Indonesia's Fires and Haze

The Cost of Catastrophe

Reprint 2006 with update

edited by

David Glover & Timothy Jessup

Indonesia's Fires and Haze

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David Glover & Timothy Jessup

INSTITUTE OF SOUTHEAST ASIAN STUDIES, Singapore

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE, Canada

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Street scene in Jambi, Sumatra,
showing the extent of the haze in September 1997
Courtesy of David Portnoy

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PREFACE TO THE FIRST REPRINT EDITION 2006

Since 1999, when this book was first published, the region has not seen a recurrence of fires and haze on the scale of 1997–98. This is in large part due to to favourable climate conditions. Without the very dry conditions created by the El Niño climatic disturbance, the conditions for massive spread of fire have not been present. But the deliberate setting of fires to clear land for agriculture continues, and when conditions are right, smoke haze and its spread to neighbouring countries have been the result. Parts of peninsular Malaysia were severely affected by smoke blowing in from Indonesia in September 2005. Schools and businesses were closed, and people complained of health problems.

The biggest changes in Indonesia since 1997 are political and economic. In 1997, the Suharto government was in free fall and so was the economy. Under such conditions, the international community needed to be patient in expecting the country to turn its attention to environmental and transboundary problems.

Eight years later, Indonesia has a democratic government under President Bambang Yudhoyono and a stable economy. Large amounts of foreign development assistance have gone into early warning systems to detect fire outbreaks, while researchers and non-government organizations (NGOs) have issued repeated warnings that the fires could come back. So, while inaction by Indonesia was perhaps understandable in 1997, today neighbouring countries have less reason to be patient.

Furthermore, new research shows that the consequences of recurring fires may be more serious than originally realized, and the costs of preventing them even lower. One study shows that the 1997–98 haze may have resulted not only in short-term health costs but in large increases in infant mortality in Indonesia.[1] Meanwhile, the World Wide Fund for Nature (WWF) research has shown the cost of preventive measures, such as clearing land for agriculture without burning, to be modest.[2]

Given the lessons learned from the 1997–98 disaster, Indonesia has more reason than ever to take action to prevent its recurrence.

David Glover
Director
Economy and Environment Program for Southeast Asia (EEPSEA)
14 February 2006

1. S. Jayachandran, "Air Quality and Infant Mortality during Indonesia's Massive Wildfires in 1997", Bureau for Research in Economic Analysis of Development Working Paper No. 95, May 2005.
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FOREWORD

The year 1997 was the worst on record for forest and bush fires throughout the world, especially for developing countries in the tropics and sub-tropics. It was, in the words of the World Wide Fund for Nature (WWF), "the year the world caught fire". Catastrophic fires occurred in Indonesia, Brazil, and other countries across Asia and the Pacific, Latin America, and Africa. These fires were largely the result of human activity, particularly land-clearing that uses burning. Degradation caused by heavy logging also makes forests more susceptible to fire. The fires were exacerbated by the droughts induced in many parts of the world by the most severe El Niño event ever recorded. (The increasing severity and frequency of the El Niño is thought by some climate experts to be a consequence of global warming, itself the cumulative result of human activities that release carbon dioxide and other so-called "greenhouse gases" into the atmosphere.)

The unprecedented magnitude of the fires and accompanying smoke-haze caught governments, international organizations, and the general public by surprise, despite the fact that previous El Niño events had been accompanied by unusually strong droughts and fires, notably those in Indonesia and Australia in 1982–83 and in Indonesia again in 1994. Despite meteorologists' warnings several months ahead of the main event, decision-makers were woefully unprepared for the tragedy that unfolded in 1997.

The damage inflicted by the fires and haze was terrible. Wildlife, natural habitats, and ecosystems in the worst-affected areas were devastated beyond hope of recovery. There were also heavy losses felt more directly by people, including damage to health from months of breathing heavy smoke-haze, losses to businesses forced to shut down for weeks or months by the haze — which interrupted transport, choked air-breathing engines, and disrupted work schedules — and destruction of farms, plantations, timber, and other natural resources. Huge quantities of carbon dioxide and other greenhouse gases were released from burning biomass into the atmosphere. For every fire-setter who gained some short-term economic benefit from burning as a quick, dirty, and cheap way to clear land or obtain access to forest resources, countless others paid a heavy toll in loss of income, bodily injury, and environmental destruction.

The WWF responded to these fires in a variety of ways. In Indonesia, it helped guide emergency relief to people in some critical areas affected by drought, fire, and haze where it already has field projects. WWF Indonesia also worked with government to strengthen fire-monitoring capacity through the Geographic Information System (GIS), launched a joint initiative with several partner organizations to investigate the causes and impacts of fires and haze leading to policy recommendations to prevent future fires, and communicated information, technical advice, and public service messages about the fires to the Indonesian public, government policy-makers, and national and international media. WWF Malaysia provided information and advice about fires and haze impacts to the government and general public and established a much-visited "Haze Alert" web site. WWF International coordinated communications and assistance efforts among various national organizations and international agencies and launched two major communications initiatives aimed at an international audience: a video news release on Indonesian and Brazilian fires and a discussion paper entitled "The Year the World Caught Fire".

Indonesia's fires were among the worst in the world and attracted widespread attention from news media, environmental organizations, and governments around the world. Because of the country's location in the midst of a densely populated region, neighbouring countries were seriously affected by smoke-haze from the fires. For months, dense, choking haze affected some 70 million people in Indonesia, Singapore, and Malaysia, with lesser effects in the Philippines and southern Thailand. The international concern generated by the fires and haze brought assistance from donor governments and multilateral agencies — although fire-fighting efforts *per se* turned out to be of little avail given the extent and persistence of the problem — but also heightened critical scrutiny of Indonesia's poor record of environmental management, over-rapid forest conversion, and weak enforcement of environmental laws. Attention was also drawn to the immense human and environmental costs borne by Indonesia and her neighbours, which came on top of economic privations they were already suffering because of the Asian financial crisis.

In collaboration with the Economy and Environment Program for Southeast Asia, WWF Indonesia launched a study of the economic value of damages from the Indonesian fires and haze in order to focus attention on the problem and encourage preventative action. The results of that study were presented in summary form to the world media and discussed with Asian policy makers. They are presented in more detail, and in the context of the causes and broader environmental impacts of the fires, in this volume.

I hope this publication can encourage more efforts to significantly prevent such a terrible disaster from ever occurring again.

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The **Economy and Environment Program for Southeast Asia** (EEPSEA) is a development cooperation programme supporting research and training in environmental economics in ten Southeast Asian countries. Established in 1993, it is administered by the International Development Research Centre (IDRC) and sponsored by the IDRC, the Canadian International Development Agency, the Swedish International Development Cooperation Agency, the McArthur Foundation, and the Foreign Affairs Ministries of Denmark, Holland, and Norway.

The **World Wide Fund for Nature** (WWF) is dedicated to protecting the world's wildlife and wildlands. The largest privately supported international conservation organization in the world, the WWF has sponsored more than 2,000 projects in 116 countries over the past 36 years. The WWF directs its conservation efforts towards protecting and saving endangered species, and addressing global threats.

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James Schweithelm's professional interest is the sustainable management and conservation of forests in tropical areas of Asia and the Pacific. He has worked for the past two decades on a variety of topics including watershed management, rural land-use planning, forest policy, and management of national parks and other protected areas. He has worked for a total of nine years in Indonesia at field sites on most of the major islands of the archipelago. His most recent Indonesia assignment was as Forest Officer of the World Wide Fund for Nature Indonesia. He is currently working as a consultant from his home in Volcano, Hawaii.

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1

CAUSES AND IMPACTS OF THE FIRES

James Schweithelm
and David Glover

In the middle of 1997, forest fires burning in Indonesia began to affect neighbouring countries, spreading thick clouds of smoke and haze to Malaysia and Singapore. Seasonal rains in early December brought a brief respite but soon after, the dry conditions and fires returned. By 1998, Brunei and to a lesser extent, Thailand, Vietnam, and the Philippines had also felt the haze. By the time the 1997–98 fire episode was finally over, some 8 million hectares of land would have burned[1] while countless millions of people suffered the effects of air pollution. The fires — deliberately set for the most part, and exacerbated by the drought conditions of El Niño — were one of the century's worst environmental disasters.

This book assesses the extent of the damage caused by the fires and haze and expresses these in terms that are readily understandable: dollars and cents. Written while the fires of 1998 were still raging, it looks at the damages suffered by Indonesia, Malaysia, and Singapore during the first outbreak of fires in 1997. From October 1997 to May 1998, the Economy and Environment Program for Southeast Asia (EEPSEA) and the World Wide Fund for Nature (WWF) Indonesia engaged in a rapid assessment and valuation of the damages and publicized the findings widely in the world media and in discussions with government and non-governmental organizations. The purpose of the project was to show — in an objective but dramatic fashion — the extent of the damages and in so doing to encourage prompt action to prevent further fire outbreaks. The study's summary findings were widely quoted and played an important role in policy discussion within the region. This book presents in full detail the methods used to obtain those estimates and elaborates on the policy recommendations tabled in 1998. It is sobering that so much remains to be done in implementing these recommendations.

For the project's voice to be heard before further fire outbreaks occurred, the study had to be truncated. It assessed only the damages for the 1997 episode — not those that occurred in 1998. The total damages for the entire El Niño–related event were considerably higher than those reported here.

