	0.00*
Settlement	1	1					0.1667	
Road	1	1	1				0.1667	
Slope	1	1	1	1			0.1667	
Wildlife	1	1	1	1	1		0.1667	
Elevation	1	1	1	1	1	1	0.1667	

Table 7.5. Pairwise comparison matrix of the relative importance factors, weighting factors and consistency ratio for the economic base scenario

Factors	F1	F2	F3	F4	F5	F6	The eigenvector of weight	Consistency Ratio (CR)
Boundary	1						0.4148	0.01*
Settlement	1/2	1					0.2547	
Road	1/3	1/2	1				0.1532	
Slope	1/5	1/3	1/2	1			0.0896	
Wildlife	1/7	1/5	1/3	1/2	1		0.0540	
Elevation	1/9	1/7	1/5	1/3	1/2	1	0.0336	

Table 7.6. Pairwise comparison matrix of the relative importance factors, weighting factors and consistency ratio for the ecological base scenario

Factors	F1	F2	F3	F4	F5	F6	The eigenvector of weight	Consistency Ratio (CR)
Boundary	1						0.4076	0.03*
Wildlife	1/2	1					0.2490	
Slope	1/3	1/2	1				0.1582	
Elevation	1/5	1/3	1/2	1			0.1043	
Settlement	1/7	1/5	1/3	1/3	1		0.0535	
Road	1/9	1/7	1/7	1/5	1/3	1	0.0274	

Key labels:
F1 (Boundary) : proximity to the park boundary
F2 (Settlement) : proximity to the nearest settlement
F3 (Road) : proximity to the nearest road
F4 (Slope) : slope category
F5 (wildlife) : proximity to the wildlife corridor
F6 (Elevation) : elevation category
* : Consistency ratio (CR) is acceptable

7.4.5. Areas best suited for buffer zones

Once the weights were assigned to seven factor maps, the seven weighted maps and constraint map (Boolean non encroachment map) for each scenario were combined using MCE process to produce the suitable areas of buffer zones. MCE was completed by multiplying each raster pixel within each map by its weight. A weighted Linear Combination (WLC) method was utilised to sum the multiplied maps. The resulting map had a range of values that matched the IDRISI standardised 0 - 255 levels. The constraint map was then overlaid with the resulting map in turn in order to remove the unsuitable areas (0 zones). The suitability map for each scenario was developed in the IDRISI standardised range of 0 - 255 levels.

In IDRISI, the higher values in a standardised map represent those areas which are considered to be highly favoured in the decision making. Depending on different management and decision-making considerations, the standard can be modified in order to filter out the most suitable areas. In this study the areas with a rank in the

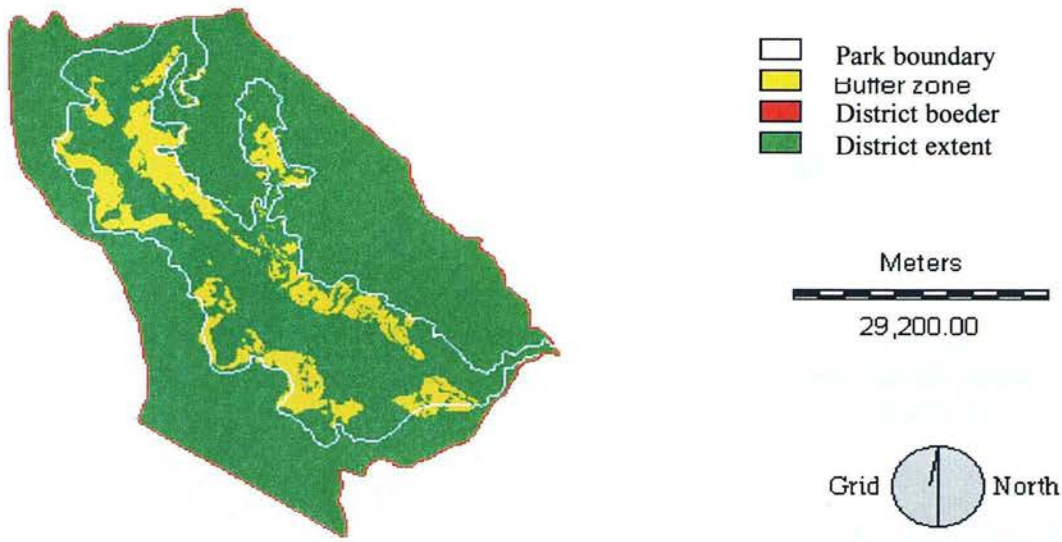


Figure 7.3. Buffer zone in KSNP based on baseline scenario

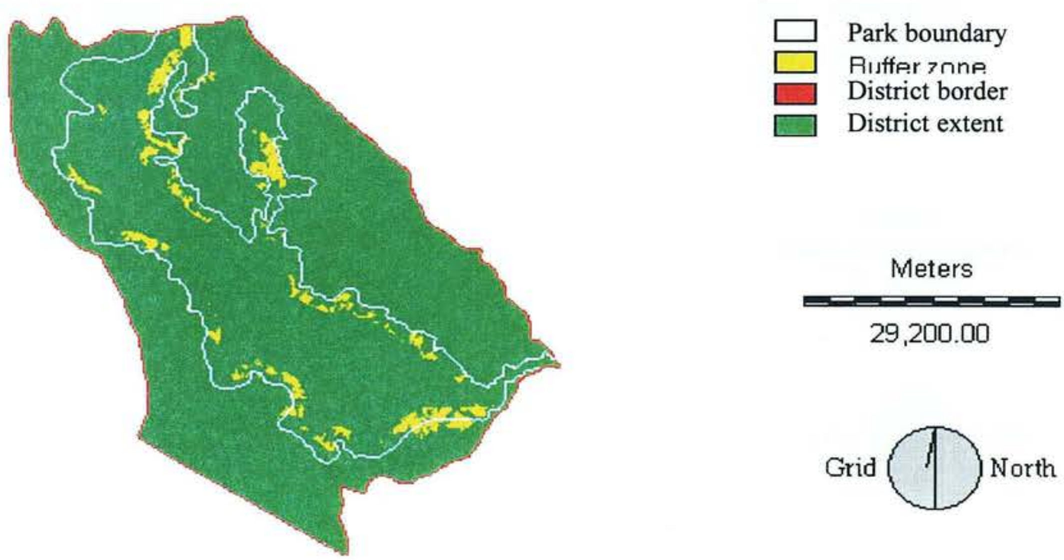


Figure 7. 4. Buffer zone in KSNP based on constraint base scenario

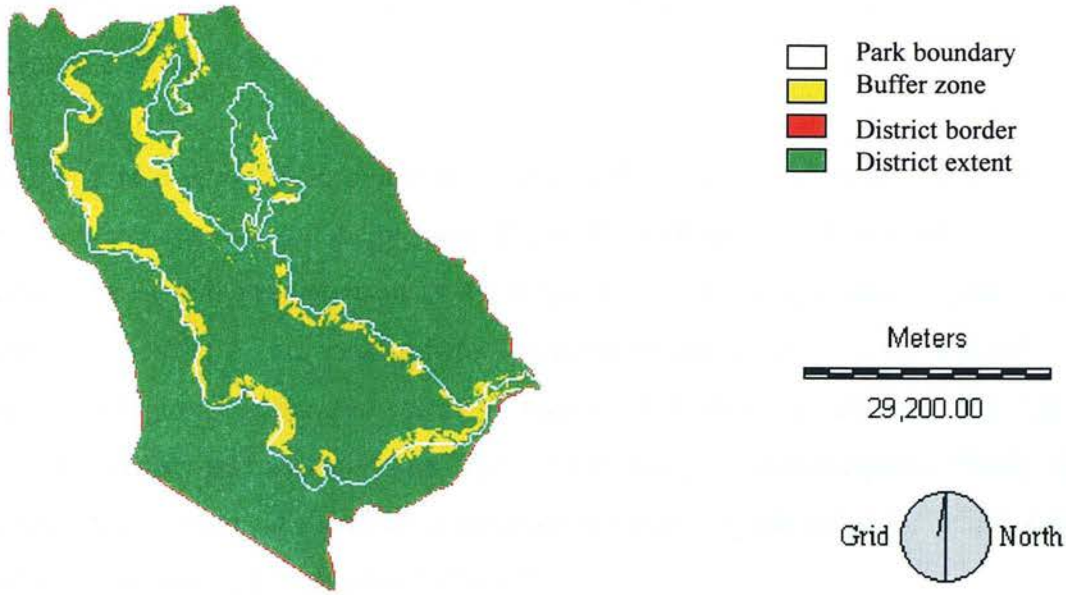


Figure 7.5. Buffer zone in KSNP based on economic base scenario

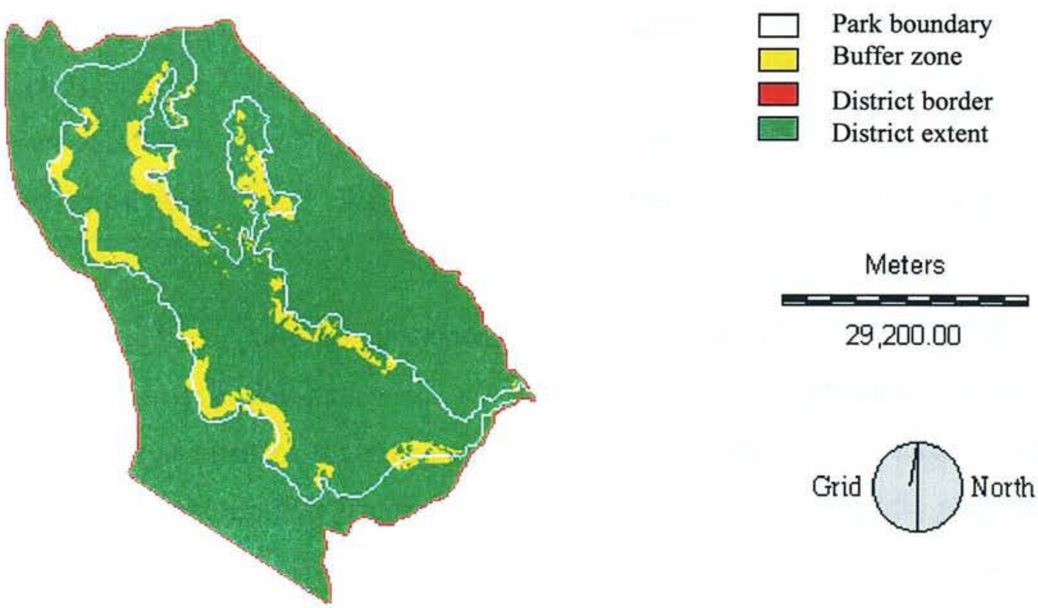


Figure 7.6. Buffer zone in KSNP based on ecological base scenario

suitability map equal or greater than 200 were subjectively defined as the most suitable area for buffer zones in each scenario.

The final step using MCE, therefore, was to define the most suitable areas for buffer zones within the four suitability maps. The RECLASS module was adopted to extract areas that meet the requirement as the areas of suitability map equal or greater than 200. The results of the most suitable areas for buffer zones for each scenario are shown in Figure 7.3 (Baseline scenario), Figure 7.4 (Constraint base scenario), Figure 7.5 (Economic base scenario) and Figure 7.6 (Ecological base scenario). Finally, the Query area module was applied to calculate the most suitable areas for buffer zones of each scenario as presented in Table 7.7.

Table 7.7. Comparison of scenarios based on the resulting most suitable areas for buffer zones in KSNP

Scenario	MCE method	The most suitable area (pixel score > 200)
Baseline	Weighted linear combination	40,785 ha
Constraint base	Boolean overlay	14,511 ha
Economic base	Weighted linear combination	25,587 ha
Ecological base	Weighted linear combination	29,911 ha

There are two types of judgement involved in the process of buffer zone development: scientific judgement and management related judgement. The process of criteria selection for the area best suited to buffer zone and the methodological approach for the relative importance of factor weighting are scientific judgements. Whilst the choice of economic or ecological priority considerations for buffer zone establishment by the Park manager is mainly a management related judgement.

The results show that each scenario produced a different area best suited to buffer zone. The area varied from 25,587 hectares (Economic base scenario) to 40,785 hectares (Baseline scenario). These buffer zones are all located outside the Park boundary of 1995. Therefore, all scenarios met the criteria of a buffer zone stipulated by the Indonesian Act No. 5 of 1990.

These scenarios provide alternative preferences for the Park manager to establish the most suitable buffer zones in KSNP that may be best suited to the priority objectives of the Park management. It is important that the current socio-economic predicament in Kerinci District as well as the present political situation are taken into consideration in the decision for the scenario selection. The selected scenario will be utilised for further analysis in the development of alternative management in order to alleviate population pressure on the Park (Chapter Eight).

7. 5. Comparison with the Existing Traditional Use Zones

Traditional use zones are one of the zones which may be established within a national park. Based on the Indonesian Act No. 5 of 1990 this zone aims to compensate villagers for the loss of access to the park. In this zone, therefore, local people are permitted to collect firewood, animal fodder, medicinal plants and other forest products to fulfil their daily needs and which were formerly collected inside the park.

Using a subjective conventional approach, traditional use zones in KSNP were established by the Director General of PHPA in 1994 covering an area of 12,240 hectares. The encroachment area is the only factor utilised for the designation of traditional use zone. Therefore, the zones are scattered within the Park across the Park boundary.

The objectives of traditional use zone designation in KSNP are two fold: to maintain the ecological integrity of the Park and at the same time provide an alternative income opportunity for the villagers. A Multi Purpose Tree Species (MPTS) programme within traditional use zones was launched by the Park authority to accomplish these objectives. This programme has been carried out by replacing cinnamon trees with other species of 'high economic value' which are not cut down for harvesting. Therefore, this would decrease the rate of soil erosion and increase villagers' income.

After the Park boundary rationalisation in 1995, most traditional use zones were excluded from the Park. Therefore, those areas are no longer relevant to the Act No. 5 of 1990 as traditional use zones and then were established as buffer zones. There are some different physical characters of these buffer zones compared to the designed buffer zone in this study using GIS-based method. These differences include their location in relation to the park boundary, settlements, rivers and roads, their distribution by slope and elevation and the area designed for buffer zones.

Therefore based on this study, it is suggested that the existing established traditional use zone which finally acted as the buffer zone might be revised with the designed buffer zones resulting from this study. The buffer zone scenario chosen depends much on the Park management objectives with consideration of the existing socio-economic condition and stressed on the balance between the priority of economics and ecological factors.

However, it is also possible that the Park authority utilise his own weighting factors based on this study formula to develop the desired buffer zone most suitable with the present priority objectives of the Park. The framework of buffer zone development in this study provide more accurate technique to develop buffer zones which could also be applied for different national parks throughout the country.

7.6. Summary

The development of a buffer zone in a national park in which neighbouring people are dependent on the park resources for their subsistence needs is an important factor for resolving people-park conflict. This requires a thorough understanding of both the economics and ecological factors needed for the park conservation and the socio-economics context relevant to the surrounding people's aspiration. GIS was found to be useful in bringing together this information for effective buffer zone establishment. Four scenarios of buffer zone in KSNP were produced in this study using the GIS based-method. This will provide a more accurate system in designing a buffer zone to meet its objectives. The next chapter presents the GIS modelling of encroachment risk in KSNP.

CHAPTER EIGHT

GIS MODELLING OF ENCROACHMENT RISK IN KSNP

8.1. Introduction

GIS has been widely used as a tool to aid the design, management and monitoring of national parks and other protected areas (e.g. Aspinall, 1993; Walsh *et al.*, 1994; Brown *et al.*, 1994; Pulsford and Ferrier, 1994; Jordan, 1994; Goodchild *et al.*, 1996; Mladenoff, *et al.*, 1996; Singh, 1998). However, the use of GIS for simulation, modelling and prediction of national park degradation is more limited (Schneider and Robins, 1995). Even though the risk of encroachment, forest degradation and disintegration in most of Indonesia's national parks and protected areas is very high, predictive modelling on these subjects has not been carried out to date.

Examples of the use of GIS for simulation modelling in Park management were undertaken by Jordan (1994) in Sagarmatha National Park, Shreier *et al.* (1994) in a Himalayan watershed, Nepal, Fan (1997) in a natural recreation area of Taiwan, and BAPPEDA and IPB (1993) in KSNP, Indonesia.

Jordan (1994) initially developed modelling of park deforestation in England. The model was then tested in the field, leading to an improvement in predictive value through field work and the application of local expert knowledge. Schreier (1994) utilised GIS based methods to analyse deforestation and afforestation processes in the Middle Mountains of Nepal. Based on this analysis an alternative land allocation model best suited for optimising the production of both forest trees and fodder was generated. Fan (1997) utilised GIS modelling to aid a planning process for the developing roads and viewpoints in the natural recreation area of Taiwan. A similar model of the land suitability for some agricultural crop species such as cinnamon, coffee, rice field, potato, vanilla etc. was developed by BAPPEDA and IPB (1993) in Kerinci District. However, the KSNP area was included in the model. This is apparently not relevant to the Park's objectives. With limited agricultural land to meet the needs of the enclave community, inclusion of the Park area for agriculture commodities in the model might stimulate the District policy to suggest the exclusion of some park areas most suitable for agricultural purposes. This may lead to further disintegration of the Park.

The analysis of land use change in KSNP as presented in Chapter Five suggested that the area of encroachment in Kerinci District has increased sharply in the last decade. The relatively fast growing population and high unemployment together with limited available agricultural lands might lead to further encroachment expansion in the near future. In order to maintain its integrity and to halt degradation in the Park, appropriate management needs to be effectively implemented. Such management needs to be aware of likely future areas of encroachment. Therefore, the development of simulation and prediction model for future encroachment in the Park is necessary.

This chapter aims to assess the application of a GIS based method as a tool for predictive modelling of encroachment in KSNP. This involved the construction of a predictive map to classify the Park area into categories reflected the degree of encroachment risk.

8.2. Principles for model development

There is a growing acceptance that the use of models can help to understand and predict the behaviour of a system. By creating a model corresponding to the real world system, one can seek to understand the phenomena of change, and then anticipate and evaluate it to concern with the optimisation of the conceptual system. However, application of a model to a real world problem is not a simple process.

Hamilton *et al.* (1969) suggested five major steps that need to be defined and undertaken for building a model as shown in Figure 8.1. These include problem definition, model formulation, model simulation, model validation and application of the model. These steps were adopted for this study and each step of model development is discussed in turn in the following sections.

8.2.1. Problem definition

The first step in model development is to define the problem and make an explicit statement of the model objectives. This will be the most critical part of all activities, because it will control the model design (Lee, 1973). The encroachment problem in KSNP was addressed in Chapter One and Chapter Two. The objective of developing an encroachment risk model in this study is to provide a general indication of where future encroachment in the Park may be likely to happen. Understanding which Park areas are most susceptible to future encroachment is of importance to the design of sustainable Park management and to relieve the Park disintegration in the future.

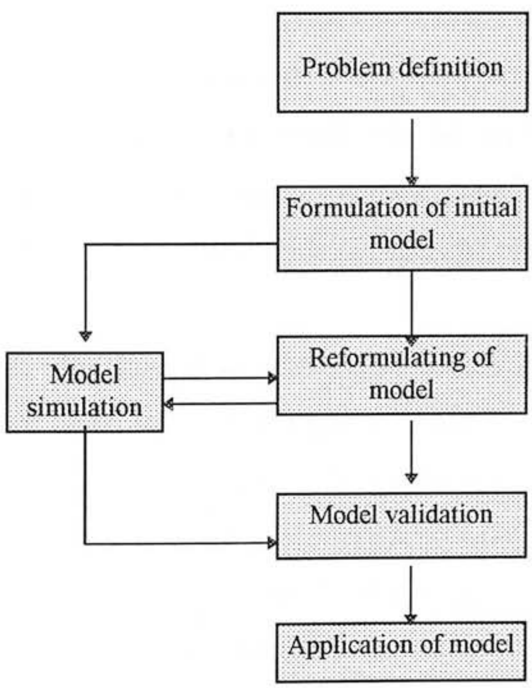


Figure 8.1. Model development as an integrative process (Modified from Hamilton *et al.*, 1969)

8.2.2. Model formulation

Based on the model objectives, the problem definition and the system situation, a suitable model of the system could be formulated. The formulation of a model includes several steps: variable selection, categorisation, decision concerning the treatment, specification and calibration (Lee, 1973).

8.2.2.1. Variable selection

Variable selection is an important step in building a model. All variables which are relevant to the problem and model's objectives should be included, and those which are not relevant should be excluded. A great variety of variables influence the likelihood of encroachment in KSNP. These include physical environmental conditions of the Park, socio-economic condition of people surrounding the Park as well as the operation of a range of policies by the Government especially the Park authority.

Since the model of encroachment risk in this study is intended to provide a general indication of where future encroachment may be expected, assumption and input limitation is necessary. In order to simplify the model, physical and environmental factors of the Park were the only variables considered for building the model.