Furthermore, the study did not attempt to value every possible damage. In some cases, data were unavailable; in others, there is not widespread agreement even among economists on what estimation methods could be devised. This is particularly true for damages such as loss of life or biodiversity. Many of the costs of the fires and haze were therefore omitted in this project; the reader is reminded that the estimates presented are lower bounds; in reality, the damages must have been higher.

In spite of this, the damage estimates are significant, amounting to some US$4.5 billion. It is not only the total size of the damages that is impressive, but their variety. Those assessed in this study included (from fire): damage to timber, agriculture, a wide range of direct and indirect forest benefits, fire-fighting costs, and release of carbon, affecting climate change; and (from haze): short-term health costs, tourism losses and some losses of production. The damages assessed, and their values, are defined and described in Chapter 6, TABLES 6.1 and 6.2.

WHY VALUATION?

The valuation of environmental damages can be useful in several ways.

First, valuation can allow more complete and more accurate cost-benefit analysis (CBA) of projects or policy measures. At one time, projects were typically subject to analysis of only those costs and benefits to which the market attaches monetary value. Environmental damages were neglected because environmental goods and services are generally not bought or sold in markets and thus have no obvious price. Such neglect led — and often still leads — to bad decisions.

More recently, it has become common to add an environmental impact assessment (EIA); the EIA can assess the benefits or damages left out of the CBA. But the decision maker is then left with two non-comparable assessments: a CBA in monetary terms and an EIA in physical terms (e.g., tonnes of pollution emitted or hectares of trees lost). If the CBA and the EIA come to opposite conclusions, the decision maker is left without guidance as to how to proceed. By estimating monetary values for environmental impacts, the results of the EIA can be integrated into an "extended CBA" that provides an unambiguous conclusion.

Second, valuation can tell us the relative importance of an environmental improvement or insult and how the impacts are distributed across the affected population. This is impractical if environmental impacts are measured only in physical terms. In the case of Indonesia's forest fires, for example, knowing that 5 million hectares of vegetation were burned by fire and 70 million people affected by haze cannot tell us which effect was more important. That judgement is possible only when the two effects have been put into the same unit of measurement (e.g. dollars).

Third, valuation can draw attention to environmental problems and make their importance more palpable. Even if monetary values are not used in formal CBA, they can make it easier for policy makers and the general public to appreciate the scale of a problem, since they can more readily be compared with other damages or alternative uses of resources.

In this study, the second and third uses of valuation predominate. Our aims were mainly to draw attention to the magnitude of the disaster; put it in perspective relative to other disasters and other uses of resources; identify which components of the damage were largest; and see which countries suffered most.

The methods used to estimate the damages are presented in Chapter 2. The estimates, and the step-by-step calculations used to produce them, are presented for Malaysia, Singapore, and Indonesia in Chapters 3, 4, and 5, respectively. A summary of the damages, showing their distribution across the three countries, is presented in Chapter 6, along with recommendations about how to prevent the recurrence of this disaster.

First, however, we present an analysis of the causes of the fires and a description of the principal damages, including those for which economic valuation was not possible.

WHY DO RAIN FORESTS BURN?

Indonesia's rain forests burn due to a number of interdependent natural and human-related factors that are often obscured by politically charged rhetoric, oversimplifications, and lack of information. The danger that a forest will burn is dependent upon the levels of fire hazard and fire risk. Fire hazard is a measure of the amount, type, and dryness of potential fuel in the forest. Fire risk is a measure of the probability that the fuel will ignite. The level of fire risk is usually related to human actions, such as burning in close proximity to a forest when fire hazard is high. Timber harvesting, land clearance, and agricultural settlement practices in Indonesia have created a high fire risk/high fire hazard environment in most lowland forest areas that has led to massive wildfires such as those in 1997/98.

Sumatra and Borneo share a general forest type that is commonly known as tropical rain forest. These two islands contain the largest and most diverse rain forests in Southeast Asia, and are the most species-rich forests on earth in terms of flora. The associated animal fauna is also very diverse. The biological richness of the forest varies from place to place even within one forest type (e.g., lowland forest). Most forests on Sumatra and Borneo have been affected by humans, and tens of millions of hectares have been converted to agriculture and grasslands. Much of the remaining forest has been logged in recent years. What remains is a mosaic of vegetation types and land uses. Fire regime is a term that refers to the frequency, intensity, and spatial extent of fires in a specific vegetation type under certain climate and management conditions. The fire regime of Indonesia's rain forests has changed dramatically over the past two decades as fires have become more frequent, more intense, and larger.

HISTORY OF FIRE

Undisturbed rain forest is highly resistant to burning, but will burn during severe droughts, especially after it has been logged or otherwise disturbed. Rain forests are not adapted to fire, and recover slowly from intense burns. Analysis of charcoal in the soils of Kalimantan indicate that the forests have burned periodically starting at least 17,500 years ago. Major fires probably occurred naturally during climatic periods that were drier than today's climate, but humans have also burned forest over tens of thousands of years to facilitate hunting and clear agricultural plots. Written accounts from the last century and the oral histories of some forest-dwelling peoples confirm that forest fires are not new to the Indonesian rain forests. The fact that Sumatra and Kalimantan remained forested until recent decades indicates that neither naturally caused fires nor human use of fire caused significant deforestation in the past.

SHIFTING AGRICULTURE

Swidden or shifting agriculture has been widely practised in Indonesia over thousands of years, and continues in many areas to the present. Traditional shifting agriculture is thought to have little long-term impact on forest ecosystems, but may change the vegetation composition in intensively used areas. The trend is now towards opening larger plots for longer periods and giving the vegetation less time to recover between rotations. The population of many forest areas has also increased dramatically as agricultural settlers have followed logging roads into the forest. The intensification of swidden agriculture, coupled with higher human populations in forests, has increased both deforestation and fire risk over the past two decades.

EL NIÑO

El Niño–related droughts occur every two to seven years in Indonesia with varying intensity. Severe episodes cause crop failures, water shortages, and impacts on forests including tree mortality and disrupted flowering cycles. The 1997/98 El Niño reduced annual rainfall to approximately 10 per cent of its normal volume in parts of Kalimantan. The extreme dryness, coupled with heavy fuel loads in logged forests and widespread use of fire for land clearance created extreme fire danger. Fires can start naturally under such conditions (e.g., from lightning strikes or coal seam fires), but human carelessness and greed were responsible for the great number and wide distribution of the fires in Indonesia.

TIMBER CONCESSIONS

Forest management and land-use practices in Sumatra and Kalimantan have evolved very rapidly over the past three decades. Commercial use of forest resources and forest lands was very limited up to and including the middle decades of this century. This changed dramatically when former president Soeharto's New Order regime took power in 1966. Millions of hectares of forest land were awarded to logging companies in the late 1960s and early 1970s, leading to a timber boom in Sumatra and Kalimantan that changed the landscape of these two islands over a period of two decades. Government policies and *de facto* procedures for allocating and supervising timber concessions were flawed and open to corruption, leading to logging that caused severe impacts to forest ecosystems, biodiversity, and forest-dwelling peoples. Poor logging practices resulted in large amounts of waste wood left in the forest, greatly elevating fire hazard. Failure by the government and concessionaires to protect logged forests and close old logging roads led to an invasion of the forest by agricultural settlers whose land-clearance practices increased the risk of fire in the remaining stand.

TREE PLANTATIONS

The 1990s has seen the rise of tree plantations as the most powerful force behind the conversion of forest lands in Sumatra and Kalimantan. The government supported the development of pulp wood and palm oil plantations, using incentives such as free land, subsidized capital, and free use of standing timber. Rising domestic and international demand for palm oil, pulp, and paper, coupled with the fact that Indonesia is a low-cost producer of these commodities, has given additional impetus to the growth of these industries, often backed by foreign capital and technical assistance. As was the case with timber concessions before them, the plantations have created a long list of environmental and social problems including being the single largest source of fire risk. Plantation firms and the land-clearance contractors they hire use fire almost exclusively for land clearance. The scale of the burning grew each year during the 1990s as the area cleared increased from year to year. Widespread, intentionally set fires created haze during every dry season. During the drought of 1997 the fires escaped into forests, peat swamps, and mature plantations, burning millions of hectares and covering the whole region in haze.

PEOPLE

People living in and near forests are often both the exploiters of the forest and the victims of commercial exploitation. This paradox is becoming more common as formerly remote areas become accessible to people with both the means and incentive to exploit forests at unsustainable levels. Individual farmers were responsible for almost half of the area burned in South Sumatra province in 1997 because they used fire to clear land and burn agricultural wastes. Indigenous peoples and newcomers alike are victimized when powerful agents of exploitation such as timber concessions and plantations expropriate the forest lands and resources upon which the people are dependent. The exploiters and the exploited use fire as a weapon against each other. Lack of clear land tenure laws and weak government procedures for allocating land to commercial uses is responsible for this conflict and contributes to the government's inability to regulate the use of fire for land clearance. A further obstacle to fire management is the fact that most rural Indonesians and private land managers see fire as a valuable tool, and most are still not convinced of the need to control its use.

In conclusion, fires in Indonesia's rain forests are rare under undisturbed conditions, but are by no means unprecedented, even prior to human settlement of the forests. Human actions have greatly increased the hazard and risk of fire over the past three decades. The 1997/98 fires resulted from poor forest management and weak fire control coupled with a severe, but not unprecedented drought. The lowlands of Sumatra and Kalimantan will continue to be converted to plantations and other non-forest uses in coming years, but means must be found to control fire use to prevent destruction of forests that are designated for timber production, nature conservation, and watershed protections, and to avoid air pollution and damage to the atmosphere.

WHAT WERE THE IMPACTS OF THE FIRES?

The impacts of the 1997/98 fires in Indonesia can be divided into the categories below based on the mechanism that caused the impact and the spacial and temporal relationship between burning and impact:

- Direct: immediate damage caused by the flames such as consuming natural vegetation or agricultural crops and killing animals;
- Indirect, short-term: impacts resulting from damage to vegetation such as wildlife that die from food and habitat loss, human loss of forest-derived food and income, accelerated soil erosion, sedimentation of water bodies, impairment of the hyrological functions of forests, and disruption of nutrient cycles. Smoke and haze cause acute human ailments, disrupt tourism, transport, and business, reduce enjoyment of life, contribute to the production of ozone, acid rain, and greenhouse gases, and reduce photosynthesis in plants by blocking some solar radiation.

- Indirect, long-term: these impacts are more difficult to document and link to fires than those in the two categories above. Included are the possible long-term human health effects of exposure to smoke and haze from vegetation fires and fire-caused changes in species composition or ecological processes that last for decades or centuries.
- Cumulative: long-term ecological changes that result from a series of large fires that occur at short intervals such as those in Indonesia over the last two decades. Alone or in combination with other disturbance factors such as forest conversion, the cumulative effect of sequential fires can lead to extinction and irreversible changes in forest species composition and vegetation structure.

WHAT BURNED?

Knowing what burned is an important starting point for fire impact analysis. A preliminary remote sensing assessment of the area burned in 1997 indicated that approximately 1.5 million hectares were affected in Sumatra and 3.06 million hectares in Kalimantan (Liew et al. 1998). Of this, 20 per cent was estimated to be forest, 50 per cent agricultural land, and 30 per cent non-forest vegetation and grasslands. Most burn scars were near inhabited areas, roads, and rivers, indicating that the fires were started by humans. A more complete analysis will likely result in a significantly higher estimate of burned area, especially when the 1998 fire scars are included.[2] For the purposes of this book, a burned area estimate of 5 million hectares was adopted for the 1997 fires. See Chapter 5 for more detail.

THE HAZE

The smoke and resulting haze, rather than the fires themselves, caught the attention of the news media, ASEAN governments, businessmen, and people living in affected areas. The haze that blanketed the region from September to November 1997 is normally called smog, an airborne mixture of pollutants including fine soot particles, gases that are toxic to humans and animals, and large amounts of carbon dioxide and other gases thought to contribute to global warming. Some of these chemicals undergo reactions in the atmosphere that produce ozone and acid rain, both of which are harmful to humans, animals, and plants. Air pollution levels were far above the level considered hazardous to human health in the worst affected areas of Sumatra, Kalimantan, Sarawak, and Brunei. Many people developed chronic respiratory, eye, and skin ailments, creating a large demand for health services. Premature deaths may have occurred among medically vulnerable people who suffered long-term exposure to the haze. Schools and businesses were forced to close for periods of days to weeks, and parts of Sarawak were under a state of emergency at the height of the crisis. Air, land, and sea transport were affected by the drastically reduced visibility, airports were closed, and the haze was implicated in a number of ship collisions and a commercial airliner crash in North Sumatra.

THE FORESTS

Based on work conducted on the ecological effects of the 1982/83 fires in East Kalimantan, researchers have found that fire damage to Indonesia's rain forests increases in proportion to the level of prior human disturbance (Schindele et al. 1989). Carelessly logged forests are particularly fire-prone because excessive amounts of waste wood are left on the forest floor and the forest canopy is opened, causing ground vegetation and dead branches to dry out quickly. Heavily disturbed forest tends to burn almost completely, leaving few live trees to begin the regeneration process. Pristine forest is much less likely to burn, and when it does, usually only ground level vegetation is consumed, leaving the middle and upper tree layers intact. Lightly burned pristine forest is quick to recover after a fire. Moderately to heavily burned forest takes decades or centuries to regenerate due to an invasion of pioneer tree species and the loss of seeds and seedlings of species normally found in a mature forest. Intense burns and subsequent soil erosion result in the loss of soil constituents that facilitate vegetation regrowth. Heavily burned forest may be converted to grasslands by repeated intentional burning. Forest ecologists do not yet know how much fire damage a tropical rain forest can sustain before ecosystem processes and recovery mechanisms cease to function effectively.

Kutai National Park in East Kalimantan is a good example of how fires have affected Indonesia's forests. Kutai covers 190,000 hectares, and is one of the only large areas of lowland forest that is protected in Kalimantan. Approximately 50 per cent of the park burned in 1982/83, and additional burning in 1997/98 brought the total up to 90 per cent. Some parts of the park burned during both fire episodes and also during the 1991 or 1994 droughts. Ecological studies conducted in Kutai in the years after the 1982/83 fires (Tagawa and Wirawan 1988) provided encouraging results in terms of the speed of forest recovery and the resilience of most animal populations. The cumulative effects of subsequent fires have made ecologists familiar with Kutai more pessimistic about the ability of the park's ecosystems to fully recover given that it is now an island in the midst of grasslands and plantations, and that threats such as illegal logging and agricultural encroachment will slow recovery and increase the risk of fire in the future. There are other similar examples of fire impacts on protected areas in the lowlands of Sumatra.

WILDLIFE

Wildlife are killed directly by heat and smoke during fires and subsequently die from lack of food and water, or habitat loss. Small, slow-moving animals and insects are most likely to be killed outright by fires, and animals with very specific food, habitat, shelter, or climate requirements are most at risk during the immediate post-fire period. Individuals of territorial species fleeing to unburned areas often encounter aggression from residents, and may be killed or injured in fights. The loss of key organisms such as pollinators and decomposers can significantly slow the recovery of the forest ecosystem.

In the months and years after a fire, the changing composition of vegetation and fruits in a recovering forest provide alternate, and sometimes superior food sources for some animals and insects. Studies in Kutai National Park after the 1982/83 fires indicate that most large herbivore and omnivore mammals can survive a fire and adapt to new food sources in the regenerating forest (Tagawa and Wirawan 1988). Pigs, primates, and deer populations may actually increase due to a flush of nutritious new vegetation and the growth of species of fruit trees not usually found in a mature forest. Populations of birds, reptiles, small mammals, and insects are severely affected by fire, but most seem to rebound in a few years. Species that are dependent on trees or habitat only found in mature forest may disappear until the forest grows back to maturity. These rather optimistic findings only pertain when the forest is allowed to regenerate rather than being repeatedly burned or converted to grassland or plantations, which have virtually no food or habitat value for most wildlife.

The 1997/98 fires have had a severe impact on orangutans in East and Central Kalimantan. Orangutans are the primary flagship species for forest conservation in Borneo, and their numbers in their favoured habitats are an indication of the level of ecosystem health. There are believed to be between 10,000 and 15,000 orangutans on the island of

Borneo and their numbers have been declining in recent years due to habitat loss, poaching, and capture for the pet trade. Many of these great apes were driven from the forest by fire and smoke and lack of food and water. Hundreds of adults were killed by villagers, and similar numbers of infants were captured and sold as pets. Large areas of their preferred habitat of swamp and lowland forest have burned. Previous research has shown that orangutans adapt their diets to post-fire vegetation, but many primatologists believe that the 1997/98 fires will mark the beginning of a steeper downward trend in the already declining populations of Bornean orangutans.

THE WATERS

Rivers, lakes, and nearshore ocean waters are also adversely affected by forest fires. Rain water runs off burned areas rapidly, carrying soil, ash, and woody debris into rivers and lakes and polluting the water with sediment and excess nutrients. Aquatic life is smothered in mud, and fish populations decline as a result of diseases caused by changes in water chemistry. Nearshore marine environments are also affected by the discharge of excess sediment and fresh water into the ocean. Corals are easily smothered by sediment, and cannot tolerate large changes in salinity. Juvenile fish are killed by heavy sediment deposition in nursery areas such as mangroves and estuaries.

PEOPLE

Forest-dwelling peoples depend on the forest for agricultural land, wild foods, construction, and handicraft materials, and products to sell for cash. Severe drought can dramatically reduce their critical-for-survival rice crop, and fires can destroy tree crops and wild food plants and make hunting more difficult. Studies of forest-dwellers in the aftermath of the 1982/83 East Kalimantan fires indicate that most overcame fire impacts, but some were forced to move to urban areas (Colfer 1993; Mayer 1996). Fire impacts on forest dwellers have been exacerbated by drought-related food shortages and cash income reductions caused by the economic crisis that began in mid-1997.