In this study, the physical and environmental variables included in the model were determined in two ways: based on the questionnaire analysis of encroachers' opinion on the reason of the site selection for future encroachment (refer to Chapter 4); and based on the GIS analysis of the characteristics of the existing encroachment areas derived from the picture element (pixel) of Boolean encroachment images in 1982 and 1991. The variables selected were proximity to road, proximity to river, proximity to settlement, degree of slope, level of elevation and distance to the existing encroachment as briefly presented in Chapter 3 (Research Methods).

8.2.2.2. Variable categorisation

Once the variables needed for building the model have been determined, decisions about how to categorise the variables have to be carried out. The critical areas most susceptible to encroachment, based on previous analysis, are those with the slope between 15- 40 % and elevation between 500-1500 m. The variables categorisation, therefore, is necessary not only to simplify the process of GIS analysis aimed at deriving data from each pixel but, also to relate with the categorisation in the previous findings. Slope and elevation were categorised in different classes using a Reclass module in IDRISI. Whilst, distance containing variables were classified using a Distance Operation Module. The encroachment risk map produced was then classified into the area with low, medium and high risk probability of encroachment.

8.2.2.3. Preparation for model development

In order to enter all variables included in the model into the GIS data base, seven images related to the variables were utilised as data sources for building the model. They included: Boolean encroachment 1982, Boolean encroachment 1991, road image, river image, settlement image, slope image and elevation image.

Characteristics of picture elements (pixels) in land use images both in 1982 and in 1991 were defined as reference basis for building the intrusion model. For the analysis of the Logistic Regression model, a picture element of both land use images in 1982 and 1991 were designed as a dichotomous or binary function (yes or no encroachment area). The encroachment area was coded as one and non encroachment area was code as 0. Any pixel in the Park which had the same characters with those of Boolean encroachment was considered as the area of likelihood of future encroachment risk.

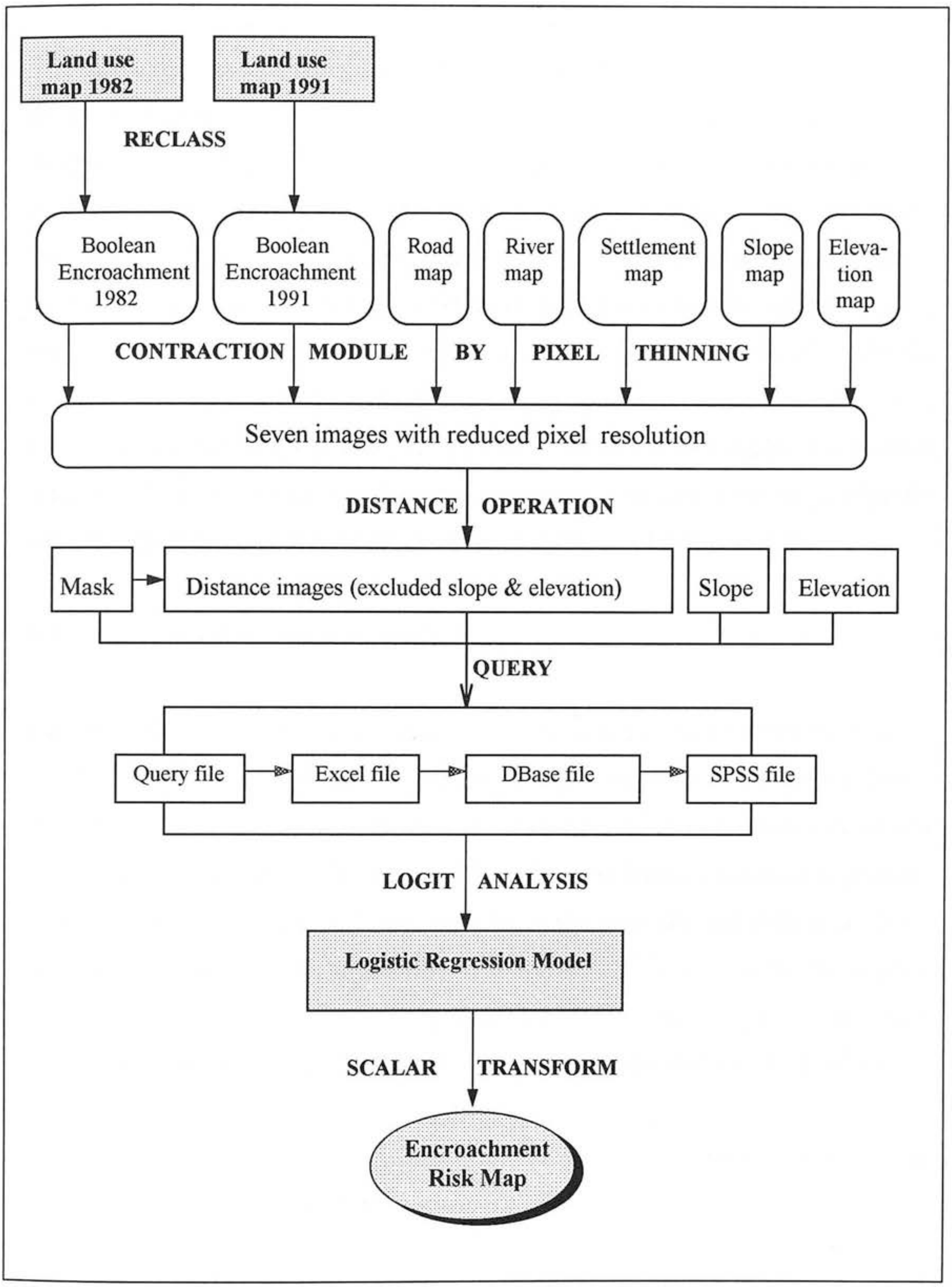


Figure 8.2. Flow diagram of the process analysis of Logistic Regression Model and creation of encroachment risk map in KSNP

The characteristics of every pixel in KSNP were derived from those seven images using the Contract module, Distance operation and Query module. The Contract module was applied to limit the number of pixels derived from the images and therefore the analysis can be carried out within the software limit capacity. Whilst the Distance module aimed to measure the derived pixel from the nearest model variables such as encroachment of 1982 and 1991, river, road and settlement. From the Query file, the data then transferred to Excel file, DBase file and finally to an SPSS file for subsequent analysis. Based on the data generated using GIS based method (part of the data is presented in Appendix 6), Logit analysis in SPSS was applied for building a Logistic Regression model. A flow diagram of the procedure of the preparation for the production of Logistic Regression model is summarised in Figure 8.2.

8.2.2.4. Logistic Regression Analysis

Logistic Regression Analysis (LRA) or Logit Analysis (LA) was utilised to estimate the coefficients of a probability model, involving a set of dichotomous or binary dependent variables which best forecast the probability of an event occurring or not occurring (Norusis, 1993; Hair *et al.*, 1995). This was because Logistic Regression analysis addresses the type of binary variables in the most efficient manner possible. The use of binary dependent variables is the primary difference between Logistic Analysis and Multiple Regression. Application of the ordinary regression on such binary independent variables would violate several assumption (Hair, *et al.*, 1995).

The probability of an encroachment occurrence could be calculated using the equation model of Norusis (1993) below.

$$\text{Probability of encroachment occurrence (P)} = \frac{e^{\beta_0 + \beta_1 X_1 \ldots\ldots \beta_n X_n}}{1 + e^{\beta_0 + \beta_1 X \ldots \beta_n X_n}} \qquad (3.2)$$

or equivalently,

$$\text{Probability of encroachment occurrence (P)} = \frac{1}{1 + e^{-Z}} \tag{3.3}$$

In this expression Z is the linear combination:

$$Z = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots\ldots + \beta_{n} X_n \tag{3.4}$$

Where :

e is the base of the natural logarithms, approximately 2.718

Z is dependent variable

X is the independent variable

β_0 and β_1 are coefficients estimated from the data

Based on these equations, the encroachment risk map in KSNP was created using the IDRISI Scalar and Transformation modules. A macro command was created for this purpose. The detailed transformation of Logistic Regression modelling into an encroachment risk map is presented in the relevant section.

8.2.2.5. Procedure of model selection

A Forward Stepwise Selection method was applied to control the entry of independent variables into the model. This method has the same function as a Stepwise Selection in a normal Linear Regression, that is entering a variable into the model followed by removing any variables already in the model that are no longer significant predictors (Norusis, 1993; Hair *et al.*, 1995). This means that variables whose importance diminishes as additional predictors were added were removed. Forward Stepwise Selection started with a model that contained only the constant term.

At each step, the significant variable with the biggest R-value was added to the model. Removal testing was based on the probability of likelihood-ratio statistics and on the maximum-likelihood estimates (Norusis, 1993). A variable was entered into the model only if the probability of its statistics value is significantly different from 0 at the 5 % (or 0.05) significant level, and removed if the value was greater than or equal to 0.10. These procedures were run using the SPSS for MS Windows software package release 6.1.

8.2.2.6. Assessing the model

The methodological approach for assessing the goodness-of-fit of the estimated Logistic Regression (LR) model is different from the normal Multiple Regression (MR). Multiple Regression minimises the squared deviation (least squares value) for estimating coefficient, whilst Logistic Regression maximises the likelihood value that an event will occur (Norusis, 1993; Hair *et al.,* 1995). To test the goodness-of- fit of the estimated Logistic Regression model, a classification table was created and a Chi-square test of significance was performed. The classification table compared the actual encroachment events (occurring or not) versus the predicted values (occurrence or not). Based on this table, the goodness-of-fit of the model indicated by the percentage of overall events that were correctly predicted from the samples was revealed as shown in Table 8.2.

8.2.2.7. The result of Logit model based on the LU 1982

Prior to the model development, the correlations matrix among the independent variables (the predictors X_n) and their correlations with the encroachment dependent variable (Y) were assessed as shown in Table 8.1. Examination of the correlation matrix indicates that predictor 6 (X_6, distance to the encroachment area 1991) is most closely correlated with the dependent variable (0.3784). Therefore, the first step in building the model was using this best predictor, then continued with the next smallest correlation value. The result of the developed model is summarised in Table 8.2. and shown in the Equation (8.1)

Table 8.1. The correlation matrix of the model's variables based on the land use 1982 image.

Variables	Predictors					
	X_1	X_2	X_3	X_4	X_5	X_6
X_1 Slope	1					
X_2 Elevation	0.1332	1				
X_3 Road	0.3052	- 0.1135	1			
X_4 River	0.0559	0.1728	- 0.1206	1		
X_5 Settlement	0.3415	0.0167	0.8308	- 0.1458	1	
X_6 Encroachment 82-91	0.2835	- 0.0065	0.7707	- 0.1009	0.9276	1
Y Encroachment 82	- 0.1766	- 0.1227	- 0.2873	- 0.0389	- 0.3606	- 0.3784

The correlation matrix in Table 8.1. shows some positive and negative correlation between the predictors and the independent variable. Negative correlation indicates that increasing value (distance or degree) of predictors leads to the decreasing probability of encroachment in those area. Conversely, positive correlation indicates that increasing the predictors value will be followed by the increasing probability of encroachment.

However, as shown in Table 8.1, all predictors indicated a negative correlations with the dependent variable of encroachment in 1982. This means that the further the distances of a pixel from settlement, road, river and the existing encroachment of 1982 as well as the higher the degree of a pixel's slope and elevation, the smaller the probability that those pixel will likely be encroached by the surrounding people.

The primary indication of the correlations between the predictors and the dependent variable is a pair correlation. Its correlation might differ when the combined interrelation between all predictors is considered in the model. Note that predictor X_6 is highly correlated with predictor X_5 (0.9276). This provides a first clue that use of both predictors (X_5 and X_6) might not be appropriate because they are highly correlated with each other as they are with the dependent variable. Therefore, the coefficient correlation and its significance were then assessed after all predictors were combined in the building process of Logistic Regression model. The test result and the Logistic Regression model revealed are shown in Table 8.2 and Equation (8.1).

Table 8.2. The Logistic Regression model for the probability of encroachment occurrence in KSNP based on encroachment 1982 Boolean image

Dependent Variable	Predictor	β Coefficient	Signif.	Goodness of fit of the model	
				Overall	Chi-square signif.
Encroachment	River distance	- 0.7568	0.0001	86.06 %	
	Road distance	- 0.1600	0.0001	correctly	861.21
	Settlement dist.	- 0.4361	0.0001	classified	<0.0001***
	Slope	0.0132	0.0001	from the	
	Constant	0.0976	0.4718	samples	

Based on the encroachment pattern in land use 1982 image (Table 8.2), the Logistic Regression model of the probability of encroachment occurrence can be formulated as follow:

$$\text{Probability of encroachment occurrence (P)} = \frac{1}{1 + e^{-Z}}$$

Where:

$$Z = 0.976 - 0.0008\ Ri - 0.0002\ Ro - 0.0004\ Se + 0.0132\ Sl \qquad (8.1)$$

Ri : river distance; Ro : Road distance;
Se : Settlement distance; Sl : Slope

The predictors, except slope, are reciprocal to the Logit (Log Odd) value of encroachment in KSNP. The further the distance of targeted pixels from river, road and settlement, the smaller the probability of encroachment occurrence in those pixels. Note that the distance between encroachment area predictor was removed during the process of model building. The test of goodness-of-fit of the model based on the table classification revealed that overall 86.06 % pixel samples were correctly classified in the model.

Beta coefficient provides indication that increasing one unit of the predictor value, with the assumption that the other predictor values remain the same will lead to the decreased or increased the Logit value of encroachment by the absolute value of β coefficient or in another words it will decrease or increase by a factor of exponent β.

8.3. Simulation and Validation of the Model

Once the initial formulation of the model has been completed, simulation and validation of the model is necessary to ensure that the model represents the general population and the characteristics and behaviour of the real-world system. Application of the model on the real-world system may alter the initial model formulation as the understanding of the condition and the system being dealt with increases (Lee, 1973; Hair, 1995).

The model simulation and validation process carried out in this study was based on the following procedures:

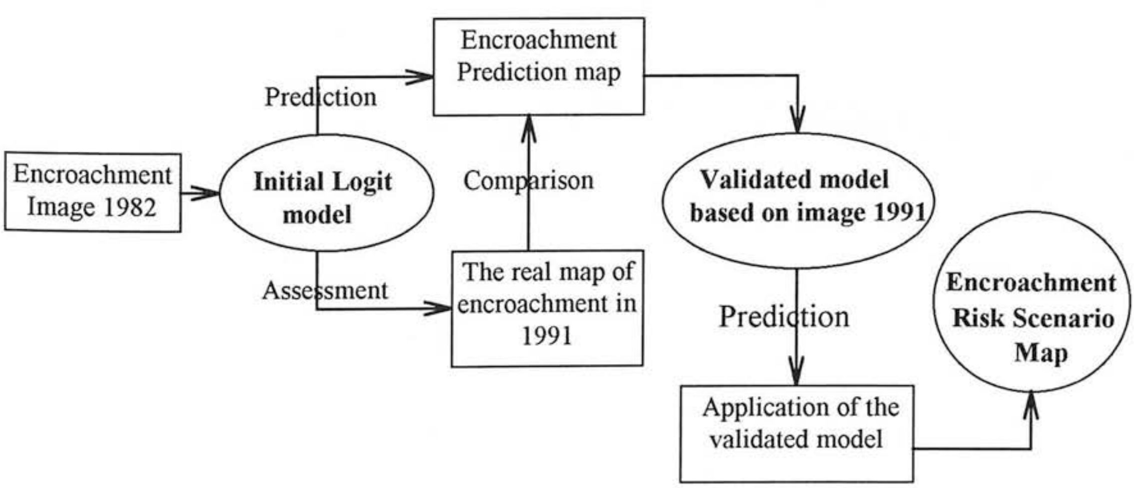


Figure 8.3. Model simulation and validation process

The model validation was carried out by applying the model to predict the encroachment in 1991. Transformation of the equation model into an encroachment prediction map revealed that the resultant map showed a different appearance from the real-world map of encroachment in 1991. This might be because the pattern of the encroachment system before establishing the Park in 1982 is different from that of after the Park establishment. After the Park's designation, encroachment has been prohibited, the low enforcement has been strengthened and the available area for encroachment is very limited. As a result, encroachment might have moved to more remote areas with the higher slopes and elevations. Therefore, it is necessary to amend or extend the initial formulation model based on the encroachment image of 1991.

8.4. The Logit Model Based on the LU 1991

As in the previous procedures for the building of the Logistic Regression model, initial assessment on the correlations matrix among the independent variables as predictors Xn and their correlation with the dependent variables (Y) were assessed. In this stage, the encroachment image in 1982 was involved in order to show the correlation with the encroachment image in 1991. Their correlations are shown in the matrix Table 8.3.

Table 8.3. The correlation matrix of the model's variables based on the land use 1991 image.

Variable	*Dependent*		*Predictors*					
	Y_1	Y_2	X_1	X_2	X_3	X_4	X_5	X_6
Y_1 Encr-82	1							
Y_2 Encr-91	0.5577	1						
X_1 Slope	-0.1766	-0.1686	1					
X_2 Elevation	-0.1227	-0.1548	0.1332	1				
X_3 Road	-0.2873	-0.3883	0.3052	-0.1135	1			
X_4 River	-0.0389	-0.0474	0.0559	0.1728	-0.1206	1		
X_5 Settlement	-0.3606	-0.4690	0.3415	0.0167	0.8308	-0.1459	1	
X_6 Encr 82-91	-0.3784	-0.4701	0.2835	-0.0065	0.7707	-0.1009	0.9276	1

All predictors for both encroachment area in 1982 and 1991 showed a negative correlation. A low correlation (0.5577) between encroachment in 1982 and 1991 as shown in Table 8.3 supports the previous analysis that the pattern of encroachment before and after the Park designation might have demonstrated different characteristics.

The development of Logistic Regression model started with a model that contained only a constant term. Then a variable with the greatest significance and R value was entered into the model followed by the variable with smaller significance and R values. The rule of entering and removing a variable into and from the model was the same as in the previous analysis. The result of the developed model is summarised in Table 8.4 and displayed in the Equation (8.2).

Table 8.4. The Logistic Regression model for the probability of encroachment occurrence in KSNP based on encroachment 1991 Boolean image

Dependent Variable	Predictor	β Coefficient	Signif.	Goodness of fit of the model: Overall	Chi-square signif.
Encroachment	River distance	- 0.3523	0.0001	85.03 %	
	Road distance	- 0.1968	0.0000	correctly	1719.99
	Settlement dist.	- 0.0934	0.0080	classified	<0.0001***
	Encr82 dist.	- 1.0189	0.0001	from the	
	Elevation	- 0.0005	0.0006	samples	
	Slope	0.0245	0.0001		
	Constant	1.2168	0.0001		

Table 8.4 demonstrates an improvement of the Logistic Regression model compared to the previous initial model. All seven predictors including the constant term showed a significant correlation with the dependent variable. Whilst in the previous model only four predictors showed such a significant correlation. Compared to the previous model, there are two new predictors involved in the final result of the model development: the predictor of distance of encroachment area 1982-1991 and the elevation predictor. This supports the previous analysis that after Park establishment

the encroachment affected remote areas with the higher elevations. A positive slope coefficient also indicates that encroachment is moving into the steeper sloped areas. It is understandable because of the limited agricultural land and most of the available low land plain area in the enclave has been utilised for agricultural purposes. This could possibly be a strategy to avoid the detection by the Park's staff. The test of goodness-of-fit of the model based on the table classification revealed that overall result represents 85.03 % pixel samples were correctly classified in the model.

Based on the encroachment pattern in land use 1991 image (Table 8.4), the Logistic Regression model of the probability of encroachment occurrence can be reformulated as follow:

$$\text{Probability of encroachment occurrence (P)} = \frac{1}{1 + e^{-Z}} \qquad (8.2)$$

Where:

$$Z = 1.2168 - 0.3523\ Ri - 0.1968\ Ro - 0.0934\ St - 1.0189\ En - 0.0005\ El + 0.0245\ Sl$$

Ri : River distance; Ro : Road distance; Se :Settlement distance
En : Encroachment '82 distance; El : Elevation; and Sl : Slope

Predictors except slope are reciprocal to the Logit (Log Odd) value of encroachment of 1991 in KSNP. The farther of the distance of targeted pixels from river, road, settlement and the existing encroachment areas and the higher the elevation will lead to the smaller of the probability of encroachment occurrence in those pixels.

Increasing one unit of the predictor value, with the assumption that the other predictor values remain the same, will lead to the decreased or increased the Logit value of encroachment by the absolute value of β coefficient or it will decrease or increase by a factor of exponential β. This value is usually automatically generated by SPSS in the process of the building Logistic Regression model.

8.5. The Prediction of Encroachment Risk in KSNP

Once the Logistic Regression model has been developed and validated, it can be utilised for many different applications such as an integration model into a planning process and the prediction on the probability of an event occurrence (Lee, 1973; Hair *et al.*, 1995).

The prediction of encroachment risk map in KSNP was created by employing the Logistic Regression model on the image arithmetic calculation using the GIS IDRISI Scalar and Transform modules as shown in Figure 8.4. The Scalar module involved adding, subtracting, multiplying etc. of the pixels in the input image constant value. Whilst the Transform module aimed to convert the data values in an image into the natural logarithms of the related values.