COMPLEXITY, UNCERTAINTY, AND NON-CAPTURABLE LOSSES

Fire impact analysis in tropical rain forests is at a very early stage of development. Scientific knowledge about these complex ecosystems is not well developed and further uncertainty is created by the difficulty of isolating fire impacts from the effects of other human-caused changes in the forest environment. Post-fire ecological surveys provide a useful snapshot of the effects of forest fires but are most revealing in showing how little humans know about Indonesia's rain forest ecosystems. These studies cannot identify critical thresholds beyond which fire-related ecological changes or animal and plant population trends may lead to the loss of species or the irreversible degradation of ecosystems. Forest ecosystems are resilient enough to recover from fire and other disturbance factors up to a point, but no one knows exactly what that point is for tropical rain forests. The inability to view the larger ecological picture is particularly distressing because the effect of fire is only one factor in a larger pattern of disturbance that includes drought and accelerating land clearance.

The direct economic values of fire-caused biodiversity loss and damage to ecosytem processes are difficult if not impossible to capture given the current state of ecological knowledge about these ecosystems and the fact that most of their ecological benefits do not have a market value. Economists have developed methods to capture some non-market values of tropical forests as discussed in Chapter 5. Many losses from the 1997/98 Indonesia fires are impossible to evaluate, such as the destruction of some of the last intact lowland rain forest in Sumatra and Kalimantan, the death of a large percentage of Indonesia's wild orangutans, and the possible extinction of species that are not known to science.

NOTES

1. *Straits Times*, 23 November 1998.
2. Measuring burn scars using data from satellite-borne sensors presents technical difficulties that remote-sensing specialists are working to overcome (Fuller and Fulk 1998).

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2

RESEARCH METHODS

David Glover

The previous chapter provided a qualitative description of the damages suffered by people and ecosystems in the 1997 fires and haze. The Economy and Environment Program for Southeast Asia (EEPSEA) and the World Wide Fund for Nature (WWF) have attempted to calculate the monetary value of some of these damages, using a variety of methods developed in recent years by environmental economists (Freeman 1994).

In estimating the monetary value of damages from the fires and haze, this chapter was guided by several general considerations:

- Local damages were normally calculated in local currency, and converted to U.S. dollars at the following (July/August 1997) exchange rates: US$1 = S$1.4; US$1 = Rp2,500; US$1 = RM2.5.
- Damages were calculated in "present value terms" (i.e., many losses occur one time only; others recur. Income streams or environmental services that could provide recurring benefits were converted to a one-time only [present value] equivalent).
- Damages were calculated in net terms (i.e., damages are net benefits foregone. Net benefit equals gross value of the foregone good or service minus the cost of producing or extracting it. This is equivalent to value added; or profit minus normal rate of return to capital; or economic rent).
- The study attempted to approximate consumer (or producer) surplus foregone, rather than actual expenditures on prevention miti-

gation. The latter may substantially understate damages (e.g., in the case of health damages, some people were able to obtain medical treatment or evacuate an affected area. Other people were similarly affected but were unable to do so. Actual expenditures for treatment were therefore extrapolated to the entire affected population).

- Valuation is not appropriate or adequate for depicting the significance of some damages. For example, the magnitude of damage is felt relative to the ability to bear its cost: wealthy people can sustain larger losses than very poor people, so dollar figures are not necessarily a good measure of suffering. Valuing loss of life is difficult and controversial. In this chapter, we assume that such losses are significant but incalculable. We were also unable to place values on such things as increased risk of haze-induced illness (e.g., cancer) in the future or increased risk of species extinction.

In cases where it was not feasible to conduct new surveys, the benefit transfer (BT) approach was used. This involves the transfer of values from existing studies to the new study site, with appropriate adjustments for the size of the affected area, income levels, and other factors. Various BT values and other adjustment factors are mentioned below. These are derived from various sources, including the World Bank and the Asian Development Bank (ADB 1996). Wherever possible, BT values were "reality-checked" against local conditions.

For each type of damage, there are considerable uncertainties about both its physical extent and monetary value. In some cases, our estimation procedures produced a range of estimates. However, given the large number of impacts to be valued, many of them comprising numerous sub-components, expressing estimates as ranges was unworkable. Instead, the mid-points of ranges were used, to permit aggregation and a comprehensible presentation.

The methods used to estimate the monetary value of damages are described in step-by-step format below.

ESTIMATION METHODS FOR HAZE DAMAGES

This section outlines a common methodology prescribed for the three country studies. Methods were adapted to local conditions and data availability in each country during application; the adjustments are described in detail in the country reports in succeeding chapters.

The period covered was 1 August to 31 October 1997. In principle, the study should compare the situation with and without haze. In practice this involved a comparison of August–October 1997 to a "normal" August–October. The "normal" values used here were either:

- August–October 1996;
- average of August–October over the past five years; or
- the projected trend of August–October over the past five years, depending on what was most appropriate in a given case.

In a "normal" year, forest fires and haze still occur, though on a much smaller scale, and do result in damages to people and the environment. This chapter only estimates the damages in excess of "normal" damages; in this respect it understates the total damages that occurred in 1997.

Care was taken to separate the effects of the haze from those of the drought and the Asian financial crisis.

SHORT-TERM HEALTH COSTS: ADJUSTED "COST-OF-ILLNESS" APPROACH

The three steps used to obtain an adjusted cost of illness (COI) are outlined below:

a. Estimate Treatment Cost

i. Estimate hospital and clinic admissions for haze-related ailments per 10,000 population for August–October 1997. Use "haze-related ailments" as defined by each country's health service. If there is no such definition, use the Malaysian definition: upper respiratory tract infections (URTI), asthma, bronchitis, and conjunctivitis.

ii. Estimate the hospital and clinic admissions for August–October 1996 or the average hospital and clinic admissions during August–October over the previous five years.

iii. Subtract (ii) from (i) to get "excess" admissions.

iv. Adjust for affected but untreated population. The ratio of untreated to treated case varies from country to country but is in the range of 3 or 4 to 1. The ratio for each country can be found in standard health sector studies by the World Blank or the Asian Development Bank.

v. Adjust for treatment costs beyond hospital visits (mainly medicines). As per (iv), there is a standard adjustment factor that varies by country.

vi. "Shadow price", i.e., add the value of any government subsidies for treatment. Alternatively, use the price of a visit to a private clinic.
vii. If necessary, extrapolate to area outside that where the hospital data was collected; use visits per 10,000 ratio in (i).
viii. If possible, get cross-section data on affected and unaffected areas as a check on time series in (i).
xi. Get adult/child breakdown on hospital data. This will not be used in valuation of treatment costs, but in estimating lost workdays (see below).

These steps were modified for individual countries, depending on data constraints. For Singapore, they were followed largely as outlined. In Malaysia, data on hospital and clinic admissions were matched with pollution levels to produce a dose-response function. This was extrapolated to areas of Malaysia where data on admissions were unreliable. The dose-response function was also transferred to Indonesia, where a map of cumulative haze intensity was overlaid on a population map to estimate the number of people exposed to haze pollution of various levels.

b. Estimate Workdays Lost

i. Use hospital and/or clinic visits by adults as a proxy for workdays lost. Adjust visits to workdays lost by a factor suggested by local doctors.
ii. If feasible, adjust for any double counting, if people frequently go first to a clinic and then to a hospital on the same day for the same sickness episode. This would not necessarily affect treatment cost, but would affect workdays lost.
iii. Multiply each workday lost by the average or minimum daily wage (depending on which is most suitable in a given country; indicate which one used). Do this for all adults, male and female. (If employees continue to receive wages while on sick leave, workdays lost are considered a loss to the employer. Firms may also be slightly overstaffed to cover absenteeism; or they might pay overtime or hire temporary help later to make up for shortfalls in production. These are also costs to employers, for which workdays are an approximation.)

c. Adjust COI for Discomfort (to Approximate Willingness to Pay)

Add (a) treatment cost + (b) workdays lost to get (c) COI.

i. The COI has been found to seriously underestimate "total" damage from an illness, as measured by an individual's willingness to pay (WTP) to avoid it. (This is because in spite of treatment and sick leave, the individual still suffers discomfort.) The ratio of WTP to COI varies with the ailment. Some ranges of values can be found in the *ADB Workbook* (1996, p. 188). For asthma, it is about 2:1.
ii. This "adjusted COI", for lack of a better term, is the value to be used for short-term health damages only. Long-term, cumulative damages are not valued.

HAZE-RELATED PRODUCTION LOSSES

These could include rural and urban activities such as reduced crop yields resulting from reduced sunlight. In practice, the only losses measurable were:

- foregone profits in Malaysia from fishing due to reduced visibility (fishing days foregone multiplied by expected profit per day) and
- reduced industrial and commercial activity due to the ten-day state of emergency in Kuching (percentage of GNP foregone).

TOURISM LOSSES

Estimate reduced tourist arrivals from non-ASEAN sources (to control for the effect of the 1997 Asian economic crisis): compare August–October 1997 to a "normal August–October". Point-of-origin of tourists was further disaggregated in the Singapore case.

AIRLINE AND AIRPORT LOSSES

To obtain the losses incurred from airport closures due to poor visibility, one would need data on cancelled flights, expressed in mileage lost, multiplied by the airline's average profit per mile. To this should be added any profits foregone from the operation of the airports themselves.

ESTIMATION METHODS FOR FIRE DAMAGES

The estimation methodology consists essentially of multiplying the area burned in August–December 1997 and multiplying those by per hectare values for various vegetation types and land uses. The per hectare values are taken from existing data on Indonesia and, failing that, from comparable ecosystems elsewhere with appropriate adjustments. Economic damages are in net terms (i.e., profit foregone, not total revenue foregone). Discounting of future costs was done at a rate of 10 per cent.

1. Area burned: Estimates are based on a total area burned of five million hectares, distributed as follows: 20 per cent forest, 50 per cent agriculture/plantation, 30 per cent others (unproductive). These figures are derived primarily from satellite mapping studies of Sumatra and Kalimantan by the National University of Singapore's Centre for Remote Imaging, Sensing and Processing (CRISP), with adjustments by EEPSEA and the WWF for areas burned outside those provinces.
2. Timber: Timber values take into account estimates of timber stock by the government of Indonesia, as well as growth estimates of forests and net international prices. A net price of US$50 per cubic metre was used. This was cross-checked with an alternative estimation method based on land values and found to yield consistent results.
3. Agriculture: Agricultural losses were estimated on lost production in terms of years of output. Differences in productivity between plantations and smallholdings were factored in, and agricultural land productivity estimates used in this chapter were generally corroborated with observed agricultural land prices; such prices would be expected to capitalize future production values. We have assumed that, after burning, full agricultural productivity would be re-established in three years, with partial productivity being re-established in years one and two after the burning. This is consistent with the average productive cycles of mixed crops (a combination of annuals and perennials and tree crops).
4. Direct forest services: A benefit transfer (BT) approach was used, drawing on average world values of tropical rain forest ecosystems, applying them only to the forest area in the sample (i.e., 1 million hectares). The principal source was Costanza et al. (1997). Figures provided in that source are probably less precise than stated values for culture, timber, and climate control/regulation and genetic resources were removed to avoid double counting with independent estimates described elsewhere. This yielded a net value lost of US$530 per hectare per year. It was assumed that non-timber forest products would be re-established over a period of five years.
5. Indirect forest services: A similar procedure to that described for

TABLE 2.1
Summary of Research and Valuation Methods, by Country

Impact Area	Singapore	Malaysia	Indonesia
Health impacts and production losses from the haze	Cost of illness, based on direct estimates of people affected and productivity losses	Cost of illness, using econometric dose-response (DR) estimates correlated to the Air Pollution Index (API); includes direct costs of selected plant shutdowns	Cost of illness, based on a transfer of Malaysian DR estimates to Indonesian haze index maps digitized from NOAA satellite images
Tourism impacts of the haze	Lost tourism arrivals, based on actual data	Lost tourism arrivals, based on estimated visits	Lost tourism arrivals based on trend and regression analysis of historical figures; includes airport closures
Timber losses from fire	Not applicable	Not applicable	Net value of timber burned within forest
Agriculture losses from fire	Not applicable	Not applicable	Net value of agricultural production lost assuming current land productivity and three-year recovery period
Forest services	Not applicable	Not applicable	Benefit transfer techniques applied to direct values such as food, raw materials, non-timber forest products and recreation, and indirect values such as erosion control, disturbance regulation, water supply and regulation, soil formation, nutrient cycling, and waste treatment
Biodiversity impacts	Not applicable	Not applicable	Benefit transfer, based on international willingness-to-pay estimates
Fire-fighting	Actual expenditure		
Carbon release	Carbon release estimates based on factors calculated by National University of Singapore's CRISP applied to 5 million hectares burnt, valued at US$10 per tonne carbon		

direct forest services was applied and yielded a net value lost of US$1,481 per hectare per year. It was further assumed that the losses applied only to the area "effectively burned" of forest which, consistent with the "combustion factor" in CRISP estimates, was 50 per cent of actual forested area. It was assumed that indirect forest services would be re-established over two years.

6. Biodiversity losses: The approach used here is to value "capturable biodioversity" from Indonesia's perspective. It is not the full value of international value of biodiversity. The figure takes a value of US$300 per square km. per year as an average of values found from various studies of willingness to pay (WTP) to preserve tropical rain forest of various qualities.
7. Fire-fighting costs: This includes all documented costs for fire-fighting beyond "normal year" expenses. It includes the contributions of personnel and cash from within and outside Indonesia.
8. Carbon release: Carbon dioxide and methane emission estimates in the CRISP study were increased by the ratio of total area burned (five million hectares) to area assessed by CRISP (4.56 million hectares). Such emissions increase global warming, which in turn is assumed to cause economic damage. Previous studies for the Intergovernmental Panel on Climate Change (IPCC) have put a value of up to US$30 on the damage caused by a tonne of carbon emitted (Watson et al. 1996); figures up to this amount are commonly used in international negotiations (Pearce 1998). In this chapter, a conservative figure of US$10 per tonne was used.

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3

MALAYSIA

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The haze first presented a considerable disruption to daily life in Malaysia in April 1983. The disruption continued in August 1990, from June to October 1991, and has recurred every year since 1992 to plague the months of August, September, and October. The effects of the haze reached their zenith in 1997 when the sky remained dull with pollution from August until November of that year.

In 1983 the reasons for the haze were unknown and speculation attributed the causes to suspended ash particulates from volcanic eruptions, suspended smoke particulates from large-scale forest fires, open agricultural burning in neighbouring countries, as well as local agricultural burning. But the cause of the recent haze points firmly towards forest and plantation fires in Southern Sumatra, Kalimantan, and some other islands of Indonesia.

The 1997 haze reached new levels of intensity and duration, causing much inconvenience and disruption to the Malaysian economy. The haze aggravated respiratory diseases, forced a decline in crop and fishing yields and caused disruption to transport services, manufacturing output and the tourism industry. Air Pollution Index (API) readings reached 500 for the first time and a state of emergency was declared for a ten-day period in Sarawak. The API monitors air quality by measuring fine particles (below 10 microns) and several gases — carbon monoxide, sulphur dioxide, nitrogen dioxide, and ozone — which are hazardous to health. The API can be used to ascertain the effects of air quality on health (see TABLE 3.1).

Continuous hazy conditions affect the health of all, especially high-risk groups such as children, senior citizens and people who smoke, people who work outdoors or sufferers of asthma, bronchitis, pneumonia, chronic lung diseases, cardio-vascular problems, or allergies.

TABLE 3.1
Malaysia's Air Pollution Index

Air Pollution Index	Diagnosis
0–50	Good
51–100	Moderate
101–200	Unhealthy
201–300	Very unhealthy
301–500	Dangerous

COUNTING THE COST

We have used a production function approach to estimate the value of the haze. This approach links changes in air quality to changes in production relationships. An increase in air pollution causes firms (and households) either to reduce the production of goods and services or to incorporate preventive or mitigation measures to reduce the impacts of the pollution. Firms combine environmental conditions with purchased inputs to produce commodities. The production function for a firm can be represented as:

$$Y = f(L, K, I, Q)$$

Where L and K are labour and capital inputs, I is a vector of purchased inputs such as utilities and materials, Q is air quality, and Y is the output produced. Assuming that the first derivative of Y over Q ($\delta Y/\delta Q$) is positive, then a decrease in air quality will, *ceteris paribus*, reduce the output levels. Put another way, to maintain a given level of Y, the amounts of other inputs must be increased. These other inputs include the preventive and mitigative measures to maintain production or societal welfare to the level prior to the change in air quality.

The change in expenditure made due to the need to substitute other inputs for the change in the air quality can be used to estimate the value of the haze. Two popular production function approaches used to estimate the change in these expenditures are avoided-cost and dose-response methods. Expenditure made to prevent the spread of forest fires and to reduce the haze belong to the avoided-cost approach, while estimations of the cost of illness and haze-related production losses belong to the dose-response approach.

The approach used to estimate the value of the haze aims to estimate incremental costs over a "normal" situation. Haze incidents occur within a domestic framework in Malaysia, even without the outbreak of forest fires in Indonesia. Therefore, we are only interested in the incremental impacts occurring in 1997 relative to domestically sourced impacts from previous years.

ILLNESS

Exposure to the haze has an impact on health. Symptoms include an itchy throat, coughing, difficulty in breathing, nasal congestion, painful and watery eyes, a runny nose, cold attacks, itchy skin, and chest pains.

We used a dose-response function (DRF) to establish quantitative health damage throughout Malaysia. This DRF provides a relationship between how much illness a given dose of haze pollution can cause. In adopting this approach a DRF has to be established first. Two DRFs were estimated; one for the impact of the haze on the number of out-patient treatments sought at public hospitals and health centres; and the other for the impact of the haze on the number of people hospitalized. Establishing the DRF requires measurement of exposure and measurement of damage. The measurement of exposure was obtained from the published daily API readings in the state of Sarawak (which experienced a range of haze incidence from a very low API of 39 to an extremely high reading of 831 during a forty-five-day period from 1 September to 15 October). Data on damage was obtained from haze-related out-patient treatment and hospitalization figures published by the Sarawak Ministry of Health. Similar data was not available publically in other Malaysian states. The regressed DRFs are reported in APPENDIX 3.1. These DRFs were then used to obtain the incremental number of out-patient treatments and incremental number of hospitalization cases arising from the haze from August to October 1997 relative to the same period in 1996 for all the haze-affected states of the country.