The transformation procedures of Logistic Regression model into the prediction of encroachment risk map in KSNP is listed below. However, to ease the process a macro command was programmed for this series operations. The process of transformation refers to the Equation (8.2):

$$\text{Probability of encroachment occurrence (P)} = \frac{1}{1 + e^{-z}} \qquad (8.2)$$

Where:

Z = 1.2168 - 0.3523 Ri - 0.1968 Ro - 0.0934 St - 1.0189 En - 0.0005 El + 0.0245 Sl

The transformation procedures are:

Step 1:

Application of the Scalar module for the calculation of the constant and each map coefficient, and using the Overlay module to combine the maps.

Z = 1.2168 - 0.3523 river map - 0.1968 road map - 0.093 settlement map - 1.0189 encroachment 82 map - 1.0005 elevation map + 0.0245 slope map.

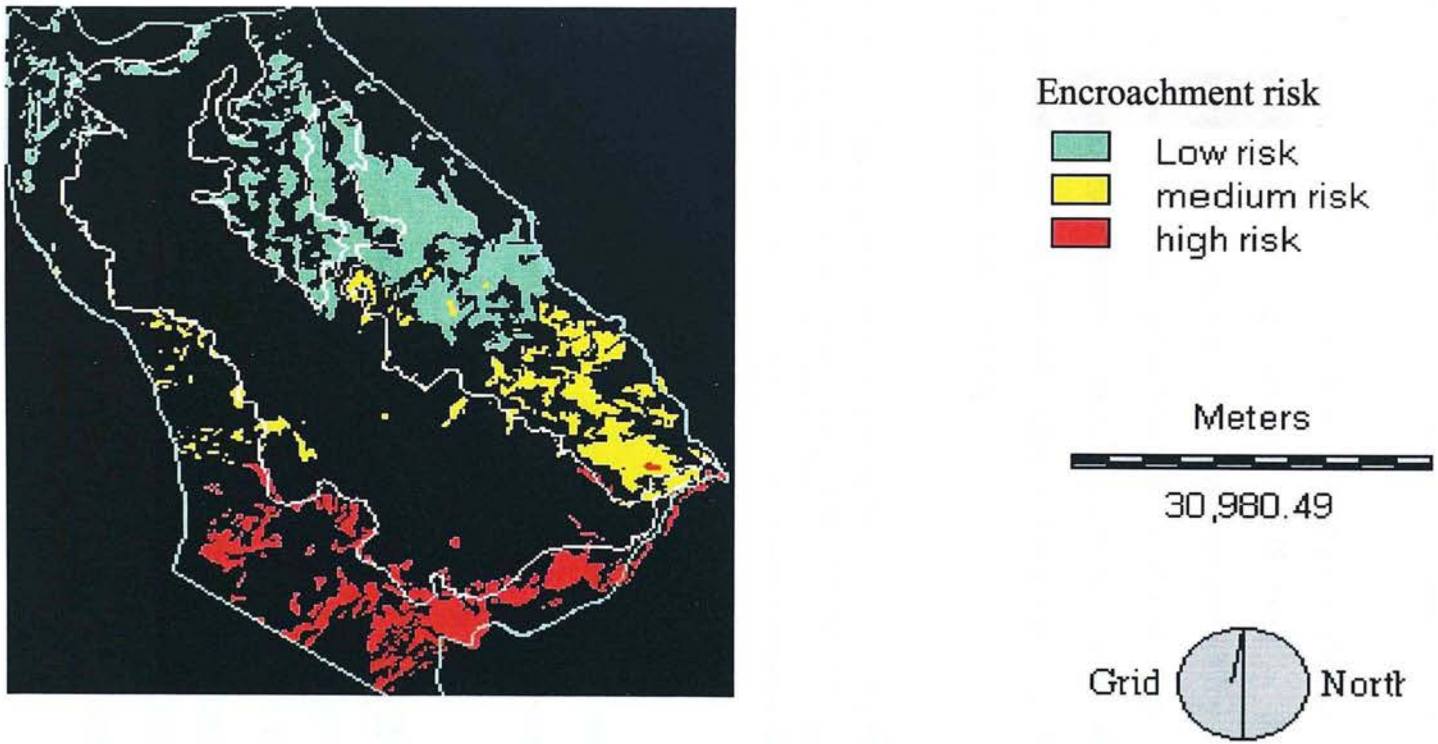


Figure 8.4. Simulation model of future encroachment risk in KSNP

Step 2 : Multiplying Z by -1 using the Scalar module

Step 3 : $\mathbf{e}^{-Z}$ using the Transform module

Step 4 : Add 1 using the Scalar module

Step 5 : Reciprocal $1/(1 + e^{-Z})$ using the Transform module

The resulting prediction of encroachment map is displayed in Figure 8.4. The map was standardised ranging from 0 to 255 level in the IDRISI environment representing from the lowest to the highest probability of the encroachment risk which is likely to occur. Then using the Reclass module, the map was subjectively classified into three different encroachment risk categories based on the value of standardised range: a low risk (value: < 100), a medium risk (the value: 100 -200) and a high risk (the value : >200).

Table 8.5. The predicted area of encroachment risk in KSNP, Kerinci District

Risk category	Area (Ha)	% of the total risk area
Low risk	38,429	50.56
Medium risk	17,417	22.92
High risk	20,154	26.52
Total	76,000	34.46*)

*) : % of the total area of KSNP in Kerinci District

Finally, the Query module was applied to calculate the predicted area of the encroachment risk in KSNP as shown in Table 8.5. It was revealed that a total of 76,000 hectares (34.46%) of the total area of KSNP in the Kerinci District is predicted to be susceptible to the future encroachment risk. This was classified into 38,429 hectares (50.56 %) is in a low risk category, 17,417 hectares (22.92 %) is in the medium risk category and 20,154 hectares (26.52 %) is in the high risk category.

The findings of the predicted encroachment risk model are of importance for effective planning aimed to resolve people-park conflict in KSNP. The buffer zone management should be more prioritised in the villages close to the predicted areas with the high risk of encroachment. For those areas, some alternative Integrated Conservation and Development Programs (ICDPs) should be promoted to involve people participation in the Park management, and at the same time to provide income generation and to increase their awareness of the conservation issues. With the limited available staff of the Park, this result also offers an alternative priority for the selective observation to preserve the Park's integrity.

8.6. Summary

The application of GIS for predictive modelling shows an important prospect to aid the more effective Park management planning. The predictive modelling in this study was carried out under variable limitations, especially based on the physical aspects of the Park. Nevertheless, a predictive modelling for the encroachment risk in KSNP was successfully revealed. A total of 76,000 hectares (34.46 %) of the Park area was predicted to be susceptible to the future encroachment risk. A better predictive model of the encroachment risk was obtained from the model validation based on the latest encroachment image. This model, however, could be further improved by ground truthing and revalidation based on the application of local knowledge. Encroachment is not only dependent on the bio-physical aspects of the Park but also on the socio-economics aspects of the surrounding peoples. Involving both aspects in the model might improve the accuracy of the predictive model. The next chapter presents the management options aimed at resolving people-park conflict in KSNP.

CHAPTER NINE

MANAGEMENT OPTIONS IN KSNP

9.1. Introduction

The application of Multi Criteria Decision Making (MCDM) techniques to generate management options for natural resources in order to minimise conflict of interests has been widely utilised in many sectors such as agriculture, water resources and recently in forestry and protected areas management (e.g. UNESCO, 1987; Romero and Rehman, 1989; Romero, 1991; Teckle, 1992; Opricovic, 1993; Rehman and Romero, 1993; McGregor and Dent, 1993; Piech and Rehman, 1993; Bailey *et al.*, 1997).

National parks all over the world, especially in most developing countries, are facing considerable pressure from increasing human populations whose subsistence needs as well as economic well-being are dependent on park resources (McNeely, 1994). It is possible that this pressure could be minimised through integrated parks management programs, and the concept of national parks and protected areas management has been changing in the last decade from the traditional protective approaches to the integrated park management approaches with the aim of relieving this pressure. With the new concept, local people are more accommodated as part of the sustainable park management. Parks' authorities, therefore, need to seek the best management option to minimise people-park conflict. This development may require the need of techniques for achieving compromise solutions between the competing pressures on the Park.

This chapter aims to provide alternative management options for Kerinci Seblat National Park based on the application of the MCDM model using especially the Composite Programming (CP) technique, in order to define the trade-offs that will exist between economic, environmental and social variables that are associated with alternative management options. Further discussion on the overview of the MCDM approaches, method and procedure for Composite Programming, and the assessment of management options for KSNP management are presented in the following sections.

9.2. Overview of MCDM Approaches

The MCDM approaches encompass a general class of mathematical programming techniques for solving problems in which several objectives are considered simultaneously (Mendoza *et al.*, 1987). These approaches provide a suitable framework for handling qualitative data for problems solving which enable decision-makers to choose feasible solution in accordance with their priorities for different objectives (Mendoza *et al.*, 1987; Romero and Rehman, 1989).

MCDM include those types of techniques which can be classified into three main categories. First those which generate single solutions, such as goal programming (GP) require a prior specification of preferences from decision makers. Second are those techniques such as multi-objective programming (MOP), which identify the set of efficient solutions to a problem and do not require a prior specification of preferences. And thirdly are interactive techniques, in which preferences are articulated progressively through interaction with the model. The structure of MCDM classification is presented in Appendix 7. The two main MCDM techniques which are commonly utilised in practice are summarised below.

9.2.1. Goal programming

Goal programming (GP) is an important and the oldest technique within multi criteria decision making (Romero, 1991) which has been widely utilised in agriculture and other natural planning problems (Field, 1973; Bell, 1976; Field *et al.*, 1980; Mendoza, 1987; McGregor and Dent, 1993). Its aim is to optimise several goals simultaneously and minimise the deviations between the desired target and the level that can be achieved in practice, given the need to satisfy targets for other objectives.

In GP, there is no requirement that objectives be defined in the same value terms. However, ordinal priorities and goal ranking are needed in order to provide a solution. The minimisation of the deviations can be accomplished by introducing weights to reflect the relative importance of achieving each goal. Within the GP category, Lexicographic goal programming (LGP) and weighted goal programming (WGP) are the most widely utilised for these purpose. LGP carries out the minimisation process by attaching pre-emptive weights to the set of goals situated in different priorities. Whereas WGP considers all goals simultaneously within a composite objective which minimises the sum of the deviations. These deviations are weighted according to the relative importance of each goal to the decision maker.

9.2.2. Multiple objective programming

Multiple objective programming (MOP) seeks to find the most efficient set of solutions to a multi criteria problems, where ordering and prioritising objectives as suggested in GP are not available. There are three techniques to generate the efficient set of solutions: the weighing method, the constraint method and the multi-criterion simplex method (Rehman and Romero, 1993). For many years MOP techniques have been proposed for multiple-use of forest planning (Allen, 1986; Mendoza *et al.*, 1987). In this category the most widely used techniques are compromise programming and composite programming approaches (Zeleny, 1973; Teckle, 1992).

Compromise programming first establishes an ideal solution point, the co-ordinate of which are given by the optimum values of different objectives when each is optimised individually. However, this ideal point is usually infeasible resulting in conflict and the necessity for trade-offs among objectives. The best compromise solution is, therefore, determined by the point closest to the ideal solution point.

In a recent review of 15 MCDM techniques used to resolve natural resource management problems, Teckle (1992) suggested that Composite Programming and Compromise Programming were the most preferred techniques.

9.3. Composite Programming Evaluation

The Composite Programming (CP) technique was chosen in this study because it is highly flexible in use of indicators for qualitative elements and it has a capability of handling both qualitative and quantitative data. The Composite Programming approach is a decision making technique to help the decision maker choose the optimal solution from the efficient ones generated by Multi-objective programming (MOP) through a step-wise or hierarchical analysis of indicators. It is an extension and adaptation of the Compromise Programming technique (Bailey *et al.,* 1997) in which a set of basic indicators reflecting the character of the system are compounded into second level and third level quality indicators and finally into a total or overall quality index of the system concerned. The third level indicators are usually classified as a socio-economic and an ecological indicator.

9.3.1. Method

The procedure of the Composite Programming approach for assessing KSNP management options in this study was adopted from the recommendations of UNESCO (1987) in the integrated assessment of water resources. The procedure involves six main activities which can be classified into three phases (refer to Chapter 3). This includes: (1) a descriptive phase in which the present condition of the Park was analysed for developing basic indicators as a potential basis for the problem solution; (2) an evaluative stage where measurement, normalisation and weighting of the determined indicators were carried out; and (3) a decision stage where graphical features, simulation and sensitivity analysis were presented. This procedure is summarised as a flow diagram in Figure 9.1. The concept of each step is discussed in turn in the following sections.

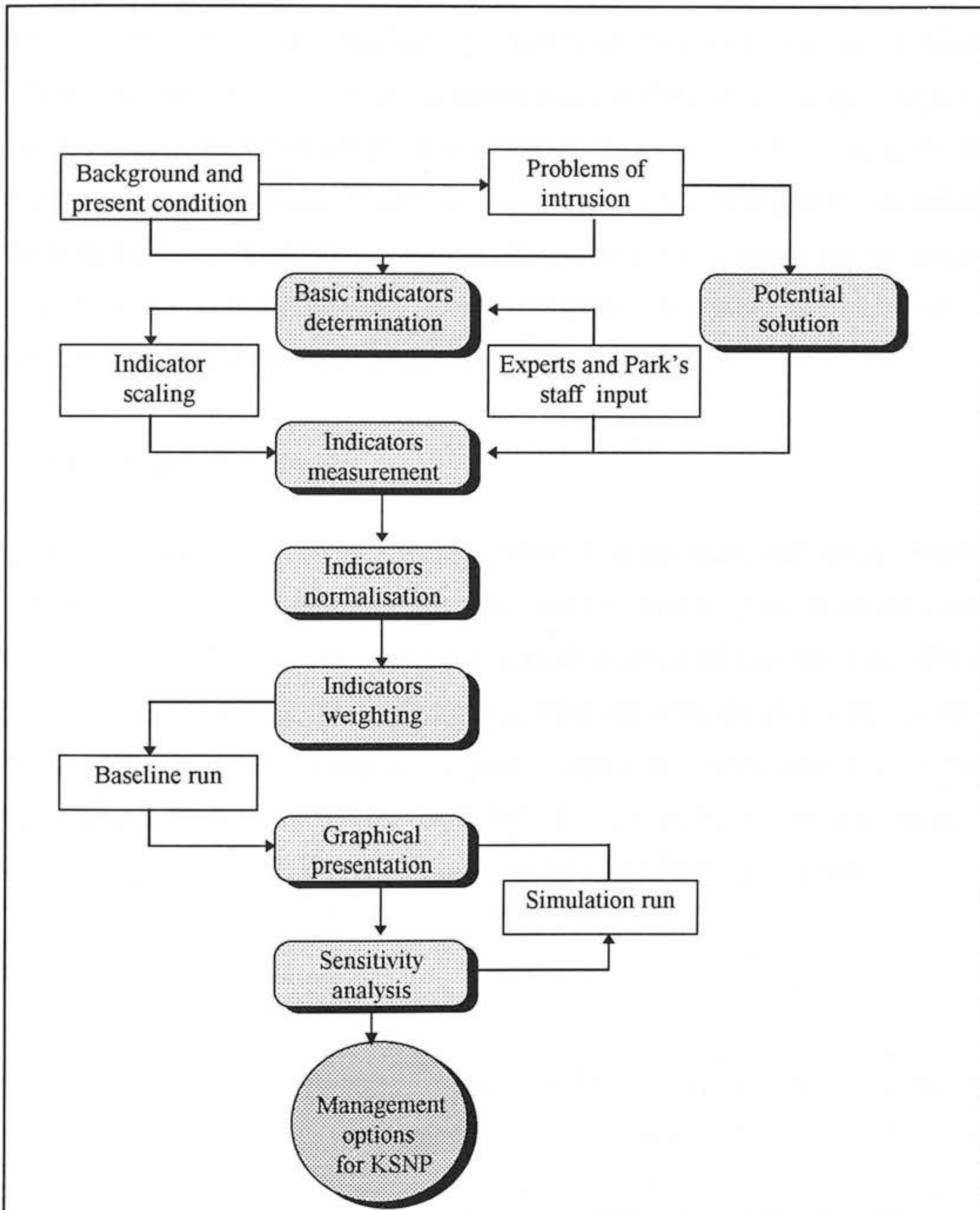


Figure 9.1. Composite programming approach for assessment of management options in Kerinci Seblat National Park.

9.3.2. Present condition and the Park management problems

As discussed in the previous chapters, the designation and management of KSNP impacts on a diverse set of interests, some of which are in conflict with each other. Encroachment was determined as the main problem in the management of KSNP. With the increasing population and limited available lands for agricultural purposes in the enclave area, the encroachment problem has led to the people-park conflict in KSNP, and this is predicted as a continuing threat to the Park integrity (Chapter 8). Therefore, any solution to this problem is likely to be a compromise between the Park management and the people's needs over agricultural lands. The present condition of the Park and factors which may hamper the prevention of encroachment program as well as socio-economics and ecological factors that might be impacted by increasing encroachment activities are as follows:

9.3.2.1. Financial problem

All management options to impede the encroachment expansion will require funding. The main financial source for the Park management so far has been from the Central Government's budget. However, it was too small to cover all activities needed by the Park management programs. At present, the Park authority together with the World Bank and WWF is developing a joint project on Integrated Conservation Development Programs (ICDPs) in KSNP. Encroachment prevention, therefore, should be prioritised in this program to avoid the further Park disintegration.

9.3.2.2. Regional planning

Comprehensive spatial planning in Kerinci District to integrate biodiversity conservation and development objectives, has not been well developed. The lack of detailed spatial planning has resulted in 'wild development' leading to the threat of the Park's integrity. As an enclave area, three main development activities should be carried out with great caution since they could provide advantages for the surrounding people, but disadvantages for the Park objectives. They include road construction, agricultural development and settlement expansion.

Road construction has implications for the park integrity since it will provide access to new settlers or opportunities for extending present encroachment. Therefore, the inter-provincial road already partly constructed by the Department of Public Work from West Sumatra to Jambi Province which traverses the Park area was eventually cancelled after intervention and criticism by the World Bank, non government organisations (NGOs) and the Ministry of Forestry. In the last decade, agriculture development and settlement have expanded considerably, not only in the enclave but also beyond the Park boundary. Most of the villages and the farm lands in the Park, however, have been excluded from the Park. Therefore, a clear allocation of space in the regional development planning is necessary in order to achieve a balance between the park conservation and the development objectives.

9.3.2.3. Recreation and tourism

Tourism could provide a source of revenue towards the Park maintenance cost as well as alternative livelihood opportunities for some village communities. KSNP in Kerinci District contains natural scenic areas with a great potential interest for ecotourism and recreation activities. These include hiking to the Kerinci volcano, waterfall, lakes, natural landscape, ecology and tracking to observe endangered species and other wildlife in their natural habitats. At present KSNP offers very few facilities and services to attract any type of ecotourism. As a remote area, therefore, KSNP needs to enhance tourism promotion campaigns and develop better recreation facilities to attract more tourists. The development of ecotourism may in turn provide an alternative income for the villagers through home stay, tourists guide and selling handicrafts. Unfortunately, the sustainability of some tourism objects are threatened by the Park fragmentation because of the increasing rate of the encroachment expansion.

9.3.2.4. Habitat and wildlife species

Kerinci Seblat National Park contains varieties of unique and rare habitats from the lowland to the mountainous areas. These include threatened habitats such as Rawa Bento swamp, areas of high attitude peat swamp, dwarf woodland at the elevation of 1350 m that are especially rich in flora and fauna, migration corridors and areas known to support population of key species such as rhinos, Kerinci hares, elephants and tigers. Unfortunately about 50 percent of Bento swamps has been converted into rice fields (World Bank, 1993), whilst other unique habitats are threatened by expanding encroachment and settlements leading to the disintegration of the Park.

The more dissected the Park the more difficult it will be to protect and manage. If the Park becomes fragmented into separate forest blocks then the length of boundary compared to area will increase, and there will be increased danger of encroachment. As a result, the smaller a block of habitat the faster it losses species (MacKinnon *et al.*, 1986). It is therefore crucial to maintain corridors of natural habitats between different blocks of the Park and between the Park and adjacent forest lands.

9.3.2.5. Soil quality

As discussed in the previous chapters under encroachment systems, forest cover is slashed and burnt to cultivate cinnamon and annual crops. With the removal of land cover in the first three years, the kinetic energy of rain fall directly hitting the land causes soil erosion and surface run-off. This might decrease the quality of the Park soil due to the loss of its nutrients from the topsoil by erosion and in runoff water. Increasing soil erosion and changing land cover type may also affect the capability of the Park to act as a water regulation system and thereby eventually influencing the overall water balance in the Park.