Haze-related medical cases comprised out-patient and in-patient treatments. Out-patient treatments are composed of the number of people seeking treatment and the number of people who did not seek treatment from qualified medical doctors but administered self-treatment by purchasing medicine. In-patient treatments refer to the number of patients hospitalized due to the haze. The number of people seeking treatment is calculated using the following equation:

$$NT = \Sigma_i CHL_i \times DRC1 \times HD_i \times F1 \times POP_i/10{,}000 \quad (1)$$

The number of people administering self-treatment is calculated using the following equations:

$$NST = \Sigma_i CHL_i \times (DRC1 + DRC2) \times HD_i \times F1 \times F2_i \times POP_i/10{,}000 \quad (2)$$

$$TCTST = NT \times PT + NST \times PST \quad (3)$$

where:

NT = the incremental number seeking treatment in the country;
NST = the incremental number seeking self-treatment or directly buying medicine in the country;
CHL_i = the difference between the average haze index in state i and the normal haze index of 25;
DRC1 = the dose-response coefficient per 10,000 population for the number of out-patient treatment cases in public hospitals only (0.0125);
DRC2 = the dose response coefficient per 10,000 population for the number of hospitalized cases in public hospitals only (0.000055);
HD_i = the number of hazy days in state i. HD is 60 in Sarawak, 75 days in Kuala Lumpur and Selangor, and 30 days for the other at-risk states;
F1 = the factor of 2 used to reflect the summation of public and out-patient treatment cases. The ratio of public to private clinic out-patient treatments is 1:1. No breakdown by states was done owing to the unavailability of data;
$F2_i$ = the factor of those seeking self-treatment in state i;
POP_i = the population at risk in state i. The total population at risk is 18,018,795. This figure is the entire population of Malaysia with the exception of the states of Kelantan, Terengganu, and Pahang.
TCTST = the total cost of treatment and self-treatment;
PT = the price of out-patient treatment and medication; and
PST = the shadow cost of self-treatment.

The number of people seeking self-treatment has been calculated in equation 2 and includes a dose-response coefficient to indicate the incremental number of hospital admission cases per 10,000 population.

This dose-response coefficient has been included in order to obtain the total number of incremental medical cases. This resulting figure was then multiplied by $F2_i$, or the factor of those seeking self-treatment in state i. Recent interviews with doctors in Sarawak suggest a factor of 1 in Sarawak and Sabah and a factor of 0.5 at the most in the states of peninsular Malaysia. It should be noted that Malaysia supports various rural medical posts, even in remote aboriginal communities. For instance, in Sarawak there are 1,718 village health representatives serving 165,000 people from 956 villages.

After determining the number of out-patient medical treatments, it is possible to estimate the incremental cost of medical treatment (TCTST). Incremental costs of out-patient treatment have been calculated using equation 3 and are reported in TABLE 3.2. It is assumed that no significant price changes have occurred with respect to medical treatment fees as a result of the 1997 haze. This assumption is supported by the fact that government clinics already had sufficient medical supplies to treat patients suffering from upper respiratory tract infection (URTI) and asthma (*Sarawak Tribune*, 2 October 1997). The price of out-patient treatment and medication (PT) is estimated at RM25 (US$10) per visit in private clinics. Although this price may be higher than charges at public clinics we have used the RM25 rate as a shadow price to incorporate government subsidies to public clinics. For those seeking self-treatment (derived from the purchase of medicine) the financial cost per case is less than half of PT, but in seeking self-treatment the person at risk has foregone the opportunity of obtaining the benefit of the doctor's advice. This loss of benefit is also a cost to the person at risk. Thus the shadow cost of self-treatment (PST) must include the opportunity cost of consultation. PST is thus assumed to be RM25, as in PT.

Around 18 million Malaysians were put at risk by the 1997 haze or 83.2 per cent of the total population. But the level of risk varied from state to state depending on the intensity and duration of the haze. The incremental cost incurred by the population at risk for the treatment of haze-related illnesses (at both public and private clinics and hospitals), and for self-treatment (mainly via the purchase of medicines) was estimated to be around RM5.02 million (approximately US$2 million) for the period August–October in 1996 and in 1997 (TABLE 3.2).

Apart from out-patient treatments, the haze increased the number of hospital admissions of acute asthma and bronchitis cases. The number of admitted cases and the total number of admissions per day have been

TABLE 3.2
Incremental Cost of Out-Patient Treatment and Self-Treatment Arising from the August–October Haze in 1997 Compared with the Same Period in 1996

Incremental dose-response coefficient per 10,000 population[1] (DRC1)	0.0125
Incremental number seeking treatment[2] (NT)	141,112
Incremental cost of treatment sought[3] (CT)	RM3,527,803 (US$1,411,121)
Incremental number seeking self-treatment or directly buying medicine[4] (CST)	59,593
Incremental cost of medicine bought when not seeking treatment[3, 5] (CNST)	RM1,489,835 (US$195,934)
Total cost of treatment and self-treatment[6] (TCTST)	RM5,017,638 (US$2,007,055)

Note: All figures in the table are rounded up and may not tally with subsequent reported figures, which are based on non-rounded up data used in the analysis proper.

[1] Dose-response coefficient (DRC) for reported number of out-patient treatment cases in public hospitals only. The estimated DRCs are reported in Appendix 3.1.

[2] NT is calculated using the following formula:

$$NT = \text{Sum over } i \ CHL_i \times DRC1 \times HD_i \times F1 \times POP_i/10{,}000$$

where:

CHL_i = the difference between the average haze index in state i and the normal haze index of 2.5;
DRC1 = the DRC for the number of out-patient treatments in public hospitals;
HD_i is the number of hazy days in state i. HD is 60 days in Sarawak, 75 days in Kuala Lumpur and Selangor, and 30 days for the other states at risk;
F1 = the public and private out-patient treatment factor of 2 to reflect the 1:1 ratio of public to private clinic out-patient treatments; and
POP_i = the population at risk in state i. The total population at risk is 18,018,795, this figure is for the entire population of Malaysia with the exception of the states of Kelantan, Terengganu, and Pahang.

[3] Assuming that demand for treatment and medicine is price-inelastic (close to zero), the price of out-patient treatment and medication (PT) is RM25 per visit, CT = NT x PT.

[4] The formula used is:

$$CHL_i \times (DRC1 + DRC2) \times HD_i \times F1 \times F2_i \times POP_i/10{,}000$$

Computed as an equation for NT but with the inclusion of another DRC (DRC2 = 0.000055), which is the coefficient for an incremental number of hospital admission cases per 10,000 population, and an additional multiplication by $F2_i$, which is the factor of those seeking self-treatment in state i. Recent interviews with doctors in Sarawak suggest a factor of 1 in Sarawak and Sabah, and at most 0.5 in the states of peninsular Malaysia.

[5] Assuming that demand for treatment and medicine is price-inelastic (close to zero). The financial cost of seeking self-treatment is only RM10 (US$4) per case but in doing so the person at risk has foregone the opportunity of obtaining the benefit of a doctor's consultation and advice. This loss of benefit of consultation is also a cost to the person at risk. Thus the shadow cost of self-treatment (PST) should include the cost of the benefit of the lost consultation. PST is thus assumed at RM25 (US$10) as in PT. CST = NST x PST.

[6] Computed as TCTST = CT + CST.

calculated using equations 4 and 5.

$$NA = \Sigma_i CHL \times DRC2 \times HD_i \times F3 \times POP_i/10{,}000 \quad (4)$$

$$NDA = NA \times LH \quad (5)$$

$$CA = NDA \times PH \quad (6)$$

where:

NA = the number of admissions to both public and private hospitals, calculated by adding up the number of admissions and dividing it by the population at risk in all the "i" states;
CHL_i = the difference between the average haze index in state i and the normal haze index of 25;
DRC2 = the incremental dose-response coefficient for the number of hospital admission cases in public hospitals of 0.000055;
HD_i = the number of hazy days in state i;
F3 = the factor that reflects public and private hospitalization cases. We were not able to verify the breakdown between public and private hospitalization cases. A proxy factor of 1.22 was used. This ratio is based on the number of available public to private hospital beds of 1:0.22;
POP_i = the population at risk in state i;
LH = five days, the average length of stay in hospital per patient;
NDA = the total number of days of hospital admission throughout the country;
CA = the incremental cost of hospitalization; and
PH = the price of hospitalization per day, assumed to be RM125 (US$50).

The incremental cost of hospital admission is obtained from equation 6 and is reported in TABLE 3.3. Again it has been assumed that no significant price changes have taken place with respect to medical treatment fees as a result of the 1997 haze. The price of hospitalization per day (PH) is assumed to be RM125 (US$50). This figure has been obtained by using the cost of hospital admission to out-patient treatment of 5:1. The incremental cost incurred with respect to hospital admission was estimated to be RM1.2 million (approximately US$580,000).

LOSS OF PRODUCTIVITY

Malaysia suffered a loss in productivity due to haze-related illnesses, more specifically, production opportunities were missed due to a depleted work-force and productivity was reduced due to the diminished

TABLE 3.3
Incremental Cost of Hospital Admissions Arising from the August–October Haze in 1997 Compared with the Same Period in 1996

Incremental dose-response coefficient per 10,000 population[1] (DRC2)	0.000055
Incremental number admitted[2] (NA)	379
Incremental number of days admitted[3] (NDA)	1,894
Incremental cost of hospitalization[4] (CA)	RM1,183,578 (US$473,431)

Note: All figures in the table are rounded up and may not tally with subsequent reported figures, which are based on non-rounded up data used in the analysis proper.
[1] Dose-response coefficient (DRC) for reported number of admissions into public hospitals only. The estimated DRCs are reported in APPENDIX 3.I.
[2] NA is the number of admissions into both public and private hospitals. NA has been ascertained by calculating the population at risk in different states i using the following formula:

$$NA = \text{Sum over } i\ CHL_i \times DRC2 \times HD_i \times F2 \times POP_i/10{,}000$$

where:

CHL_i = the difference between the average haze index in state i and the normal haze index of 25;
DRC2 = the DRC for the number of hospital admissions in public hospitals;
HD_i = the number of hazy days in state i;
F2 = the public and private hospital admission cases factor of 1.22 to reflect the 1:0.22 ratio of available public to private hospital beds (Department of Statistics, Malaysia, *Yearbook of Statistics 1997*); and
POP_i = the population at risk in state i.
[3] It is assumed that the average length of stay in hospital (LH) is five days. NDA = NA x LH.
[4] The price of hospitalization per day (PH) is assumed to be RM125. This figure has been obtained by using the ratio of cost of hospital admission to out-patient treatment of 5:1 as obtained in Singapore. This daily admission cost reflects the full cost of admission to a private hospital. It is also assumed that the price elasticity of demand for hospitalization is very low (close to zero).

health of the remaining work-force. The incremental number of workdays lost during hospitalization and out-patient sick leave has been calculated using equations 7 and 8. The incremental number of workdays lost during hospitalization involves only adult patients and is calculated based on information of the incremental number of hospital admissions, the percentage of adults admitted, and the average length of stay in hospital. Apart from this, workdays were lost when workers obtained sick leave due to haze-related illnesses. The incremental number of days of sick leave obtained by adult out-patients is calculated using information on the proportion of adult out-patients (see TABLE 3.4), the incremental number of out-patients, the proportion of out-patients granted sick leave, and the average length of sick leave.

The reduced activity days experienced by the working population at risk has been calculated using equation 9. This equation requires knowledge of adult out-patients and adults who sought self-treatment, an estimate of the number of reduced activity days experienced by individuals at risk, and a factor which reflects workers' reduced productivity. Thus, adding incremental workdays lost during hospitalization and sick leave among out-patients and the reduced productivity days gives the total man-days of productivity losses of the work-force (see equation 10). The number of man-days multiplied by the average wage rate provides us with an estimate of the incremental productivity loss from haze-related illnesses (see equation 11). These sources of haze-related productivity losses are estimated to be RM4.3 million or approximately US$1.72 million (see TABLE 3.4). The total cost of all three kinds of incremental costs of illness (COI) was estimated to be RM10.51 million (approximately US$4.204 million).

$$\text{NWDL} = \text{NA} \times \text{AAR} \times \text{LH} \tag{7}$$

$$\text{NSL} = \text{ATR} \times \text{NT} \times \text{LMC} \times \text{MCR} \tag{8}$$

$$\text{NRAD} = ([\text{NT} + \text{NST}] \times \text{ATR} \times \text{LRA} - \text{NWDL} - \text{NSL}) \times \text{F4} \tag{9}$$

$$\text{TNWDL} = \text{NWDL} + \text{NSL} + \text{NRAD} \tag{10}$$

$$\text{TPLI} = \text{TNWDL} \times \text{W} \tag{11}$$

where:

NWDL = the incremental number of workdays lost due to hospitalization;
NA = the incremental number of patients hospitalized;
AAR = the percentage of adult patients admitted to hospital;
LH = the average length of stay in hospital, of five days;
NSL = the incremental number of days of sick leave granted to adult out-patients;
ATR = the proportion of adults seeking treatment, 49 per cent;
LMC = the average duration of a medical certificate, estimated to be

TABLE 3.4
Productivity Losses from Haze-Related Illnesses Arising from the August–October Haze in 1997 Compared with the Same Period in 1996

Incremental number of adults hospitalized[1] (NAA)	151
Incremental number of workdays lost through hospitalization[2] (NWDL)	757
Incremental number of days of sick leave obtained by adult out-patients[3] (NSL)	20,743
Incremental total workdays lost[4] (TNWDL)	21,501
Incremental productivity foregone from workdays lost[5] (CPFWDL)	RM569,776 (US$227,910)
Incremental reduced activity days[6] (NRAD)	141,068
Incremental productivity loss from reduced activity days[7] (CPLRAD)	RM3,738,309 (US$1,495,324)
Incremental productivity losses from illness[8] (TPLI)	RM4,308,085 (US$1,723,234)

Note: All figures in the table are rounded up and may not tally with subsequent reported figures, which are based on non-rounded up data used in the analysis proper.

[1] NAA is based on information on the percentage of adults admitted (AAR). An official from the Department of Health provided the figure of 40 per cent. NAA = NA x AAR.

[2] It is assumed that the average length of stay in hospital (LH) is five days. NWDL = NAA x LH.

[3] The proportion of adults to children seeking treatment is 0.95:1, so the proportion of adults seeking treatment (ATR) of 49 per cent is used. Interviews with medical practitioners suggest that the average length of medical certificates for sick leave (LMC) is two days and the proportion of out-patients seeking treatment who obtained sick leave (MCR) is 15 per cent. So NSL = ATR x NT x LMC x MCR.

[4] TNWDL = NWDL + NSL.

[5] Average wage per employee (W) is calculated using the Malaysian annual wage of RM26.50 (US$10.60) a day. Therefore, CPFWDL = TNWDL x W.

[6] NRAD is the effective reduced activity days among adult workers at risk. F3 is the reduced activity experienced during each working day by individuals at risk. F3 is 0.3. NRAD = ([NT + NST] x ATR x LRA – TNWDL) x F3 where LRA is the length of reduced activity days experienced by individuals at risk (five days, according to medical practitioners interviewed).

[7] CPLRAD = NRAD x W.

[8] TPLI = CPFWDL + CPLRAD.

two days (this figure was derived from interviews with medical practitioners);

MCR = the proportion of out-patients seeking treatment and obtaining sick leave, estimated to be 15 per cent (this percentage was decided upon in consultation with medical practitioners);

NRAD = the number of reduced productivity days experienced by workers at risk;

LRA = five days, the number of reduced productivity days experienced by individuals at risk (this number was reached in consultation with medical practitioners);

F4 = the factor for reduced productivity (0.3) for individuals at risk but still working; and

W = the average wage per employee, RM26.50 per day, calculated from the annual wages and salaries of Malaysians.

The cost of illness (COI) quantifies medical costs and lost productivity (in terms of lost wages) associated with illness. But COI studies have been criticized because they do not take into account the individual's pain, suffering, or loss of leisure activities. Studies which incorporate the cost of the prevention of illness, pain, and discomfort indicate that adjusted COI estimates exceed current COI estimates. For asthma symptoms, the (adjusted COI:COI) ratio of affected individuals falls within a range of 1.6 to 2.3 (Asian Development Bank 1996). Therefore, in order to take into account the willingness to pay (WTP) estimates, COI figures need to be multiplied by a factor of two. This ratio adjustment is admittedly imprecise but is better than not making any adjustment at all. In summary, the adjusted incremental COI arising from the forest fires of 1997 during the months of August to October was RM21.02 million (approximately US$8.408 million; see TABLE 3.5).

The ratio of those not seeking treatment from government and private clinics in rural Malaysia is not as high as in Indonesia where it is reported that about eleven people avoid treatment for every single outpatient treatment. Dr George Chan, Deputy Chief Minister of Sarawak, has stated that rural clinics in Sarawak have sufficient medical supplies to treat patients suffering from upper respiratory tract infections (URTI) and asthma (*Sarawak Tribune*, 2 October 1997). A 1:1 ratio between those seeking treatment from private and public medical facilities and those practising self-treatment is used in this analysis for the states of Sabah and Sarawak while the ratio of 1:0.5 is valid for the affected states of peninsular Malaysia. The proportion of children to adults seeking

TABLE 3.5
Adjusted Incremental Cost of Illness Arising from the August–October Haze in 1997 Compared with the Same Period in 1996

Incremental hospitalization cost (CA)	RM1,183,578 (US$473,431)
Incremental total cost of treatment and self-treatment (TCTST)	RM5,017,638 (US$2,007,055)
Incremental total productivity loss from illness (TPLI)	RM4,308,085 (US$1,723,234)
Incremental cost of illness[1] (COI)	RM10,509,301 (US$4,203,720)
Adjusted cost of illness[2] (ACOI)	RM21,018,602 (US$8,407,440)

Note: The figures in each cell are rounded up and may not tally with reported figures in subsequent cells, which are based on non-rounded up data used in the analysis proper.
[1] COI = CA + TCTST + TPLI.
[2] For illness prevention, pain, discomfort, loss in ability to enjoy leisure activities, the WTP/COI ratio of affected individuals is the range of 1.6 to 2.3 (Asian Development Bank, 1996). The estimates of COI are multiplied by a factor (F4) of 2 in this study to obtain the adjusted cost of illness or WTP to avoid the health impacts of the haze. ACOI = F4 x COI.