9.3.3. Potential solutions

Given the condition and problems perceived by the Park, there are a number of management options available to prevent the expansion of encroachment in KSNP. The choice of management options was based on the information resulting from the discussion with various organisations such as the Park authority, the Sub Director of National Park staff in the Headquarters, WWF, NGOs and the local key persons in Kerinci District.

In total, there are eleven alternative management systems to be considered for abatement of encroachment expansion which could be classified into six categories: no management action was taken, buffer zone establishment, reforestation, people displacement, and integrated management comprising a number of previous options. The location and the target area for every management option were measured based on the GIS analysis, some of them such as buffer zones were delineated in the previous chapter. Detailed information concerning each management option is presented in the following sections.

9.3.3.1. No management action taken

The scenario of encroachment risk for KSNP in Kerinci District without any management intervention was described in Chapter eight. The likely area for the future encroachment was shown in Figure 8.4. It was revealed that if no management action taken to prevent encroachment expansion, a total of 80,671 hectares (including the present encroachment existence) or about 37 percent of the Park area in Kerinci District may change into encroachment areas. For the whole area of KSNP, a risk scenario model of the Park if no management intervention taken was developed by the World Bank (1993) as shown in Figure 9.2.

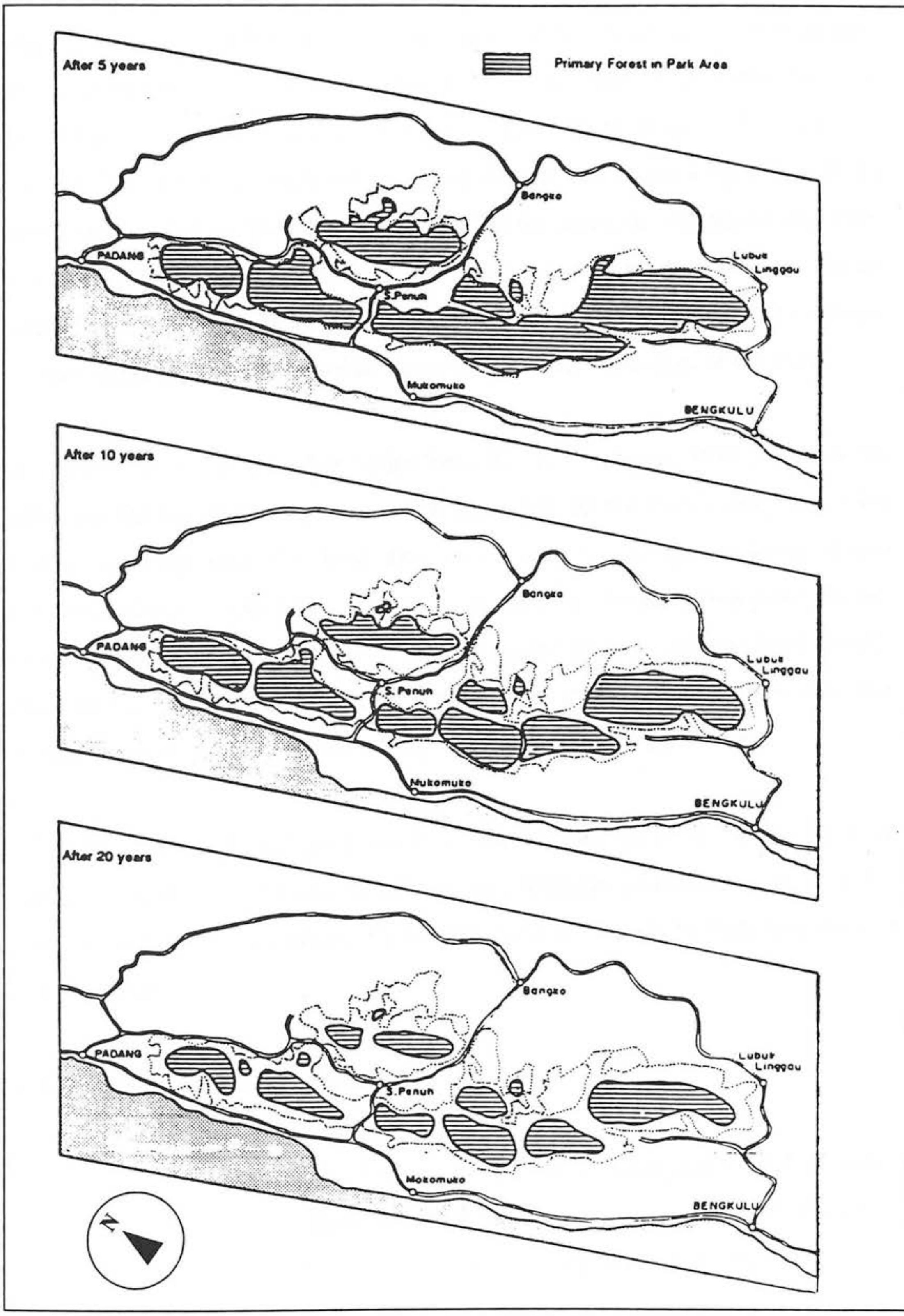


Figure 9.2. Risk scenario of the Park with no management action taken (Source: The World Bank, 1993)

9.3.3.2. Green belt boundary development

Green belt boundary is a belt of permanent vegetation between the Park and adjacent areas. Its main aim is to clearly define the boundary in order to safeguard the Park, protected areas and countryside from further encroachment (Sayer, 1991; Elson *et al.*, 1993). The absent, or unclearly identified, Park boundary marking is one of the peoples' reasons for encroaching KSNP. During the survey it was found that some concrete and pole boundary markers had been moved from their original places. Therefore, the development of a green belt boundary in combination with cement boundary markers will help the public determine the exact boundary of the Park.

The width of green belt boundary varies from 20 - 50 m (Sayer, 1991) to allow for satellite monitoring of the impacts of such green belt on the Park's integrity. Live boundary marking with the local fruit trees such as *Arenga pinnata*, *Durio zibethinus*, *Aleurites moluccana*, *Nephelium lappaceum*, *Archidendron pauciflorum*, *Parkia speciosa*, etc. could generate an alternative income for the local people participating in this scheme. They are given the right to collect fruit in the strip, but they also expected to maintain and manage the plants for sustainable yield.

In this study the width of the green belt was defined as 25 m along the Park boundary covering the total area of 955 hectares. With the plantation distance of 5 x 10 m , a total of 191,054 plants are needed to cover the whole Park boundary in Kerinci District.

9.3.3.3. Buffer zones establishment

Buffer zone development is frequently utilised as a management tool to solve encroachment problems in many areas of Indonesia such as in Dumoga Bone National Park, Gn. Leuser National Park and Cyclops Mountains Nature Reserve (Sayer, 1991). Multi Purpose Tree Species (MPTS) aim at gradual conversion of existing farming systems to permanent multipurpose fruit tree production is one of the recommended programs to be implemented in the buffer zone development. The Park should provide MPTS seedlings and technical guidance. For the analysis of management options, the results of four scenarios of buffer zone establishment presented in Chapter seven will be utilised as data bases.

9.3.3.4. Habitat rehabilitation

Encroachment activities have resulted in many degraded common 'adat' lands around the Kerinci valley. These include 8,970 hectares of abandoned land and 6,348 hectares of shrub lands. Rehabilitation of these degraded areas with multi-purpose indigenous trees and fuel woods is firstly intended to improve soil fertility and in the long term it might provide an income-bearing alternative to destructive encroachment within the Park. It is hoped that the use of these areas for agriculture in the future could lessen the population pressure on the Park.

9.3.3.5. People displacement

People displacement is one of the possible tools available to deal with existing Park encroachment. However, under the new concept of national parks, the attitude that people have no place in parks must change. Indigenous people who have lived in the region for decades before the Park designation should be considered an integral part of the local ecology. People displacement should be carried out with great caution and only after their negative impacts on wildlife, ecosystem and sustainable park management have been clearly indicated. Based on KSNP (1995) pre-survey results, a total of 866 people encroaching in the Park are prioritised to be resettled. However, every effort should be made to encourage them to relocate voluntarily. This can be achieved by offering adequate compensation as well as an acceptable displacement site. They may be given a chance for temporary use of the original site through MPTS and 'pohon kehidupan' program.

9.3.3.6. Integrated program

This type of management option is a combination of many previous choices which will be carried out simultaneously. In a situation where funding and man power are not limiting factors, an integrated program will be more effective in preventing the encroachment expansion than a single option.

The summary of recommended management options for KSNP and targeted area for resolving encroachment problems in KSNP is shown in Table 9.1. Target area were designed based on the GIS analysis and the application of the Query area module as presented in the previous chapters.

Table 9.1. Alternative management options and targeted areas in Kerinci Seblat National Park

Management system*	Type of management options	Targeted area (Ha)
I	No management action taken	-
II	Greenbelt boundary development of 25 metres wide	955
III	Establishment of buffer zone A (baseline scenario)	40,785
IV	Establishment of buffer zone B (economic base scenario)	29,911
V	Establishment of buffer zone C (ecological base scenario)	25,587
VI	Establishment of buffer zone D (1 km wide along the boundary)	70,102
VII	Habitat Rehabilitation	15,314
VIII	People displacement (Hh = Household)	866 Hh
IX	Integrated management 1 (system II, III, VI, VII and VIII)	126,201
X	Integrated management 2 (system II, IV, VI, VII and VIII)	115,327
XI	Integrated management 3 (system II, V, VI, VII and VIII)	111,003

* The same code number of management system (I to XI) will be used as the same code for management options in the next sections

9.3.4. Indicators selection

Basic indicators for Composite Programming technique should be selected based on the present condition and the relevant problems of the Park. Bouyssou quoted by Bailey *et al.*, (1997) suggests that the number of first level or basic indicator should not exceed 12 in order to avoid a complex analysis. The use of three levels of indicators according to UNESCO (1987) is seen to provide sufficient complexity and flexibility without over-complicating the analysis. Application of two indicators in the final stage (a socio-economics and an environmental indicator) offers a great advantage in enabling graphical representation of the trade-off between these indicators. In addition, sensitivity analysis based on the exploration of the relationship between these indicators for different weight can be carried out (UNESCO, 1987). This study, therefore, adopted these general guidelines for ease of analysis.

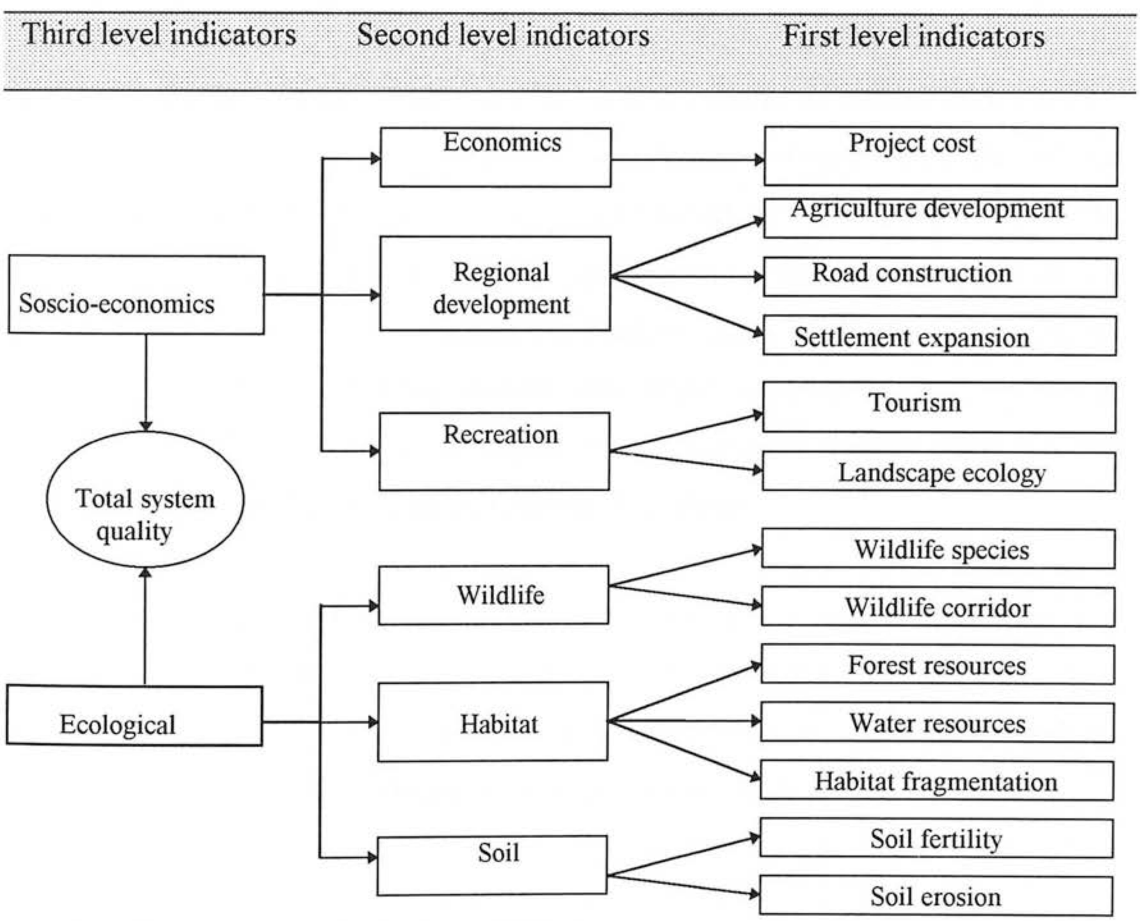


Figure 9.3. Specification of level indicators developed for analysis of alternative management options in KSNP.

A set of thirteen first level indicators as shown in Figure 9.3 were selected based on the present condition and on the nature of problems faced by the Park as presented in the previous sections. These indicators compounded into six indicators of the second level and then into two indicators of the third level and were considered reasonable to achieve the Composite Programming task. All 13 first level indicators were assumed to have been affected by encroachment activities. The structure of the first level, the second level and the third level indicators is presented in Figure 9.3.

9.3.5. Indicators evaluation

One of the advantages of the Composite Programming technique is its capability and flexibility when handling simultaneously both qualitative and quantitative indicators of the system (Tecle, 1993; Bailey *et al.*, 1997). All indicators apart from the economics are scored subjectively, as quantitative data for the performance of the management options to the selected indicators are not available. The evaluation of qualitative data indicators through subjective judgements was based on the discussion with the Park staff, NGOs, the key persons of the society, consultation with the related organisations and experts and personal views based on a literature review. The discussion was guided by the prepared questionnaire. Those judgements on the particular indicators were expressed on cardinal scales with the range varying between 1- 6 to 1- 11 depending on their views of the sensible level of accuracy. The minimum scale indicates the worst impact and the maximum scale indicates the best impact of a management option on a particular indicator.

The economic indicator of the project cost for each management option was calculated based on the standard unit cost issued by the Ministry of Forestry such as the standard unit cost of the development of timber estate, afforestation and re-greening. Standard unit costs for people displacement was based on the average cost of the transmigration program per person (the World Bank, 1993). The results of the calculation and the total cost needed for each management option are presented in the evaluation matrix of first level indicators in Table 9.2.

Table 9.2. The matrix system of the first level indicators evaluation for management options in KSNP

Indicators	Management Options**										
Normalisation	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Total cost (Rp 10^6)***	0	3,397	4,486	3,290	2,815	3,856	66,201	12,990	90,930	89,734	89,258
(1)	0	0.037	0.049	0.036	0.031	0.042	0.728	0.143	1	0.987	0.982
Agriculture development	1	6	5	8	4	7	3	6	9	11	10
(0.4)	1	0.5	0.6	0.3	0.7	0.4	0.7	0.5	0.2	0	0.1
Settlement expansion	1	7	4	6	4	7	3	5	8	10	9
(0.3)	1	0.33	0.67	0.44	0.67	0.33	0.78	0.56	0.22	0	0.11
Road construction	1	7	4	5	3	6	2	5	10	9	8
(0.3)	0	0.33	0.67	0.56	0.78	0.44	0.89	0.56	1	0.11	0.22
Tourism*	3	6	5	5	5	5	5	3	7	8	10
(0.5)	1	0.57	0.71	0.71	0.71	0.71	0.71	1	0.43	0.29	0
Landscape ecology	1	3	5	6	4	7	8	6	9	9	10
(0.5)	1	0.78	0.56	0.44	0.67	0.33	0.22	0.44	0.11	0.11	0
Wildlife species*	0	4	2	2	2	4	2	4	4	6	6
(0.6)	1	0.33	0.67	0.67	0.67	0.33	0.67	0.33	0.33	0	0
Wildlife corridor	1	2	5	4	6	3	4	3	6	7	8
(0.4)	1	0.86	0.43	0.57	0.29	0.71	0.57	0.71	0.29	0.14	0
Forest*	-2	3	4	5	2	4	6	2	4	6	6
(0.5)	1	0.38	0.25	0.13	0.50	0.25	0	0.50	0.25	0	0
Water*	-2	4	2	2	4	4	6	5	6	4	6
(0.2)	1	0.25	0.5	0. 5	0.25	0.25	0	0.13	0	0.25	0
Habitat fragmentation	1	7	4	6	6	5	5	6	7	8	9
(0.3)	1	0.25	0.63	0.38	0.38	0.50	0.50	0.38	0.25	0.13	0
Soil fertility	1	2	3	2	5	6	7	4	9	7	10
(0.4)	1	0.89	0.78	0.89	0.56	0.44	0.33	0.67	0.11	0.33	0
Soil erosion	1	3	4	4	5	7	8	5	8	6	10
(0.6)	1	0.78	0.67	0.67	0.56	0.33	0.22	0.56	0.22	0.44	0

Where:

(0.6) : numbers in the brackets are the weighting factors

* : based on the value of the composite indicator

** : the code for management options (I to XI) is the same code as used in Table 9.1

*** : £ 1 = approximately Rp 3,500 (1995)

$\boxed{1}$: numbers in the shaded rows are normalisation values of the indicator evaluation (subjective judgement values) in their upper unshaded rows

Impacts of each management option's capacity on the agriculture development indicator and the possible encroachment expansion related to the Park integrity were scored subjectively on an 11 point scale based on the discussion and expert's opinions of Agriculture Service in Kerinci. Encroachment for agriculture might expand rapidly leading to the Park fragmentation if no management intervention is taken. Therefore, the alternative system of no management action was ranked the worst. Buffer zone establishment on socio-economic base scenario (system IV) was considered to be effective both for farming and handling encroachment problems. Therefore, it was scored relatively high as shown in Table 9.2.

All other indicators were evaluated in the similar manner to the agriculture development indicator. Possible impacts on the encroachment expansion and the Park integrity were always taken into consideration in every indicator evaluation. The results of indicator evaluation are shown in Table 9.2. Some indicators such as tourism, wildlife species, forest and water were assessed on composite factors. Tourism is a composite indicator of a hostel income and a number of tourist visiting the Park. Both factors were scored on 1-5 point scale basis. The wildlife species indicator was composed from the species diversity and species safety factors evaluated on a 0 to 3 scale basis (0= unacceptable, 3= best impact). The forest indicator is a composite indicator of primary and secondary factors evaluated on -1 to 3 scale basis (-1 = detrimental, 3 = very good impact). Finally, the water indicator was composed from water quality and water balance factors judged on -1 to 3 scale basis. The results of evaluation of first level indicators are presented in the evaluation matrix Table 9.2.

9.3.6. Indicators normalisation and weighting

Once all basic indicators have been evaluated based on their minimum and maximum scale ranging from the worst to the best values, then normalisation of these values within each indicator row can be performed. With normalisation, indicators within the same composite function, even though measured in diverse units can be compared.

The normalisation was carried out using the standard formula (Romero and Rehman, 1989; Zeleny, 1973) below:

$$d_j = \frac{z_j^{max} - z_j(x)}{z_j^{max} - z_j^{min}} \quad \text{or} \quad d_j = \frac{z_j(x) - z_j^{min}}{z_j^{max} - z_j^{min}} \qquad (9.1)$$

Where:

d_j : the normalised distance between the actual achievement of the j-th objective $Z_j(X)$ and its ideal value, expressed as an index from 0 (no deviation from the ideal point thus represents the best of the available options) to 1 (represents maximum deviation from the ideal) .

Each indicator then was subjectively assigned weighting value (α) indicating its relative importance within the group of the higher level indicator (indicators grouping was presented in Figure 9.3) for the Park management priorities. Therefore, the total weight of each group of indicators for all levels is one. This procedure was carried out for each of the three levels of indicators.

$$\sum_{i=1}^{n_j} \alpha_{ij} = 1 \qquad (9.2)$$

The results of indicator normalisation and weighting were combined in the evaluation matrix as presented in Table 9.2.

9.3.7. Composite distance for higher level indicators

Based on the evaluation, normalisation and weighting of the first level indicators, the composite distance for the second level indicators was calculated using the standard compromise distance metric:

$$L_j = [(\sum_{i=1}^{n_j} \alpha_{ij} . d_{ij})^{p_j}]^{1/p_j} \qquad (9.3)$$

Where:

L_j is the composite distance measured for the j-th second level indicator;

α_{ij} is the weight expressing the relative importance of the first level indicator i, within the group of indicators comprising the second level indicator j;

d_{ij} is the actual value of the first level indicator index i, within the j-th group of second level indicators;

n_j is the number of first level indicators in the j-th group of second level indicators;

p_j is the order of the metric, balancing deviations amongst the indicators for group j (Romero and Rehman (1989) suggest the value of p is 1 or 2).

The results of the composite distances for the second level indicators is presented in Table 9.3 below.

Table 9.3. The matrix system of the composite distances for the second level indicators based on the first level compromise distance matrix

Composite indicators	Management Options										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Economics (0.4)	0.000	0.037	0.049	0.036	0.031	0.042	0.728	0.143	1.000	0.987	0.982
Regional development (0.3)	0.700	0.398	0.642	0.420	0.715	0.391	0.781	0.536	0.446	0.033	0.066
Recreation (0.3)	1.000	0.675	0.635	0.575	0.690	0.520	0.645	0.720	0.270	0.200	0.000
Wildlife (0.3)	1.000	0.542	0.574	0.630	0.518	0.482	0.630	0.482	0.314	0.056	0.000
Habitat (0.4)	1.000	0.315	0.414	0.279	0.414	0.325	0.150	0.390	0.200	0.089	0.000
Soil (0.3)	1.000	0.824	0.714	0.758	0.560	0.374	0.264	0.604	0.176	0.396	0.000

Based on the above composite distance of the second level indicators, the distance and index of the third level indicators for the desired weight were calculated using the standard conventional L_2 metric (p =2):

$$L = [(\alpha_1 L_1^2 + \alpha_2 L_2^2]^{1/2} \qquad (9.4)$$

Where:

L is the composite distance specifying the total state of the system;

L1 is the composite ecological indicator distance;

L2 is the composite socio-economic indicator distance;

α_1, α_2 are the weights applied to each third level composite indicator.

The value given by the composite distance specifying the total state of the system (L) is thus an index (between 0 - 1) of overall or total quality for each management option of the Park (1 represent the best value and 0 the worst). Under consideration of the equal relative importance for both socio-economic and ecological indicators (weighting value = 0.5), the result of the composite distances and indexes of the third level indicators and the total quality of composite value for each management option is presented in Table 9.4.

Table 9.4. The matrix system of the composite distances and indexes for the third level indicators based on the second level compromise distance matrix

The composite indicators	Management Options										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Socio -Economics distance	0.510	0.338	0.403	0.313	0.434	0.291	0.719	0.434	0.615	0.465	0.413
Socio- Economics index (0.5)	0.490	0.662	0.597	0.687	0.566	0.709	0.281	0.566	0.385	0.535	0.587
Ecological distance	1.000	0.536	0.552	0.528	0.489	0.387	0.328	0.482	0.227	0.171	0.000
Ecological index (0.5)	0.000	0.464	0.448	0.472	0.511	0.613	0.672	0.518	0.773	0.829	1.000
Total system quality	**0.346**	**0.572**	**0.528**	**0.589**	**0.539**	**0.663**	**0.515**	**0.542**	**0.611**	**0.698**	**0.820**

Table 9.4 shows that based on the overall indicators analyses, the management system XI (integrated management III as combination of green belt boundary development, establishment of buffer zone ecological base scenario, habitat rehabilitation and people displacement programs) offered the best management option of the Park for resolving encroachment conflict (the highest total quality index = 0.820). Whereas the management system I (no management action taken) is the worst choice amongst all management options for resolving people-park conflict in KSNP (the lowest total quality index = 0.346). These entirely intuitive results provide some measure of confidence in the reliability of the modelling approach.

9.3.8. Decision making analysis

To facilitate the interpretation of the results as presented in Table 9.4, the total quality of the composite value for each management option can be represented in a graphical format. The graph can show the actual achievement for each management option relative to the ideal point. The range of acceptance level of management options can be made by setting up boundaries based on the value of the composite distance specifying the total quality of the system (L). The curves (β) defining the limits of each range can be determined using the equation below:

$$\beta = [\alpha_1 (1 - x)^p + \alpha_2 (1 - y)^p]^{1/p} \tag{9.5}$$

UNESCO (1987) suggests three level bands of the total quality system (L) value as a qualitative appraisal of the soundness of the management options: $L < 0.3$ is poor, $0.4 < L < 0.6$ is acceptable and $L > 0.6$ is good, whilst Bailey *et al.* (1997) utilised the same UNESCO's band values but for $L < 0.4$ as a poor acceptance. The conceptual comparison of performance for a number of alternative management scenarios (*a...g*) is shown in Figure 9.4.

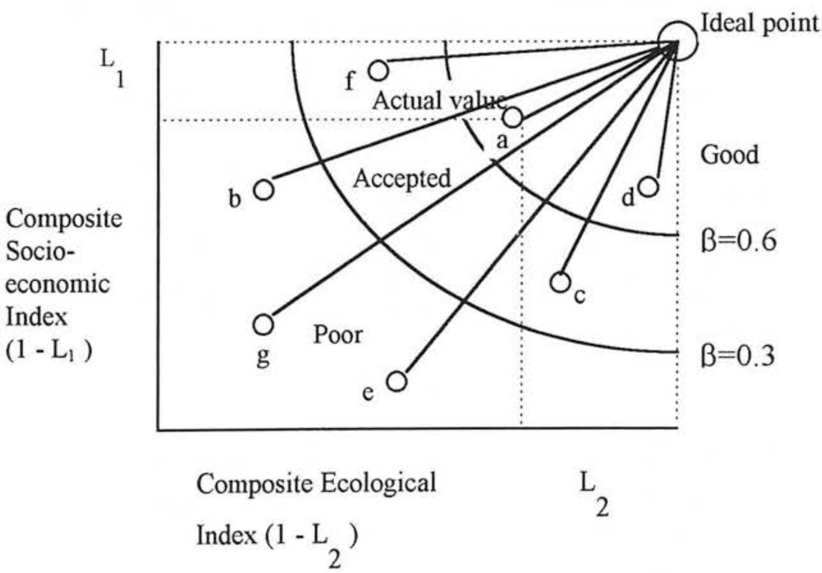


Figure 9.4. Conceptual comparison of performance of alternative management option scenarios (Bailey *et al.*, 1997)

The results of management options analysis in KSNP based on baseline run 1 to 4, as shown in Table 9.4 to Table 9.7 respectively can be presented graphically as Figure 9.5 to Figure 9.7. Bailey *at al.* (1997) suggest if the overall objective achievement derived from the management option is a straight weighted sum of the achievement of each component as an indication of its linearity, the boundary curves are then defined as straight lines. The level of acceptability for each management options (management system I to XI) was measured based on a three level boundary of the value of the total quality system as: L < 0.5 is poor, 0.5 < L < 0.6 is acceptable and L > 0.6 is good.

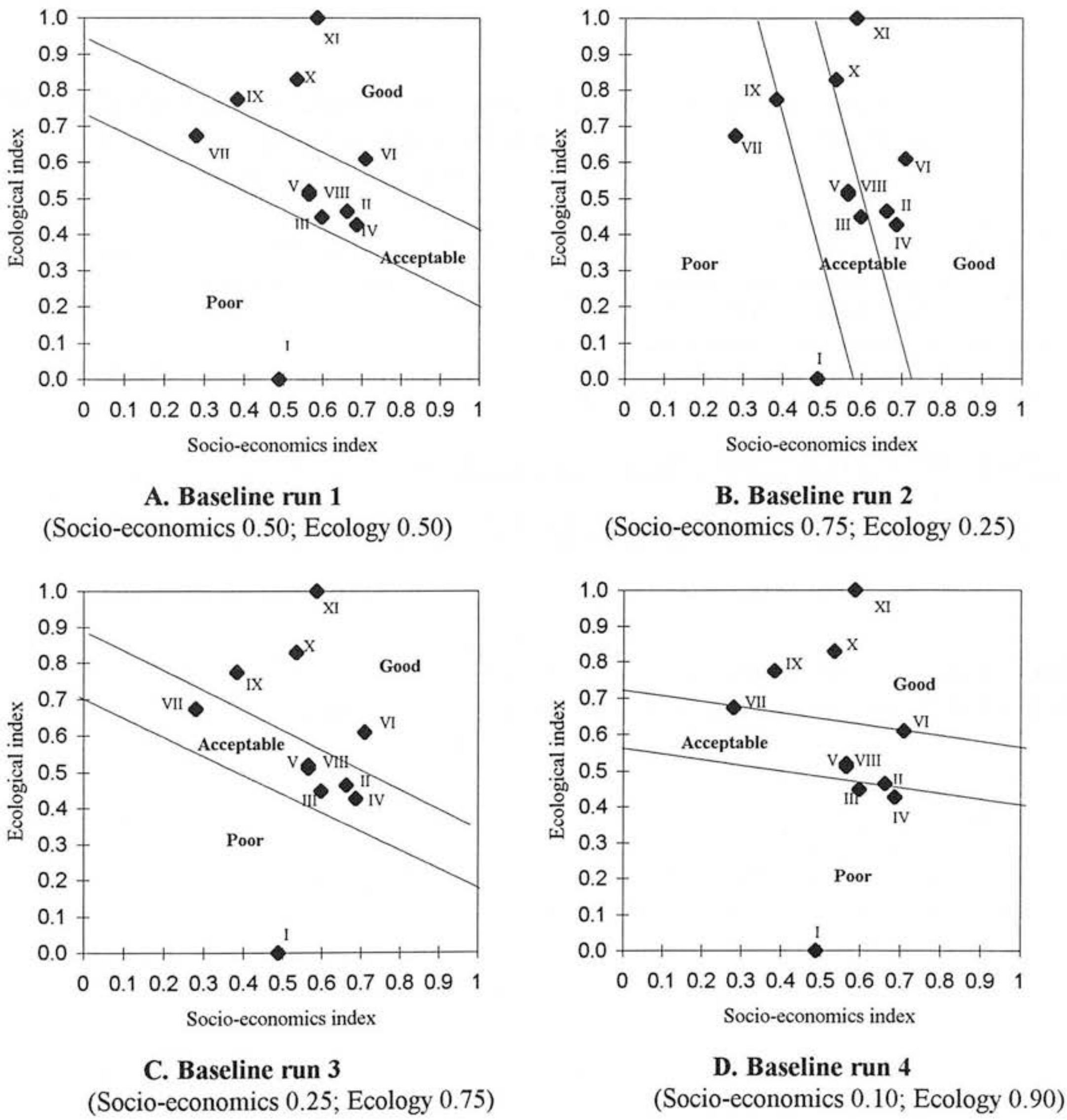


Figure 9.5. The acceptability level of management options based on baseline run for different relative weights of socio-economics and ecological indicators.

Table 9.5. The matrix system of the composite distances for the third level indicators based on the baseline run 2 (Socio-economic 0.75 and ecological indicators 0.25)

The composite indicators	Management							Options			
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Socio- Economics index	0.368	0.497	0.448	0.515	0.425	0.532	0.211	0.425	0.289	0.401	0.440
Ecological index	0.000	0.116	0.112	0.118	0.128	0.153	0.168	0.129	0.193	0.207	0.250
Total system quality	**0.424**	**0.618**	**0.563**	**0.632**	**0.553**	**0.685**	**0.415**	**0.554**	**0.495**	**0.622**	**0.713**

Table 9.6. The matrix system of the composite distances for the third level indicators based on the baseline run 3 (Socio-economic 0.25 and ecological indicators 0.75)

The composite indicators	Management							Options			
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Socio- Economics index	0.123	0.166	0.149	0.172	0.142	0.177	0.070	0.142	0.096	0.134	0.147
Ecological index	0.000	0.348	0.336	0.354	0.383	0.459	0.504	0.389	0.579	0.622	0.750
Total system quality	**0.245**	**0.521**	**0.489**	**0.505**	**0.525**	**0.635**	**0.599**	**0.531**	**0.669**	**0.766**	**0.914**

Table 9.7. The matrix system of the composite distances for the third level indicators based on the baseline run 4 (Socio-economic 0.10 and ecological indicators 0.90).

The composite indicators	Management							Options			
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Socio- Economics index (0.5)	0.049	0.066	0.059	0.068	0.566	0.070	0.281	0.566	0.385	0.535	0.587
Ecological index (0.5)	0.000	0.464	0.448	0.472	0.511	0.613	0.672	0.518	0.773	0.829	1.000
Total system quality	**0.155**	**0.587**	**0.465**	**0.498**	**0.516**	**0.623**	**0.644**	**0.523**	**0.743**	**0.804**	**0.967**

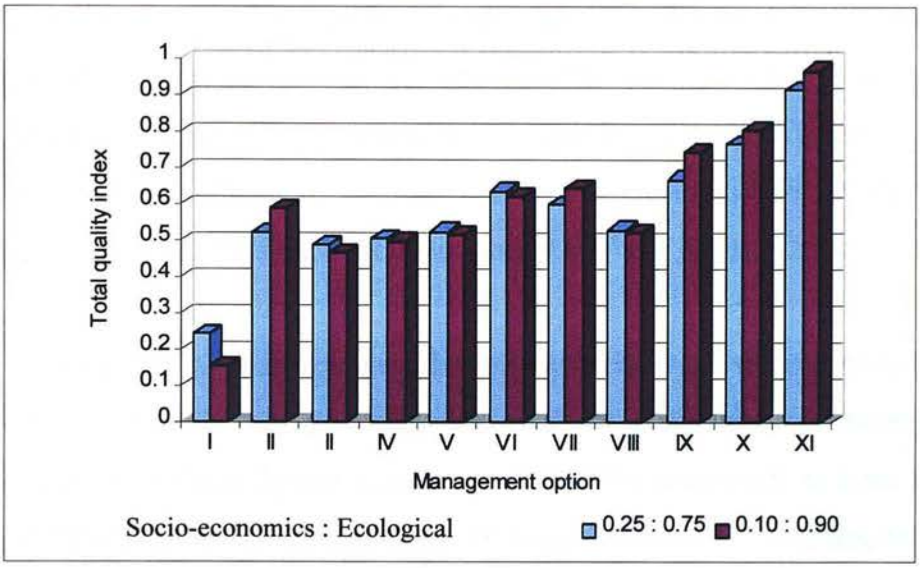


Figure 9. 6. The total quality index of each management option based on L2 matrix with ecological indicators are more prioritised

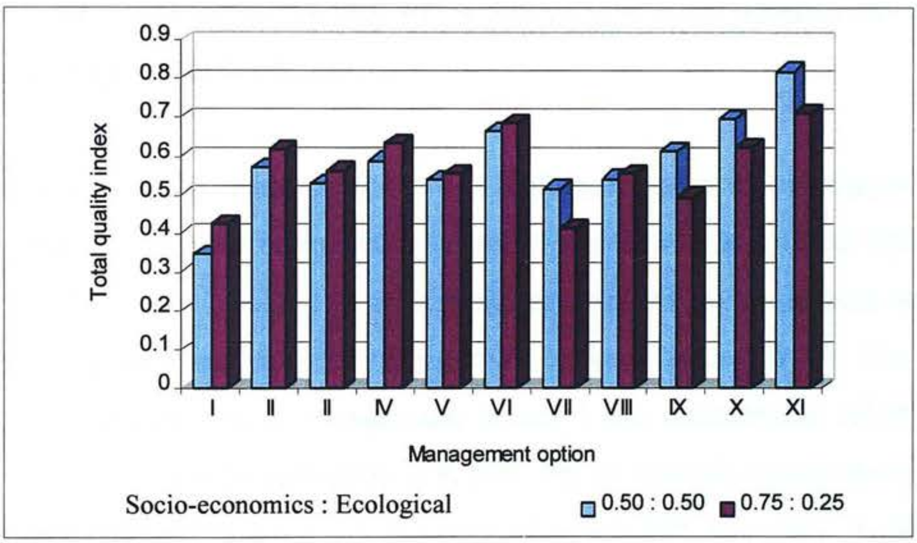


Figure 9.7. The total quality index of each management option based on L2 matrix with socio-economics indicators are more prioritised

The code and the classification of proposed management options are:

I	No management action taken
II	Greenbelt boundary development of 25 metres wide
III	Establishment of buffer zone A (baseline scenario)
IV	Establishment of buffer zone B (economic base scenario)
V	Establishment of buffer zone C (ecological base scenario)
VI	Establishment of buffer zone D (Boolean scenario)
VII	Habitat Rehabilitation
VIII	People displacement
IX	Integrated management 1 (system II, III, VI, VII and VIII)
X	Integrated management 2 (system II, IV, VI, VII and VIII)
XI	Integrated management 3 (system II, V, VI, VII and VIII)

The balance between socio-economics and ecological factors in the third level indicator is related to the priority of the Park's objectives, therefore, it is essentially a political decision. Composite programming facilitates the trade-off between those indicators to acquire the best management option most suitable to the Park's objectives by assigning different relative weights in the base line run.

Figure 9.5 to 9.7 show that changing the relative weights of socio-economics and ecological indicators resulted in different level of acceptability of management options. In general, these figures show that integrated management options (system IX, X and XI) for all socio-economics and ecological indicators weighting are better management options for resolving conflicts in KSNP compared to a single management option. This was indicated by the bigger values of the total quality systems as shown in Figure 9.6 and 9.7 as well as their good acceptability level as presented in Figure 9.5.

Prioritising the Park's objectives for more ecological preservation reflected in the greater relative weight of ecological indicator changed the management options III and IV (establishment of buffer zone baseline scenario and economic base scenario) from the acceptable level to poor management option (Figure 9.5 D). The figures also indicate that alternative management system I (no management taken) is the poorest option for conflict resolution in KSNP. For all options, management system XI (the combination between development of green belt boundary, buffer zone ecological base scenario, habitat rehabilitation and people displacement) is the best option. Therefore it is recommended to be taken into consideration for resolving encroachment problems in KSNP.

9.3.9. Sensitivity analysis

Sensitivity analysis is concerned with the way in which changes in the value of a selected key parameter affects the optimal solution of a model (Winston, 1995). It is therefore most important to see which indicator in the system would lead to relatively large change in either the value of the total quality of the system or the level of acceptability of the management options. This can be accomplished by exploring the relationship between indicators of different weights through application of a simulation run (UNESCO, 1987).

In the following four simulation runs, the effects of different relative weights assigned to the second level indicators (economics, regional development, recreation, wildlife, habitat and soil) on the final total quality composite value for each management option were examined. In the simulation Run 1 the relative weight for socio-economic indicators were simulated in which economic indicator was more important, whilst the ecological indicators were kept unchanged. In the simulation Run 2 the weighting of ecological indicators were simulated with stress on the wildlife preservation, whilst the socio-economics indicators remained the same. In simulation Run 3 both the weighting of socio-economics and ecological indicators were simulated with a stress on economic and wildlife indicators respectively. And in simulation Run 4 the relative weight for both socio-economics and ecological indicators were simulated in which recreation and habitat indicators were more prioritised. The results of these simulation runs are presented in Table 9.8 to Table 9.11 and in Figure 9.8. to Figure 9.10.

Table 9.8. The matrix system of the composite indexes for the third level indicators based on the simulation Run 1 (Economics 0.6; Regional development 0.2; Recreation 0.2 and Ecological indicators remain the same).

The composite	Management Options										
indicators	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Socio -Economics distance	0.340	0.237	0.285	0.221	0.299	0.207	0.722	0.337	0.743	0.639	0.602
Socio- Economics index (0.5)	0.660	0.763	0.715	0.779	0.701	0.793	0.278	0.663	0.257	0.361	0.398
Ecological distance	1.000	0.536	0.552	0.528	0.489	0.387	0.328	0.482	0.227	0.171	0.000
Ecological index (0.5)	0.000	0.464	0.448	0.472	0.511	0.613	0.672	0.518	0.773	0.829	1.000
Total system quality	**0.467**	**0.631**	**0.582**	**0.644**	**0.613**	**0.709**	**0.514**	**0.595**	**0.576**	**0.639**	**0.761**

Table 9.9. The matrix system of the composite indexes for the third level indicators based on the simulation Run 2 (Wildlife 0.6; Habitat 0.2; Soil 0.2 and Socio-economics indicators are remain the same)

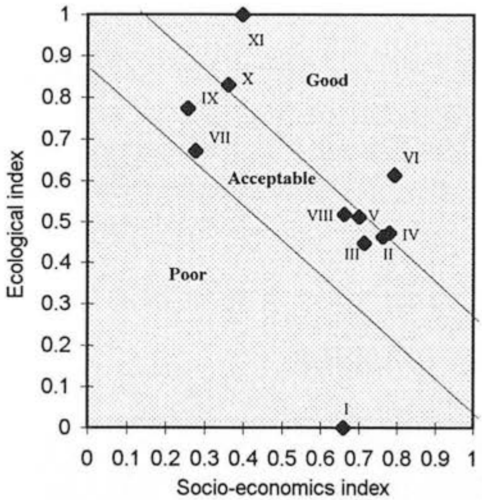
The composite indicators	Management Options										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Socio -Economics distance	0.510	0.338	0.403	0.313	0.434	0.291	0.719	0.434	0.615	0.465	0.413
Socio- Economics index (0.5)	0.490	0.662	0.597	0.687	0.566	0.709	0.281	0.566	0.385	0.535	0.587
Ecological distance	1.000	0.553	0.570	0.585	0.506	0.429	0.461	0.488	0.264	0.131	0.000
Ecological index (0.5)	0.000	0.447	0.430	0.415	0.494	0.571	0.672	0.539	0.512	0.736	1.000
Total system quality	**0.346**	**0.565**	**0.520**	**0.568**	**0.531**	**0.644**	**0.429**	**0.540**	**0.587**	**0.722**	**0.820**

Table 9.10. The matrix system of the composite indexes for the third level indicators based on the simulation Run 3 (Economics 0.6; Regional development 0.2; Recreation 0.2; Wildlife 0.6; Habitat 0.2; Soil 0.2)

The composite indicators	Management Options										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Socio -Economics distance	0.340	0.237	0.285	0.221	0.299	0.207	0.722	0.337	0.743	0.639	0.602
Socio- Economics index (0.5)	0.660	0.763	0.715	0.779	0.701	0.793	0.278	0.663	0.257	0.361	0.398
Ecological distance	1.000	0.553	0.570	0.585	0.506	0.429	0.461	0.488	0.264	0.131	0.000
Ecological index (0.5)	0.000	0.447	0.430	0.415	0.494	0.571	0.672	0.539	0.512	0.736	1.000
Total system quality	**0.467**	**0.625**	**0.589**	**0.551**	**0.606**	**0.691**	**0.514**	**0.604**	**0.405**	**0.579**	**0.761**

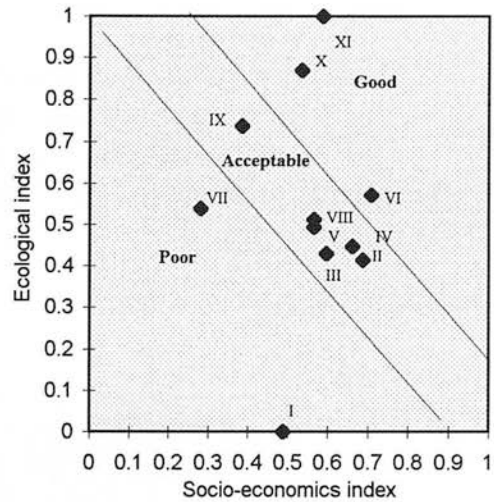
Table 9.11. The matrix system of the composite indexes for the third level indicators based on the simulation Run 4 ((Economics 0.2; Regional development 0.2; Recreation 0.6; Wildlife 0.2; Habitat 0.6; Soil 0.2)

The composite indicators	Management Options										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Socio -Economics distance	0.740	0.492	0.519	0.436	0.563	0.309	0.689	0.568	0.343	0.324	0.209
Socio- Economics index (0.5)	0.260	0.508	0.481	0.564	0.437	0.601	0.311	0.432	0.657	0.676	0.790
Ecological distance	1.000	0.462	0.506	0.445	0.464	0.366	0.269	0.451	0.218	0.144	0.000
Ecological index (0.5)	0.000	0.538	0.494	0.555	0.536	0.634	0.731	0.549	0.782	0.856	1.000
Total system quality	**0.184**	**0.523**	**0.487**	**0.559**	**0.489**	**0.617**	**0.562**	**0.494**	**0.722**	**0.771**	**0.901**



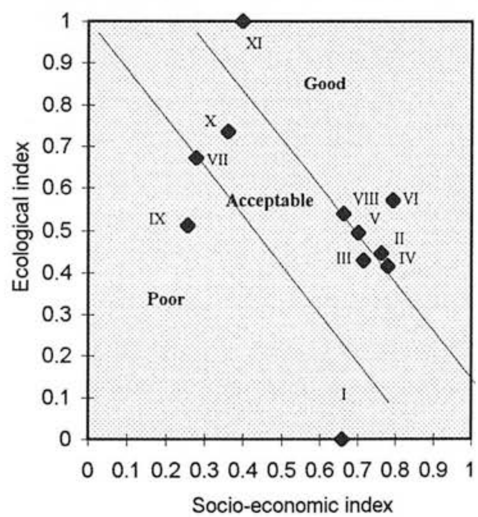
A. Simulation Run 1

(Economics 0.6; Regional development 0.2; Recreation 0.2)



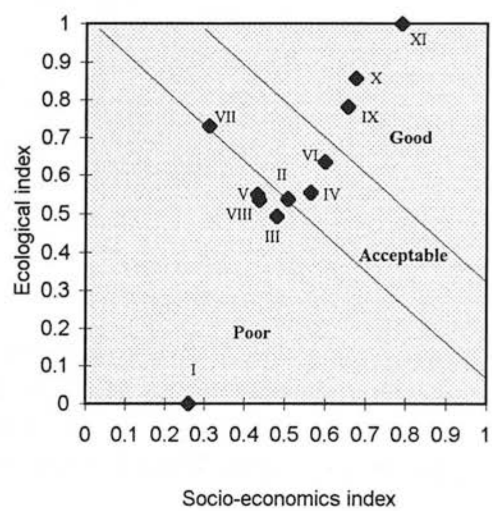
B. Simulation Run 2

(Wildlife 0.6; Habitat 0.2; Soil 0.2)



C. Simulation Run 3

(Economics 0.6; Regional development 0.2; Recreation 0.2; Wildlife 0.6; Habitat 0.2; Soil 0.2)



C. Simulation Run 4

(Economics 0.2; Regional development 0.2; Recreation 0.6; Wildlife 0.2; Habitat 0.6; Soil 0.2)

Figure 9.8. The acceptability level of management options based on simulation run for different relative weights of the second level indicators

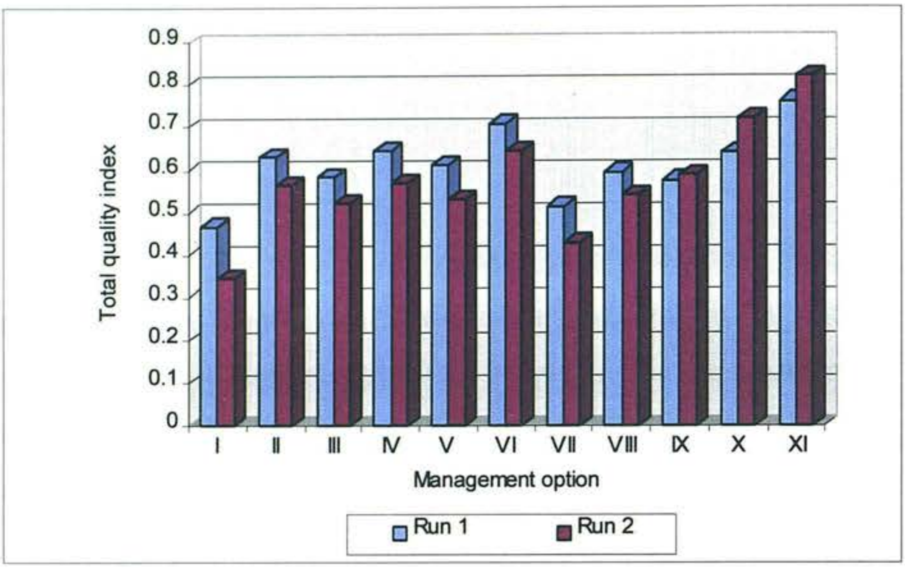


Figure 9.9. Total quality index of each management option based on simulation Run 1 and Run 2 (Run 1: Economics 0.6, Regional development 0.2, Recreation 0.2 and Ecological indicators are unchanged; Run 2: Wildlife 0.6 Habitat 0.2, Soil 0.2 and Economics indicators are unchanged)

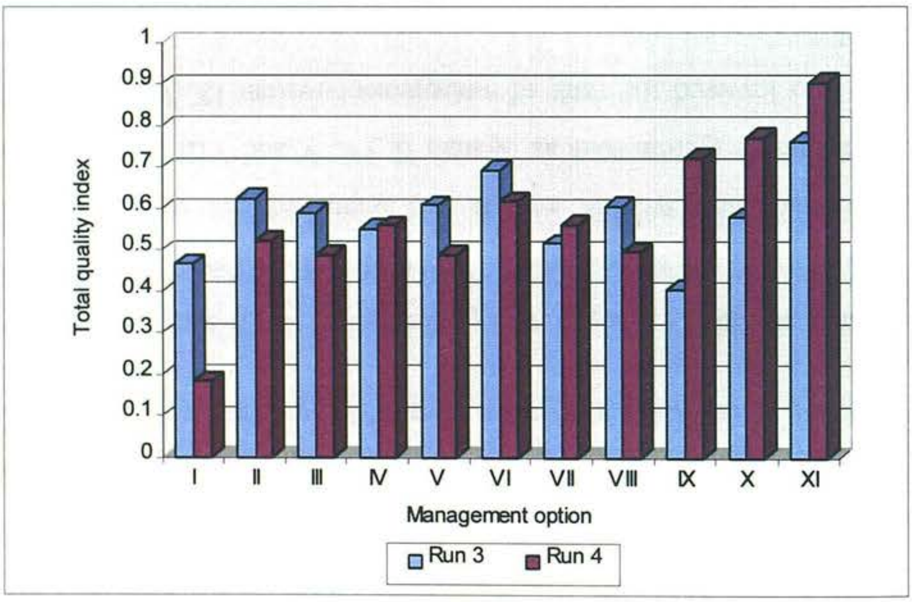


Figure 9.10. Total quality index of each management option based on simulation Run 3 and Run 4 (Run 3 : Economic 0.6, Regional development 0.2, Recreation 0.2, Wildlife 0.6, Habitat 0.2, Soil 0.2; Run 4: Economics 0.2, Regional development 0.2, Recreation 0.6, Wildlife 0.2 Habitat 0.6, Soil 0.2).

The sensitivity analysis as shown in Figure 9.8 to Figure 9.10 revealed that the total quality indexes of a management option were sensitive to the change of the relative weights assigned to the second level indicators. For instance the change of weighting on socio-economics indicators from the baseline run in which the economics factor was more prioritised shifted some management options of KSNP from good to acceptable level as shown in simulation Run 1 (Figure 9.8 A). This can be seen in the decreasing total quality index of management system IX from 0.611 (good level) to 0.576 (acceptable level). The change of relative weights of ecological indicators from the baseline stressing wildlife protection has lowered acceptability of management system VII from the acceptable class to poor category. This was indicated by the decrease in its total quality index from 0.515 to 0.429 (Table 9.4 and 9.9).

Similar sensitivity analysis was performed on both socio-economics and ecological indicators of the second level. The trade-off on these indicators giving priority to economics and wildlife aspects has improved the total quality index of many management system such as system II, IV, V and VIII (Figure 9.8 C). However, it has also lowered the rank of management system IX from the acceptable to poor level.

Total quality index of a management option seems most sensitive to the change of relative weight in both socio-economics and ecological indicators giving priority to recreation and habitat. These changes have resulted in the decreasing total quality index of system management III, V and VIII and a fall in their rank from an acceptable to a poor level of management option (Figure 9.8 D)

This analysis revealed that integrated management system X and XI were not greatly affected by the change of relative weights of second level indicators. Both of these management systems remain in the good acceptability level. Therefore, management system XI, as an integrated management system could be the best choice for resolving people-park conflict in KSNP.

In short, the trade-off between economics and ecological indicators affected most single system management options of KSNP (Management system II to VIII) and Integrated management system IX. However, it did not have much effect on the acceptability level of Integrated management system X and XI as the best management options for KSNP, neither did it effect the single management system I as a poor alternative management system for the Park.

9.4. Summary

The development of the MCDM model using a Composite Programming approach was found to be effective in determining the alternative methods to resolving encroachment conflict in KSNP management. The graphical representation of the results allowed preferred choices to be identified from all available alternative management options. Management systems that represent a better compromise between competing interests can be identified by application of the boundary of three level bands based on the value of the total quality index. Sensitivity analysis was performed to find out key parameters that affect the optimal management option for resolving people-park conflict. It was revealed that the total quality index of a management option is most sensitive to the change of relative weight on both socio-economics and ecological indicators giving priority on recreation and habitat. The Composite Programming approach found that Integrated management X and XI offered the best option for the Park management in resolving encroachment conflict.

CHAPTER TEN

CONCLUSIONS AND RECOMMENDATIONS

The discussion on various subjects in the previous chapters has provided a general picture of the conflict management in national parks, outlining the historical background of national park concepts, people-park problems faced in many developing countries and in particular in the study site, causes of national parks and protected areas degradation, factors influencing human encroachment on the Park, the degree of population pressure and impacts of encroachment activities on the land use dynamic and bio-physical factors of the Park.

Using GIS-based methods, a prediction model of the encroachment expansion and scenarios for buffer zones establishment were developed. The study also looked at the possible conflict resolution based on the MCDM model. Some alternative management options based on the Composite Programming technique for resolving people-park conflict especially of encroachment problems in KSNP, were generated.

A number of summaries and conclusions of findings for each subject have already been presented in the relevant sections. This chapter, therefore, focuses on the overall conclusions of the research findings. It also describes the limitations of the present study and provides recommendations and suggestions for future research.

The specific hypotheses addressed in this study as presented in Chapter one were:

(1) People's decisions to encroach the park are influenced by variety of factors related to their perception both of the Park and of cinnamon farming;
(2) It is possible to develop buffer zones for human requirement without any adverse impacts on the Park;

(3) It is possible to model encroachment risk using GIS-based methods and thereby to suggest alternative management options as a trade-off for accommodating encroachment systems in a form of sustainable park management.

10.1. Concluding Remarks

The subject of alternative conflict management approach which is more generally known as alternative dispute resolution, has developed in the past few decades as an instrument to address conflicts over natural resource use (Reti, 1986; Pendzich *et al.*, 1994). The objective of this technique is to utilise approaches that lead to mutually beneficial agreements as 'win-win' rather than 'win-lose' resolution (Lewis, 1996). Conflicts that are properly addressed can be of importance for resolving the real problems. Many conflicts, however, might be counterproductive and destructive, leading to deleterious results and hostile relationships.

With increasing human populations, people's livelihood in many parts of the world are greatly dependent on parks and forests resources. This may lead to increasing population pressure on the park leading to intensifying conflict between people's interest and the park's management objectives. Park managers especially in many developing countries, therefore, are facing great challenges in resolving people-park conflict over such natural resource use so that unproductive consequences can be avoided while surrounding people's well being and the park's integrity are protected.

This study has focused on people-park conflicts, in particular upon encroachment problems that arise over the use and management of the Kerinci Seblat National Park resources. It has examined alternative Park management options as a possible tool to address these kinds of disputes. In addition of the summaries and conclusions in each chapter, five specific points related to the study objectives and hypotheses emerging from the previous discussions merit further attention.

10.1.1. The need for an integrated park management

Conflicts between national parks and their surrounding human communities in many countries today are often as the indirect result of misinterpretation of the national park concept. Under the traditional protective approach of national park, humans were treated as a threat and totally incompatible with the park and protected area's objectives (West and Brechin, 1991). Therefore, the highest policy of the competent authority of the country generally set up its priority to eliminate occupation in the whole area. As a result, people were forced to move from the park perimeter, even though they have inhabited those areas for many years before the parks designation. This might lead to the intensifying of people-park conflict although various forms of compensation might be provided to soften the blow of dislocation.

At present, new approaches such as an Integrated Conservation Development Program (ICDP) are being adopted in many parts of the world as a way of helping to resolve people-park conflicts. Under the new concept of parks management, indigenous people are considered as part of the park's ecosystem. Therefore they are given access to the park resources. An evaluation of pilot projects sponsored by the World Bank for the application of the ICDP concept in many developing countries has proven its capability of reducing people-park conflict over natural resource use (Wells *et al.*, 1992). Therefore it is important that this new concept is widely tested and implemented in alternative park management systems.

This new concept is most suitable for use especially in any country in which a substantial number of people live in or near a national park or other protected areas and in which their livelihoods are mostly dependent on the protected area resources. A national park containing a relatively large enclave area such as Kerinci Seblat National Park is recommended to implement this new concept for its sustainable management.

10.1.2. People's perception and population pressure

Encroachment in KSNP is a complex system evolving many parties not only the local poor and illiterate people but also those who are wealthy and educated coming from many different regions. The study results indicated that the high rate of encroachment in Kerinci was significantly related to the people's perception of the high value of cinnamon plantation regardless their income level, social status, class and position. This finding was supportive of the first hypothesis, 'People's decisions to encroach the park are influenced by a variety of factors related to their perception both of the Park and of cinnamon farming'.

Although there are a number of plantations and crops that are more profitable than cinnamon, such as vanilla, clove etc., cinnamon is still the most famous plant for Kerinci people. It does not seem easy to change their perception of the high value of cinnamon, unless there is a widely well known evidence that can be perceived by the common people. Therefore, pilot projects to promote the greater advantages of these other plantations for local people are necessary. The change of attitude on cinnamon may lead to support of the Park's multi-purpose tree species (MPTS) program.

The study results also indicated that human encroachment on the Park was influenced by the shortage of agricultural lands in the enclave area and the relatively low level of people's perception of the concept and values of the Park. People's attitudes towards the Park were influenced by perceived benefits from the Park, level of education, and social status. Therefore ecotourism and establishment of traditional use zone, as well as environmental education and awareness, need to be promoted.

Using Park Pressure Index (PPI) as a yard stick it was revealed from the study that KSNP is now under serious population pressure as indicated by the value of PPI equals to 2.97 in 1995 (PPI < 1 = no pressure). This was mainly due to the lack of agricultural farm lands in the enclave area. To lessen the population pressure back to the pressure limit (PPI = 1), an extension of agricultural farming of more than

300,000 hectares should be provided. The need of agricultural farms could be much higher, up to more than 400,000 hectares in 2005, if no management intervention is promoted. Therefore the Park's zonation for traditional and limited uses, as well as alternatives income generation need to be developed to lessen this serious population pressure on the Park.

10.1.3. Buffer zone development

Buffer zone development could be an attractive and positive tool for the preservation of parks and protected areas against external pressures if it provides an alternative sources of income and employment for local people (Sayer, 1990; Wells *et al.,* 1990). In practice, however, buffer zones in many countries such as in Thailand and Madagascar seem to be designated basically to reduce local opposition to the establishment and expansion of parks and protected areas rather than to offer alternatives of sustainable livelihood for the local people (Ghimire, 1994). This usually happens if the idea and implementation of buffer zone development is derived totally from above without any participation of the local people in the planning process.

In this study the criteria for buffer zone development were designed based on the input both from the Park authority and the local people as well as being derived from the GIS analysis. This aimed to achieve an optimum function of the buffer zone through the participation of the local people starting from the planning process until the developing programs. The MPTS program aims at the gradual replacement of cinnamon plantations with the more beneficial fruit generating plants and was suggested to be implemented in the buffer zone program. Successful implementation of this program offers alternative sustainable livelihoods for the local people leading to the decreasing intensity of people-park conflict. This finding, is therefore, in accordance with the second hypothesis, 'It is possible to develop buffer zones for human requirement without any adverse impacts on the Park'.

The application of GIS based methods for designing buffer zones was found very useful. Based on different management objectives, four development scenarios were examined as an example of using MCE module. The area produced by these scenarios varied from 14,511 hectares for the Constraint base scenario to 25,587 hectares for the Economic scenario and to 40,785 hectares for Baseline scenario. The results showed that the development of simulation models for buffer zone establishment worked very well in which all requirements needed by a buffer zone based on the selected criteria were successfully fulfilled.

10.1.4. Land use dynamics

The GIS-based analysis demonstrated that land use dynamics in Kerinci District were very complex in that there were gains and losses in all categories of land use. Using a GIS-based method, quantitative analyses of land use dynamics on four main subjects were successfully performed. These included the dynamics between land use categories, the dynamics in relation to slope and elevation, the dynamics in the enclave and in the Park areas and the dynamics based on the Park boundary.

The results indicated that encroachment was found as the main factor inducing land use change in KSNP. During a decade since 1982, the encroachment area expanded by more than 75 % from 51,678 hectares to 90,931 hectares mainly at the expense of forest area, shrub and abandoned lands. The study revealed that forest area in Kerinci District degraded rapidly at the average rate of 3,574 hectares (1.33 %) per year during a decade between 1982-1991. This figure is 1.66 time bigger than that of the National figure which is only 0.8 % per year. The most critical areas for both forest degradation and encroachment expansion were those in the elevation between 500 and 1500 m above sea level with the slope range from 15 to 40 percent.

The risk of encroachment expansion in KSNP was successfully modelled using the Logistic Regression analysis combined with the GIS-based method. The predictive modelling revealed that a total of 76,000 hectares of the Park area was predicted to be susceptible to the future encroachment risk. Even though the model was developed under variable limitations especially based merely on the physical characters of the Park, it was supportive of the third hypothesis, 'It is possible to model encroachment risk using GIS-based methods and thereby to suggest alternative management options as a trade-off for accommodating encroachment systems in a form of sustainable park management'. Incorporating both bio-physical and socio-economic aspects of the Park as parameters for the model development would improve the accuracy of the predictive model.

10.1.5. Alternative management options

Recently, managers of national parks and protected areas in most developing countries have been challenged to make resource allocation decisions that balance competing interests and needs of a growing population with a declining natural resource base. Multi Criteria Decision Making (MCDM) techniques were widely utilised to solve this problem in order to minimise conflict of interests by generating alternative management options (AMOs) based on an acceptable trade-off between conflicting objectives. This recognises that the resulting conflict resolution based on the MCDM model represents a satisfactory compromise between several objectives rather than an optimal solution for every single objective.

In this study, alternative management options for KSNP based on the MCDM model, especially the Composite Programming technique, was explored in resolving conflict of interest between encroachment and the Park management objectives. Eleven alternative management options for KSNP (Management system I to XI) were suggested to resolving this problem. Sensitivity analysis and trade-offs between socio-economics and environmental variables associated with alternative options were assessed.

The result indicated that the MCDM model, based on Composite Programming approach, was found to be effective in determining the alternative methods for resolving the escalating encroachment conflict in KSNP management. Based on both baseline run and simulation run, integrated management systems (Management system IX, X, and XI) showed higher total quality index and therefore a better option for KSNP management than that of the single management systems (Management system I to VIII) to resolving encroachment problem.

Sensitivity analysis was performed to find out key parameters that affect the optimal management option for resolving people-park conflict. It was revealed that based on the trade-off between socio-economics and ecological indicators, the total quality index of a management option was most sensitive to the change of relative weight on both socio-economics and ecological indicators giving priority to recreation and habitat.

The analysis revealed that alternative management option XI as the combination between development of green belt boundary, buffer zone ecological base scenario, habitat rehabilitation and people displacement, was found to be the best option in both baseline run and simulation run using all possible economics and ecological trade-offs. In contrast, it should be noted that the 'do nothing' option (alternative management option I) consistently the poorest alternative management. This finding was supportive of the third hypothesis, 'It is possible to model encroachment risk using GIS-based methods and thereby to suggest alternative management options as a trade-off for accommodating encroachment systems in a form of sustainable park management'.

Introduction of the best management option will not be possible without involving many sectors in the development, since it requires financial support that will not be able to be accommodated by the regular Park's budget. Therefore, effort should be made to integrate inter-sectoral and departmental programs involving many parties such as the Kerinci District, Transmigration Department, Directorate General of Land Rehabilitation and Reforestation, WWF, the World Bank etc., to bring about the selected management option for resolving encroachment and people-park conflicts.

In conclusion, implementation of the selected management option as the combination of many programs offers alternative sustainable livelihoods for the local people leading to the conflict resolution between encroachment and KSNP management objectives. Green belt development, for example, provides clearer and unmoveable Park boundaries as an early warning system for encroachers before entering the Park. It might also increase local people income from the fruit producing plants. People surrounding the Park may establish village nurseries to supply seedlings needed by the Park authority for developing buffer zones as well as habitat rehabilitation programs. People involvement in these programs starting from the planning, actuating and monitoring process may increase their participation in the Park management. Successfully applied of MPTS program in the buffer zone development and habitat rehabilitation offers a greater chance for income generation for people surrounding the Park. The relocation program, on the other hand, will reduce population pressure on the Park. However, this should be carried out on the voluntary basis with a great caution and if necessary compensation should be provided.

Application of GIS-based methods and MCDM techniques was found very useful in enhancing the accuracy for the Park management planning. These methods seem to be equally applicable to all other national parks both in Indonesia and in other countries. Therefore, these methods are suggested to be widely applied for parks management planning.

In a wider context, the present study has concluded that involving local people in the development of alternative park management is important in building participation and improving people's perception of the Park leading to conflict resolution over natural resource use. Therefore, when the Park management is incorporated into broader participatory and eco-development strategies and adapted to the local need context, alternative conflict management can empower communities surrounding the Park to develop creative solutions to the Park resource dilemmas.

10.2. Limitations of the Research Methods

Besides the success of achieving the study objectives, there are a number of weaknesses regarding the adoption of the research methodologies as presented below.

10.2.1. Questionnaire problems

The questionnaire design is very important in the study as it will influence the type of information generated and therefore affect the analysis and the survey results. The designed questionnaire in this study was very useful in getting the desired information for further statistical analysis. However, two main problems were identified in using questionnaires survey: the number of questions and the type of questionnaire. The number of question was too many resulting in the difficulty of the analysis. Some questions could be integrated to reduce question number. The type of the questionnaire would have generated a better result if most answers were designed in a scale type rather than a binary type in yes or no choices. In addition simplification of the type of the question would have helped the interviewee avoid misunderstanding of the subject discussed.

10.2.2. Soil and vegetation sampling

The comparison of soil mineral contents based on the length of encroachment may be subject to criticism. It was assumed that there was no variation of the soil condition for all encroachment length classes within the same soil type and this might introduce bias in the analysis. This was carried out as there was no time series data in this area that could eliminate such bias.

The determination of the length of encroachment since it began was mainly based on the farmers' information. Since encroachment is illegal, there was a tendency in their information to reduce the length of encroachment in the Park. Therefore, their information was confronted with the predictive age of cinnamon plants in their farms to enhance the accuracy.

Due to the paucity of funds and time limits the plots of vegetation analysis were limited to three sample plots for each type of land cover. A larger sample size may have increased the accuracy as well as the statistical significance of the results.

10.2.3. Land use classification

For the ease of the analysis, land use in Kerinci District was simplified from many different types of land covers. The classification of encroachment in this study was based on the land cover type dominated by cinnamon plantation and its associated plants with the help of the WWF GIS expert. For the area outside of the Park, most cinnamon was planted in the government forest lands which also categorised as encroachment activity. However, this might include some small area of private cinnamon plants scattered over the Kerinci District. Due to the paucity of fund and time limits, verification of these private cinnamon plants through ground truthing was carried out via very limited sampling. Separation of all private cinnamon plants from the encroachment land use class may have increased the accuracy of the analysis of land use dynamics.

10.2.4. Buffer zone and encroachment risk modelling

The scenario of buffer zone establishment in this study was carried out under variable limitations, especially based merely on the physical aspects of the Park. In an enclave area such as Kerinci District, buffer zone development should take into consideration long term perspectives such as the future demographic trends and the need for food and other livelihood requirements. These factors were not incorporated in the model. In addition, assigning weighing factors in the pairwise comparison matrix for developing buffer zone scenarios was based on subjective judgement and for this reason may be open to criticism.

The predictive modelling of encroachment risk in this study was also carried out under variable limitations on the physical aspects of the Park. Encroachment is not only determined by the bio-physical aspects of the Park but is also influenced by the socio-economic condition of the surrounding communities as well as the degree of law enforcement by the Park authority. Inclusion of all of these aspects in the model might have improved the accuracy of the predictive encroachment model.

10.2.5. MCDM approach

The use of the MCDM approach for generating alternative management options in KSNP was successfully implemented. However, some weaknesses in the application of the MCDM approach should be noted. Once the weights for indicators are explicitly defined, it might possible that the reader get a false sense of objectivity throughout the rest of the analysis. However, this problem could be minimised by specifying and stating clearly that the values assigned are subjective judgement.

10.3. Recommendations for Further Research

The need for additional data for more effective conflict management and better resolution of encroachment problems in KSNP were discovered during the process of the data analysis. In relation to this study, the areas for future research that would enable a better understanding of land use dynamics, model development and alternative Park management include the following:

(1) More accurate survey on the land use classification, particularly for the encroachment category, is needed. Encroachment areas should be clearly differentiated from the non encroachment areas. Private lands are scattered over the whole area of Kerinci District in small patches, therefore, a detailed field

survey is necessary to reclassified the existing land use type to enhance the understanding of encroachment dynamics.

(2) Utilisation of more recent satellite imageries for the future land use analysis. Five year interval of land use map since 1982 would be more accurate for understanding of the land use dynamic in Kerinci District.

(3) Inclusion of the more socio-economic indicators in the predictive model of encroachment risk and buffer zone development. The models need to be tested and revalidated based after application in the real world.

(4) More sample data of soil and vegetation analysis are needed to generate a better figure of the encroachment impacts on bio-physical factors of the Park.

(5) Determination of more accurate stake holders, key persons and their power involved in the conflicting interest of natural resource use. It is important to include all people from a variety of socio-economic background for a win-win conflict resolution. Such an analysis could help the Park authority in targeting incentives or compensation measures.

(6) Careful analysis of encroachers needed for displacement due to their deleterious impacts on the Park integrity and ecosystem sustainability.

(7) Additional indicator selection in the MCDM model to generate better alternative Park management option. Alternative management options should provide both income generation for the local people and at the same time provide protection for the Park integrity and wildlife.

Application of both GIS-based methods and MCDM techniques was found very beneficial in increasing the accuracy of the Park management planning. However, these methods require expertise for their implementation. A GIS program should be developed in every single park, as centralised GIS in the Headquarters for all parks is not possible to perform more detailed analysis. Therefore, it is suggested that every park should have its own expert in the GIS. The need to train park staff for these particular subjects (GIS and MCDM methods) is inevitable in the future for better and more accurate parks management planning.

The change of national park philosophy from a traditional protective management approach to an integrated management approach seems more beneficial for the ecosystem integrity, more secure for biodiversity preservation and more promising to resolving people-park conflict compared to other forms of protected area policy. However, some requirements, such as the availability of park staff, their quality, a clear boundary marking, a clear management policy and regulation as well as law enforcement, will determine the success of the application of this new concept of the national park.

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Appendix 1. Questionnaires for assessment of socio-economics and participation of respondent households

Module I. RESPONDENT DATA BASE

A. Household information

Answer

1. Code number of respondent:
2. Tribe: [1= Kerinci, 2 = Minang, 3 = Java/Sunda, 4 = Batak, 5 = Others]
3. Status: [1 = Encroacher, 2 = Non encroacher]
4. Location: [1 = In the park, 2 = Outside the park]
5. Income: Rp /yr. [1= <500; 2=500-1000, 3=1000-1500, 4=1500-2000, 5= >2000] x Rp1000.-
6. Relation to the park staff : [1= Good, 2 = Fair, 3 = Poor]
7. Family members:

No.	M/F a)	Age (yr)	Education b)	Job c)	Relation d)	Religion e)	Marital status f)
1.							
2.							
3.							
4.							
5.							
6.							
7.							

Answer code:
a). 1= Male, 2 = Female
b). 1= No school, 2 = Primary school, 3 = High school, 4 = Graduate
c). 1= Farmer, 2 = Govt.service, 3 = Trader, 4 = Daily labourer, 5 = Others
d). 1= Husband, 2 = Wife, 3 = Son/daughter, 4 = Relative, 5 = Others
e). 1= Islam, 2 = Christianity, 3 = Others
f). 1= Married, 2 = Unmarried, 3 = Widow

B. Farm information

8. Farming system: [1 = Shifting, 2 = Permanent, 3 = Combination]
9. Transportation to the farm : [1 = Walking, 2 = Public transport, 3= Others]
10. Do you have any temporary house? [1 = Yes, 2 = No]
11. Do you have any permanent house? [1 = Yes, 2 = No]
12. Average slope of the farm: ....% [1 = <15%, 2 = 15-25%, 3 = 25-40%, 4 = >40%]
13. Any plan to make other farms? [1= Yes, 2 = No, 3 = Do not know]
    Reason :
14. Reason for site selection : [1= security, 2= fertility, 3= proximity to settlement, 4= proximity to river/road, 5= proximity to existing farms, 6= slope steepness]

15. Farm ownership:

Type of farm	Area (Ha)	Location a)	Start farming (yr)	Distance house to farms (km)	Type of plantation b)	Status of ownership c)
Forest						
Farm I II III						
Rice field						
Garden						
Pond						
Others						

Answer code:
a). 1= Inside the park, 2 = Outside the park
b). 1= Mono culture, 2 = mixed
c). 1= Owner, 2 = Sharecropper, 3 = Leaser, 4 = Landless

C. Knowledge base on conservation issues

[Answer code: 1 = Good/ >75%, 2 = Fair/ 50-75%, 3 = Poor/ <50%]

Answer

16. Do you know what is a national park? ☐
17. Could you please tell me the purpose of the park? ☐
18. Do you know the location of the park boundary? ☐
19. Would you like to describe the zonation of the park? ☐
20. What activities allowed and not allowed in the park? ☐

D. Participation in the Park programme

Answer

21. Are you involved in the park management? [1= Yes, 2=No, 3= Do not know] ☐
    In which area/subject? [1= Planning, 2= Organising, 3= Actuiting, 4=Controlling , 5= Others] ☐
22. Would you like to participate in the transmigration program coordinated by the park staff? [1 = Yes, 2= No, 3=Do not know] ☐
    Why?
    [1= To get a better life, 2= To have more land, 3= To have another experience, 4=Others]
    [1= Not sure to have a better life in the new place, 2=Life in Kerinci is better, 3= Getting old, 4= Some previous transmigrants escaped, 5= Others:............] ☐
23. Do you know what is the MPTS (multi purposes tree species) programme managed by the park?
    [1=Banning the cinnamon cultivation in the park 2= Replacing cinnamon cultivation, 3=Increasing farmers' income through plantation other than cinnamon, 4= Reboisation, 5=Farmers' right limitation, 6=Others: ...., 7= Do not know] ☐
24. Do you want to participate in the MPTS program?
    [1= Yes, 2= No, 3= Do not know] ☐
    If yes, what kind of tree species do you most likely to cultivate ?
    [1= Vanilla, 2= Durio, 3=Artocarpus, 4=Others, state:............] list in order. ☐

E. Resource Use

25. The source of fuelwood is from............. [1= Own garden, 2 = Forest, 3= KSNP] ☐
26. Where do you usually get timber consumption? ☐
    [1= Own garden, 2=Forest, 3= KSNP, 4 = Others: ....]
    Preferred tree species are (list in order): ....
27. What kind of livestock do you have? [1=Cow, 2= Buffallo, 3= Goat, 4= Others] ☐
    How many: .... [1= <5, 2= 5-10, 3 = 10-20, 4= >20] ☐
28. Are you envolve in the hunting activities? [1= yes, 2= No] ☐
    Preferred animals for hunting are: ☐
29. Where did you usually sell your cinnamon [1= Trader in village, 2=Whole seller, 3= Exporter] ☐

Module II. ATTITUDE AND RESPOND TO THE PARK MANAGEMENT

[Answer code: 1= Agree, 2 = Disagree, 3 = Do not know]

A. Perception on National Park concept

Answer

1. It is important to conserve endangered species of plants and animals in the park ☐
2. Conserving the park ecosystems is useful for our children ☐
3. It is not good that the park is fragmented ☐
4. Encroachment on the park is law breaking ☐
5. A park should be integrated with regional development ☐

B. Perception of the effects of the park

a. On community level

6. The park helps surrounding communities for better life ☐
7. Tourism development is beneficial for the people in Kerinci District ☐
8. The park provide jobs to people ☐
9. The park has created problems for the community ☐
10. The park is too big, therefore many people lack of agricultural lands ☐

b. On household level

11. Establishing the park has encouraged me to work better on the farm ☐
12. It is easier to expand a new farm after the park's creation ☐
13. My living condition has improved after park's establishment ☐
14. It is easier to gather firewood since the park's creation ☐
15. The park has created problems in my life ☐

c. On environmental factors

16. Endangered species of plants and animals are safer after the park's creation ☐
17. The park decreases erosion accident in Kerinci ☐
18. There are more wild animals now than before establishing the park ☐
19. Flooding is less frequent since the park creation ☐

C. Perception on management of encroachment

20. Multi purpose tree species (MPTS) programme to substitute cinnamon is good ☐
21. Banning new cinnamon planting in the park is bad ☐
22. The designed bufferzone for limited agricultural uses is good for people ☐
23. Transmigration is good for encroachers ☐
24. Transmigration for encroachers was well organised ☐
25. Law enforcement to exclude encroachers from the park is necessary ☐

Module III: ATTITUDE AND RESPOND TO CINNAMON CULTIVATION

[Answer code: 1= Agree, 2 = Disagree, 3 = Do not know]

A. Perception on economic aspects of cinnamon

Answer

1. Investment on cinnamon cultivation is more beneficial than other plants ☐
2. Cinnamon cultivation and maintenance cost is cheap ☐
3. The price of cinnamon is good and stable ☐
4. Planting cinnamon meets daily needs ☐
5. Conversion of cinnamon cultivation to other plants is loss ☐

B. Perception on social and cultural aspects of cinnamon

6. The owner of cinnamon cultivation is more respected ☐
7. The area of cinnamon cultivation is an indicator of wealthy ☐
8. It is good to maintain the tradition and culture of cinnamon cultivation from our forefathers ☐
9. Any conversion of cinnamon to other plants is uprooting the Kerinci culture ☐
10. Expansion of cinnamon cultivation is desirable ☐

C. Perception on technical aspects of cinnamon

11. Cinnamon plantation is suitable to Kerinci environment ☐
12. Cinnamon cultivation and maintenance is easy ☐
13. The risk of cinnamon cultivation is low ☐
14. It is easy to sell the cinnamon ☐
15. Cinnamon plantation can be mixed with other crops to meet subsistence needs ☐

MODULE IV. Semi structured questionnare for evaluation of the impacts of management options on the following indicators.

Management Options	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Indicator:											
Agriculture Development											
Settlement Expansion											
Road Construction											
Tourism: Number of tourist visiting the Park Hostel income											
Landscape ecology											
Wildlife species: Species diversity Species safety											
Wildlife corridor											
Forest: Primary forest Secondary forest											
Water: Water quality Water balance											
Habitat fragmentation											
Soil fertility:											
Soil erosion:											

The codes and the clssification of proposed management options are as follows:

I	No management action taken
II	Greenbelt boundary development of 25 metres wide
III	Establishment of buffer zone A (baseline scenario)
IV	Establishment of buffer zone B (economic base scenario)
V	Establishment of buffer zone C (ecological base scenario)
VI	Establishment of buffer zone D (I km wide along the Park boundary)
VII	Habitat Rehabilitation
VIII	People displacement
IX	Integrated management 1 (system II, III, VI, VII and VIII)
X	Integrated management 2 (system II, IV, VI, VII and VIII)
XI	Integrated management 3 (system II, V, VI, VII and VIII)

Categorisation of perceptions

Very positive perception (VP):
If the number of positive answers after deducted by negative answers is equal or more than 60 % of the total number of the questions

Positive perception (P):
If the number of positive answers after deducted by negative answers is less than 60% of the total questions as long as the neutral answer is less than 60% of the total number of the questions.

Neutral perception (Nt):
If the number of neutral (do not know) answers is equal or more than 60% of the total answers as long as the different between positive and negative answers is equal or less than 20 % of the total number of the questions.

Negative perception (N):
If the number of negative answers after deducted by positive answers is less than 60% of the total question as long as the neutral answer is less than 60% of the total number of the questions

Very negative perception (VP):
If the number of negative answers after deducted by positive answers is equal or more than 60% of the total number of the questions

For five questions the formula are as follows:

Category	Answer		
	positive	negative	neutral
Very Positive	5	0	0
	4	0	1
	4	1	0
	3	0	2
Positive	3	2	0
	2	0	3
	3	1	1
	2	1	2
Neutral	0	0	5
	1	1	3
	1	2	2
	0	2	3
Negative	2	3	0
	1	3	1
	1	2	2
	0	2	3
Very negative	0	5	0
	0	4	1
	1	4	0
	0	3	2

Appendix 2. The summary of IDRISI software's modules used in this study (IDRISI Technical Reference manual, 1992)

AREA: Creates a new images by giving each output pixel the value of the area of the class to which the input pixel belonged. Output can also be produced as a table or an attribute values file in a range of measurement units.

ASSIGN: Creates an image from an attribute values file by assigning the data values contained in the attribute values file to the cells belonging to defined regions. ASSIGN can also be used to reclassify integer images (see RECLASS below).

BUFFER: a buffer zone can be defined to a point, a line or an area.

CONTRACT: Reduces image resolution by thinning or aggregation.

CROSSTAB: Performs image crosstabulation and crosscorelation.

DISTANCE: Calculate the distance between each cell and the nearest of a set of target features.

EDIT: A simple ASCII text editor for use with creating a variety of IDRISI data files. With values files, EDIT creates and maintains proper documentation files automatically.

EXPAND: Increase image resolution by pixel duplication.

EXTRACT: Creates an attribute values file from an image by extracting a summary of data values found within defined regions. The summary (minimum, maximum, range, total, mean, or standard deviation) may also be output as a table.

LINEGEN: Generalizes vector lines by point selection, low-pass filtering or tolerance band selection.

LINERAS: Line-to-Raster conversion.

OVERLAY: Produces a new image from the data of two input images. New values result from applying one of the nine possible operations, such as addition, subtraction, multiplication, division, to the two input images, referred to as the first and second images during program operation.

POINTRAS: Point-to-Raster conversion.

POLYRAS: Polygon-to-Raster conversion.

QUERY: Extract pixels designated by an independent mask into a sequential file for subsequent statistical analysis.

RECLASS: Reclassifies pixels by equal intervals or user-defined schemes. RECLASS is commonly used as a database query routine by reclassifying images into Boolean maps or areas meeting the specified condition.

SCALAR: Does scalar arithmetic on images by adding, subtracting, multiplying, dividing or exponentiating the pixels in the input images by a constant value.

TRANSFOR: Undertakes attribute transformations on images (such as converting the data values in an image to the natural logarithms of those values).

WEIGHT: Weight is used to develop a set of relative weight for a group of factors in a multi - criteria evaluation (MCE).

Appendix 3. Some soil elements and their importance for plant

Element Name	Chemical Symbol	Ionic Soil Forms	Comments Concerning Forms of the Elements and their importance in Soils
Aluminum	Al	Al^{3+}	Can be toxic to plants in strongly acid soils; occurs as various hydroxyl forms
Boron	B	H_3BO_3	A water - soluble plant nutrient in a small concentrations.
Cadmium	Cd	Ca^{2+}	High atomic weight ("heavy metal") ; retained in animals and people and is highly toxic.
Calcium	Ca	Ca^{2+}	Essential plant nutrient; the cation often most prevalent in non-acid soils.
Carbon	C	HCO^-_3 CO^{2-}_3	The basic element of organic substances (mostly made by living organisms); component of carbon dioxide (CO_2)
Chlorine	Cl	Cl	An essential plant nutrient occurring in small amounts except when it is a part of soluble salts.
Copper	Cu	Cu^{2+}	An essential plant nutrient; may be as Cu^+ (cuprous) in poorly aerated soils.
Hydrogen	H	H^+	An essential plant nutrient; a small, active, strongly adsorbed and chemically active ion.
Iron	Fe	Fe^{3+}	An essential plant nutrient of low solubility in most soil; may be as Fe^{2+} in minerals as poorly aerated soil; as iron oxide (Fe_2O_3) it causes the reddish and yellowish coloring in soils.
Lead	Pb	Pb^{2+}	Toxic heavy metal; also as PbO_2 in soil.
Magnesium	Mg	Mg^{2+}	An essential plant nutrient; similar in properties and reactions as calcium.
Manganese	Mn	Mn^{2+}	An essential plant nutrient; also as MnO_2 in soil.
Mercury	Hg	Hg^{2+}	Toxic heavy metal; also as HgO_2 in soil.
Molybdenum	Mo	MoO_4^{2-}	An essential plant nutrient required in very small amounts.
Nickel	Ni	Ni^{2+}	Similar importance as is Cd.
Nitrogen	N	NO_3^- NH_4^+	An essential plant nutrient; necessary for proteins; in complex organic forms; both ionic forms are useable by plants.
Oxygen	O	O^{2-} OH^-	An essential plant nutrient; as free gaseous form, O_2, it is essential to all respiration.
Phosphorus	P	HPO_4^{2-} $H_2PO_4^-$	An essential plant nutrient; forms many low solubility phosphates with Ca, Al, Fe, and other heavy metals.
Potassium	K	K^+	An essential plant nutrient; soluble in soils, except mineral forms are very insoluble.
Silicon	Si	Si^{4+}	Common in minerals holding oxygens together; sands and quartz are mostly SiO_2.
Sodium	Na	Na^+	Not essential nutrient, although it may be for some plants; very soluble; part of "soluble salts"; causes sealing of soil.
Sulfur	S	SO_4^{2-}	An essential plant nutrient; forms S^{2-} (sulfide) form or toxic hydrogen sulfide gas (H_2S) in poorly aerated soil.
Zinc	Zn	Zn^{2+}	An essential plant nutrient; often deficient in calcareous and eroded or leveled soils

Source: Miller and Donahue (1990)

Appendix 4: Soil analysis of Kerinci Seblat National Park

PLOT	SAMPLE	MINERAL COMPOSITION							
		pH	C (%)	N (%)	P (mg/100 gr)	K (mg/100 gr)	Ca (me/100 gr)	Mg (me/100 gr)	Na (me/100 gr)
ANDOSOL SOIL									
I (1 yr)	1b	5	7.55	0.84	32	14	2.31	1.42	0.41
	2a	5.6	7.18	0.84	24	11	5.89	2.18	0.39
	3b	5.6	5.34	0.4	23	7	0.92	0.47	0.39
	4a	5.8	3.43	0.29	12	7	1.73	0.7	0.21
	5b	5.4	6.15	0.7	28	12	1.42	1.26	0.48
	6a	5.7	5.6	0.65	20	10	2.64	2.12	0.34
II (5 yr)	7b	6.1	6.85	0.77	54	98	31.83	3.83	0.25
	8a	6.4	18.57	1.57	81	71	55.6	9.29	0.34
	9b	6.5	2.07	0.23	52	56	15.35	2.42	0.26
	10a	6.2	6.92	0.71	46	62	13.86	3.19	0.24
	11b	6.3	7.18	0.82	58	86	20.42	4.26	0.35
	12a	6.2	5.8	0.64	49	66	14.16	6.34	0.26
III (10 yr)	13b	6	8.57	1.23	52	107	39.13	6.73	0.27
	14a	5.5	8.2	1.31	73	111	32.25	6.25	0.35
	15b	6.3	3.15	0.27	18	206	16.51	3.21	0.25
	16a	6.1	2.95	0.32	47	97	11.7	3.13	0.23
	17b	6.2	6.45	1.06	42	112	24.22	4.45	0.27
	18a	6	6.21	1.02	34	98	20.14	4.12	0.25
IV (15 yr)	19b	6.1	7.47	1.08	50	30	14.83	3.2	0.21
	20a	6	7.3	1.08	38	20	12.26	1.5	0.33
	21b	6	7.08	0.67	29	4	0.61	0.92	0.21
	22a	6.1	6.78	0.67	28	9	3.73	0.47	0.21
	23b	6	7.12	0.86	44	20	8.64	2.82	0.22
	24a	6.1	6.98	0.86	42	18	6.42	1.64	0.21

V (20 yr)	25b	6	7.06	1	62	43	18.47	1.8	0.4
	26a	5.8	6.64	0.74	40	147	18.05	2.78	0.24
	27b	6.3	2.32	0.3	29	127	9.77	1.65	0.27
	28a	5.6	3.8	0.47	31	36	4.03	0.74	0.35
	29b	6.1	5.82	0.62	46	120	12.41	1.44	0.23
	30a	6	4.88	0.46	38	82	11.42	2.32	0.28
VI (25 yr)	31b	6	5.4	0.74	128	123	51	3.22	0.96
	32a	6	7.54	1.29	126	60	26.36	4.43	0.38
	33b	6.1	4.93	0.59	55	17	12.69	2.36	0.21
	34a	6	6.71	0.73	50	23	13.6	1.92	0.21
	35b	6	5.24	0.62	86	82	22.21	3.24	0.36
	36a	6	6.48	0.76	78	64	26.12	2.12	0.24
VII (30 yr)	37b	6	7.53	1.41	66	44	31.27	3.74	0.26
	38a	6.2	7.55	1.49	71	29	49.46	4.14	0.28
	39b	6.4	3.9	0.45	34	19	7.7	1.03	0.2
	40a	6.5	6.16	0.77	36	11	21.51	2.23	0.26
	41b	6.1	7.12	0.52	46	24	25.21	2.34	0.24
	42a	6.3	7.24	0.65	48	18	30.15	3.16	0.28
VIII (PF)	43b	5.6	7.51	0.83	35	22	9.93	2.05	0.28
	44a	5.4	7.31	1	45	70	16.51	3.18	0.26
	45b	5.6	4.28	0.5	14	9	1.75	0.58	0.27
	46a	5.5	4.12	0.38	18	44	2.67	0.84	0.34
	47b	5.6	6.42	0.62	24	25	3.46	1.86	0.28
	48a	5.5	5.32	0.54	29	34	4.86	2.12	0.25
LATOSOL SOIL									
IX (I yr)	49b	6	1.73	0.23	52	156	3.39	1.29	0.19
	50a	5.4	1.72	0.27	94	37	1.94	1.27	0.17
	51b	5.6	1.24	0.19	58	125	2.35	0.91	0.62
	52a	5.3	1.1	0.2	114	30	62	0.56	0.41
	53b	5.8	1.64	0.22	64	124	2.28	1.22	0.32
	54a	5.4	1.22	0.24	86	48	1.24	1.12	0.28

X (5 yr)	55b	5	3.54	0.34	27	14	6.16	0.69	0.39
	56a	5.5	3.86	32	20	24	9.77	2.45	0.42
	57b	5	0.96	0.11	9	7	1.05	0.23	0.4
	58a	5.2	1.73	14	10	11	2.37	0.61	0.39
	59b	5.1	2.12	0.24	20	13	5.18	0.45	NA
	60a	5.3	1.86	0.22	18	14	6.21	0.64	NA
XI (10 yr)	61b	5	4.34	0.49	11	15	1.67	0.51	0.41
	62a	4.4	2.47	0.31	11	16	0.54	0.32	0.4
	63b	5.3	2.1	0.23	6	10	0.58	0.25	0.49
	64a	4.6	1.58	0.18	20	14	0.38	0.21	0.45
	65b	5	2.8	0.24	12	14	0.56	0.45	NA
	66a	4.8	2.2	0.18	12	15	0.46	0.36	NA
XII (15 yr)	67b	5.5	3.37	0.47	32	55	10.66	3.56	0.43
	68a	5.7	3.94	0.64	35	43	19.54	3.31	0.47
	69b	6.1	1.59	0.2	18	41	10.7	2.56	0.48
	70a	5.7	1.43	0.17	24	52	4.4	3.58	0.47
	71b	5.5	2.81	0.36	26	55	8.16	3.46	0.46
	72a	5.5	1.86	0.28	28	46	9.24	3.24	0.44
XIII (20 yr)	73b	5.4	4.94	0.54	27	10	6.46	1.24	0.41
	74a	4.7	3.77	0.43	15	12	1.37	0.51	0.45
	75b	5.1	1.88	0.19	6	9	1.5	0.27	0.5
	76a	5	ERR	ERR	ERR	ERR	ERR	ERR	ERR
	77b	5.5	4.28	0.52	24	10	4.21	1.82	0.42
	78a	4.8	3.64	0.48	18	12	3.22	0.85	0.38
XIV (25 yr)	79b	5.3	3.34	0.52	62	18	4.86	4.05	0.52
	80a	5	4.97	0.62	70	24	7.13	2.98	0.49
	81b	5.3	1.39	0.21	38	38	1.6	1.89	0.51
	82a	5	1.56	0.2	70	12	2.15	0.94	0.5
	83b	5.4	2.14	0.34	58	16	2.12	1.98	0.52
	84a	5.1	2.24	0.28	64	26	2.46	1.28	0.54

XV (30 yr)	85b	5.4	4.26	0.37	77	102	7.12	1.42	0.56
	86a	5.8	2.64	0.17	28	48	7.19	1.32	0.47
	87b	5	3.42	0.3	39	37	4.06	0.82	0.47
	88a	6	0.38	0.03	14	42	2.04	0.57	0.46
	89b	5.1	3.32	0.31	42	46	6.32	1.24	0.47
	90a	5.5	2.46	0.18	29	42	5.68	1.2	0.45
XI (PF)	91b	5.4	5.6	0.44	22	38	19.74	4.33	0.08
	92a	5	1.67	0.16	14	26	2.53	1.54	0.06
	93b	6.4	5.45	0.37	25	45	18.79	4.88	0.06
	94a	5.7	1.67	0.14	18	28	6.13	2.83	0.08
	95b	5.2	5.6	0.42	20	36	12.12	4.24	0.08
	96a	5.1	2.6	0.22	12	24	8.46	2.36	0.06
XII (SF)	97b	4.2	14.12	0.88	25	11	0.23	0.26	0.06
	98a	4.7	9.29	0.56	14	8	0.17	0.09	0.08
	99b	4.3	12.14	0.86	26	12	4.82	1.28	0.08
	100a	4.8	9.16	0.54	18	9	5.24	1.11	0.06
	101b	4.2	10.24	0.64	22	14	4.38	2.14	0.06
	102a	4.7	9.12	0.46	12	8	2.19	1.84	0.07
XIII (SHB)	103b	5.5	10.13	0.77	29	21	0.9	0.35	0.02
	104a	4.6	9.38	0.71	32	24	2.14	0.52	0.02
	105b	5.5	12.12	0.78	24	21	1.11	1.01	0.04
	106a	4.8	9.21	0.71	25	24	2.1	1.24	0.02
	107b	5.3	10.15	0.68	21	23	0.96	0.36	0.02
	108a	4.7	9.21	0.58	24	27	1.24	0.58	0.03

Note:
PF=Primary forest
SF=Secundary forest
SHB=Shrub

a=<20 cm
b=20-40 cm

Appendix 5. Plant species recorded in the sample plots of primary forest, secondary forest and shrub in Bukit Tapan, KSNP

Species	Family	Average number of species in the plot									Total
		Primary Forest			Secondary Forest			Shrub			
		Pl	Sp	Sd	Pl	Sp	Sd	Pl	Sp	Sd	
Ageratum houstonianum Mill	Asteraceae			1		2	1		1		5
Aglaia argentea Bl.	Meliaceae	1		1							2
Altingia excelsa Norona	Hamamelidaceae				3						3
Antidesma sp.	Euphorbiaceae		1						1		2
Ardisia zollingerii DC.	Myrsinaceae						3				3
Asplenium	Aspleniacea		1	2		1	2			2	8
Bhesa paniculata Arm.	Celastraceae						1				1
Breynia cernua (Poir.) Muell. Arg.	Euphorbiaceae	1		1					1		3
Calamus sp.	Arecaceae		1	1			1			1	4
Cinnamomum burmanii Ness ex Bl.	Lauraceae					1	3				4
Cinnamomum subavenium Miq.	Lauraceae		2	3			2		1	2	10
Cryptocarya densiflora Bl.	Lauraceae	5	4		1	1	2				13
Elaeocarpus sphaericus (Gaertn.)K. Schum	Elaeocarpaceae						2				2
Eugenia lineata (DC.) Duthie	Myrtaceae	4	5		1	2					12
Gomphandra javanica (Bl.) Val	Icacinaceae				2						2
Harpulia cupanioides Roxb.	Sapindaceae		1								1
Helicia robusta (Roxb.) R.Br. ex Wall	Proteaceae					1	2			2	5
Homalanthus giganteus Z. et M.	Euphorbiaceae	1		2							3
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae									1	1
Lithocarpus sp.	Fagaceae				3	1	2				6
Litsea machilifolia Gamble	Lauraceae	2	3			1					6
Macaranga triloba (Reinw ex Bl.) Muell. Arg	Euphorbiaceae			1		3	1				5

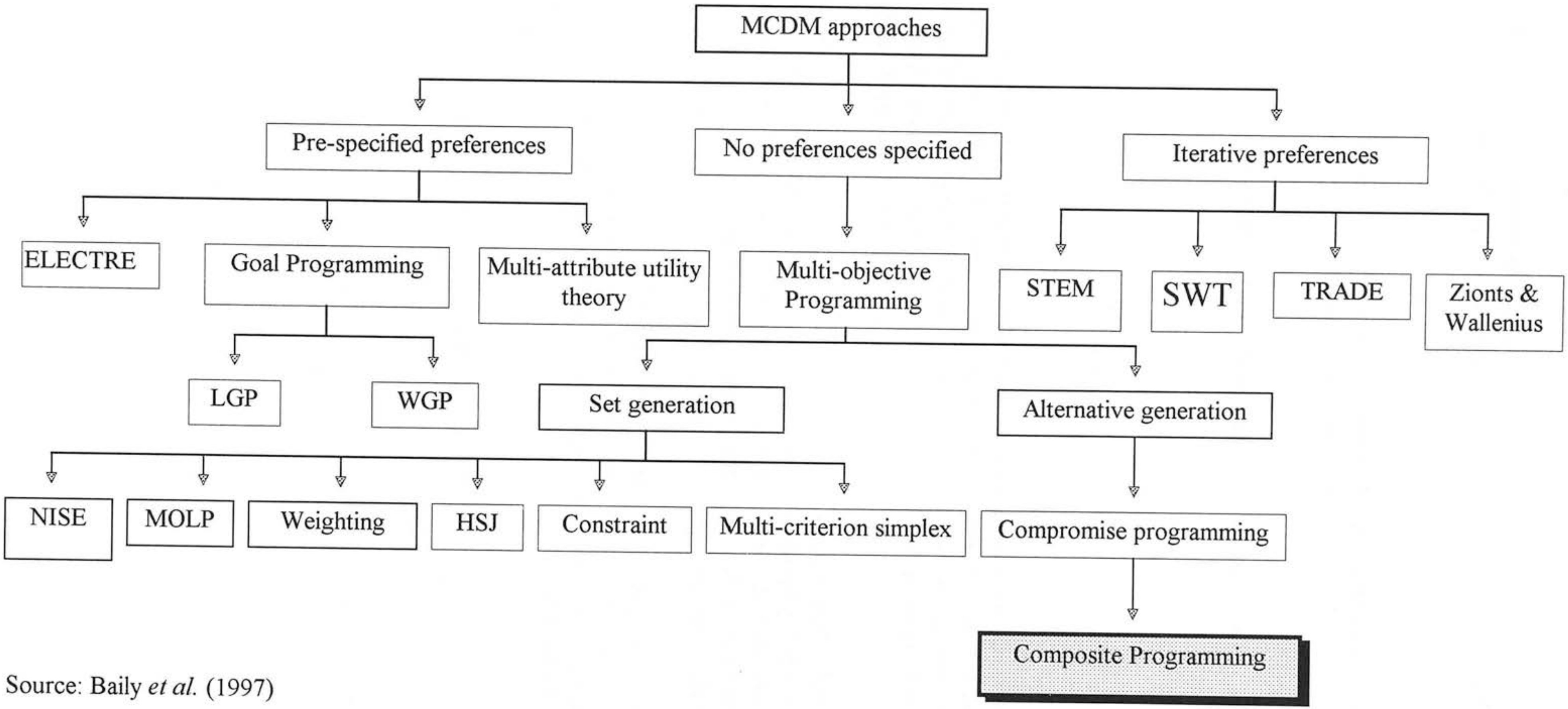
Macaranga rhizinoides (Bl.) M.A.	Euphorbiaceae			1			2			1	4
Medinilla verrucosa (Bl.) Bl.	Melastomataceae					3					3
Melastoma affine D. Don	Melastomataceae			2			1			3	6
Mischocarpus sundaicus Bl.	Sapindaceae	4	3		4	4	1				16
Nephrolepis acuminata (Houtt.) Kuhn	Polypodiaceae						2				2
Pavetta multiflora Brem	Rubiaceae					1					1
Pteridium aquilinum Kuhn.	Polypodiaceae			1	1	2	2			1	7
Quercus sp.	Fagaceae			1		1					2
Rhodamnia cinerea Jack	Myrtaceae						1				1
Saurauria sp.	Actinidiaceae		1		1						2
Saurauia pendula Bl.	Actinidiaceae									2	2
Setaria palmifolia (willd.) Stapf.	Poaceae			1						1	2
Sida rhombifolia L. ssp. *rhombifolia*	Malvaceae						2				2
Smilax zeylanica L.	Liliaceae			1						2	3
Ternstroemia foetida Kobuski	Theaceae				1	1	3				5
Turpinia sphaerocarpa Hassk.	Staphylaceae					1	1			1	3
Pinang-pinang*	Arecacea			1			1				2
Paku-paku*	Adiantaceae									3	3
Ipuh*	UI						1				1
Sepane*	UI									2	2
Rengah*	UI		1								1
Bayur*	UI		1								1
Ribo-ribo*	UI			1		1					2
Total		18	24	21	17	27	39	-	4	24	174

Key labels:

* : Local name; UI = Unidentified

Pl = Pole; Sp = Sapling; Sd = Seedling

Appendix 6. The classification of MCDM technique according to preference information required.



Source: Baily *et al.* (1997)

Appendix 7. Paper abstract of International Conference on Tropical Forestry in 21st CenturyKasetsart university, Bangkok, Thailand, 25-29 November 1996

Resolving Conflict between Encroachment and Kerinci Seblat National Park Management, Indonesia

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Abstract

Indonesian national parks have been recognised as playing an important role in conserving biological diversity. Many of the parks, however, are at serious risk because of increasing pressure from expanding scale of human activities both inside and outside their boundaries. Therefore, conflicts of interest between park management and developing local economics are inevitable.

At present, the greatest threat to the integrity of the Kerinci Seblat National Park (KSNP) comes from encroachment activities to cultivate high-profit cinnamon trees. It is estimated that about 15,000 households have penetrated the park for this purpose. Traditional approaches to the park management and enforcement activities to exclude local people from the park have been unable to solve the problem.

This paper outlines the historical background of the relationship in KSNP between park and local people and discusses local attitudes towards the park. It is believed that understanding of the linkage between the park and surrounding communities will be of importance in providing decision support system for sustainable park management.

Keywords: national park, encroachment, conflict, attitude, Kerinci Seblat, cinnamon.

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Source: FORTROP '96 Proceeding Conference 5: 48-65.