TABLE 3.6
Proportion of Children among Those Seeking Treatment

Haze-Related Disease	Proportion of Adults among Those Seeking Treatment	Ratio of Children to Adults Seeking Treatment
URTI	0.53	1:1.15
Asthma	0.53	1:1.12
Conjunctivitis	0.39	1:0.24
Bronchitis	0.71	1:2.50
Total	0.49	1:0.95

Source: *Sarawak Tribune*, 23 September 1997.

treatment for haze-related diseases is given in TABLE 3.6. The overall ratio of adults to children is 0.95:1 or 49 per cent adult. Based on the above, combined with field interviews, see TABLES 3.2, 3.3, 3.4, and 3.5 to understand how the adjusted COIs in Malaysia were calculated.

LOST WORKDAYS

When the Air Pollution Index (API) reached 500, a ten-day state of emergency was declared in Sarawak (19–28 September). During this period, only essential activities, such as food retailing, electricity and water provision, and law enforcement were allowed to operate. This clamp-down on economic activity had an impact on the economy. Employers were forced to let their employees stand idle and the state government ruled that all employees should be paid during the emergency so not only were employers deprived of the profits that they would have made during eight days (nett of Sundays) of production but they also had to meet their usual wage bill. In the majority of cases, the value of raw materials was not lost; their use was merely delayed. It should be noted that employers' loss in paid wages was a gain to employees. Therefore, as far as the country was concerned no economic loss was suffered in terms of wages, the real loss incurred being in profits foregone.

Considering the state-wide standstill in economic activity, foregone profits can be estimated using information deduced from loss of gross domestic product (GDP) during the emergency period. TABLE 3.7 illustrates the value of wage loss during the state of emergency in Sarawak and its effects on the firms' profits (returns to capital). We have calculated foregone profits by netting wages and salaries lost from the GDP during period of the emergency. Using this criteria, we have estimated foregone profits to be RM393.51 million or approximately US$157.40 million (taking the average values per day pro-rated to an eight-day period). See TABLE 3.8.

TABLE 3.7
Cost of Wage Loss during the State of Emergency in Sarawak Arising from the August–October Haze in 1997 Compared with the Same Period in 1996

Number of workdays lost	8
Number of employees[1]	831,533
Average wage per day	RM26.5 (US$10.60)
Total wage and salary	RM176,285,000 (US$705,140,000)

[1] The number of employees is for the whole Sarawak economy.

Source: Department of Statistics, *Annual Report of Sarawak, 1996*.

TABLE 3.8
Loss of Economic Activity during the State of Emergency in Sarawak: Profits Foregone, 1 August to 31 October 1997

Effective number of workdays lost	8
Estimate of GDP foregone per day, by economic sector[1]	RM71,223,880 (US$28,489,552)
Estimate of GDP foregone, by economic sector[1]	RM569,791,000 (US$227,916,400)
Estimate of wage and salary incurred, by economic sector	RM176,285,000 (US$705,140,000)
Estimate of profit foregone, by economic sector	RM393,506,000 (US$157,402,400)

[1] Gross domestic product (national total of value added) foregone per day during the emergency. Not possible to disaggregate by sectors.

Source: Department of Statistics, *Annual Report of Sarawak, 1996*.

DECLINING TOURISM

Tourism is Malaysia's second largest foreign exchange earner (it brought US$4.5 billion into the Malaysian economy in 1996). Despite the depreciation of the ringgit, this sector is now suffering from declining numbers of visitors. Some tour group operators from Hong Kong, Britain, and Japan, to name but a few, have delayed or cancelled their tours to Malaysia.

At the end of November 1997, long after the haze had dispersed, the local tourism industry had still failed to reach pre-haze levels despite foreign exchange rates favouring foreign tourists. The Sarawak Travel Association Miri Liaison Committee Chairman stated that inbound tour volume had reduced by as much as 70 per cent as a result of the haze and has yet to recover to its normal level, despite clear skies (at the time of writing, March 1998). An interview with the State Tourism Department suggests that tourist arrivals have fallen to less than 30 per cent of previous years. The value of the decline in tourism is estimated to be RM318.55 million or approximately US$127.42 million (see TABLE 3.9).

TABLE 3.9
Tourism Losses in Malaysia during the Period 1 August to 31 October in 1997 Compared with the Same Period in 1996

	1 Aug. to 31 Oct. 1997	1 Aug. to 31 Oct. 1996	Increment[3]
Tourist arrivals (non-ASEAN)[1]	320,091	457,273	–137,182
Expenditure per traveller[2]	RM5,009 (US$2,003)	RM4,203 (US$1,681)	
Total tourism expenditure	RM1,603,367,714 (US$641,347,085)	RM1,921,917,421 (US$768,766,968)	–RM318,549,708 (–US$127419,883)

[1] Tourist arrivals for 1996 are calculated using data published in the Malaysian Tourism Promotion Board's *Annual Tourism Statistical Report*, *1996*. Tourist arrivals for 1997 are calculated using feedback from hotel and restaurant operators who indicate that there was a 30 per cent decline in arrivals compared with the same period in 1996.
[2] Expenditure for 1997 is estimated using the rate of increase in tourist expenditure between 1996 and 1995 provided in the *Annual Tourism Statistical Report*, *1996*.
[3] A negative increment means a decline in tourism receipts.

FLIGHT CANCELLATIONS

According to the *Star* newspaper (27 October 1997), the Malaysian Airline System (MAS) cancelled 1,800 domestic flights (inclusive of rural flights) and international flights during the height of the haze (September 1997). These flight cancellations resulted in sales losses of RM6.5 million (approximately US$2.6 million). Flight cancellations cost money in two ways; loss of profit opportunities from airport operations, including aero-bridge operation, parking fees, and landing fees; and direct loss of profit opportunities from flight cancellations (TABLE 3.10). The total loss was RM450,000 approximately (US$180,000) (see TABLE 3.11).

TABLE 3.10
Profits Foregone from the Operation of Airports, August–October 1997

Losses from airport closures[1] (per flight)	RM460 (US$184)
Number of flights cancelled	1,800
Losses from airport closures	RM828,212 (US$331,285)
Net losses from airport closures[2] (RM)	RM124,232 (US$49,693)

[1] Lost economic opportunities from aero-bridge operation, parking fees, and landing fees.
[2] Net losses from airport closures are assumed to be 15 per cent of gross revenues.

TABLE 3.11
Profits Foregone from Airport Closures, August–October 1997

Profits foregone from airport operations[1]	RM124,232 (US$49,693)
Profits foregone from cancelled flights	RM325,000 (US$130,000)
Total profits foregone[2]	RM449,232 (US$179,693)

[1] It is assumed that foregone profits from cancelled airport operations are 15 per cent of gross losses.
[2] Reported foregone sales from flight cancellations amount to RM6.5 million (US$2.6 million). Profit before taxation is 5 per cent of turnover.

Source: *MAS Financial Reports, 1996/97*.

REDUCED FISH LANDINGS

There was a decline in fish landings during the haze but there is no direct evidence linking the haze with this reduction in crop yield. However, reports from fishermen on the west coast of peninsular Malaysia seem to provide a link. The *Star* (30 September 1997) reported that fishermen complained of a 30 per cent decline in fish landings at Pulau Lumut, Perak. Field visits to the states of Sarawak, Sabah, and Kedah suggest that a decline in fish landings only occurred during the month of September, due mainly to visibility problems at sea, which discouraged fishermen from sailing. This explanation is particularly true for fishermen with small boats. The decline in fish landings was smaller in some areas thanks to the use of geographical positioning systems and radar by the owners of larger fishing vessels. After adjusting for trends in the months prior to and after the period August–October in 1996 and in 1997, we estimate the decline in fish landings to be 23 per cent lower than in September of 1996. Using these figures, fish landings were down by about 15,900 tonnes on the previous year. See TABLE 3.12.

The decline in fish landings had the opposite effect on prices. Assuming a price elasticity of demand of –0.92, the 7.7 per cent decline in landings raised fish prices by 8.3 per cent, causing a rise in the value of fish landed during the period August–October in 1996 and in 1997. Although there was a net decrease in the number of fish caught, the rise in prices ensured a net increase in revenue of RM140,000 (US$56,000). The net return can be estimated at around RM40,000 (US$16,000) (assuming a profit margin of 30 per cent, based on the average profit margin for large and small self-employed fishermen in Kedah (Franks et al. 1997). This net return only takes into account the impacts of the haze on fishermen, not society as a whole. Net welfare gain to the entire society has to take account of changes in both producer and consumer surpluses.

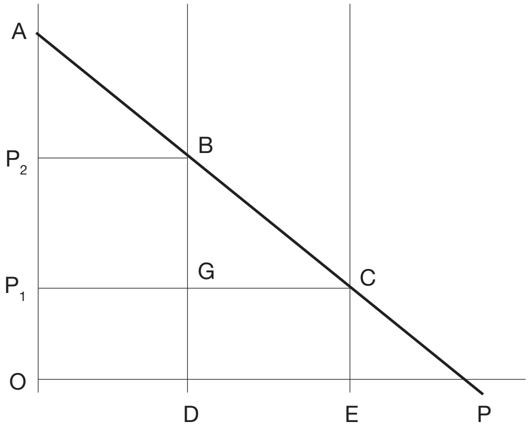
The rise in fish prices and decline in the availability of fish for consumption had a negative effect on consumers, particularly on changes in consumer surplus. Welfare loss to society clearly depends on the supply function, both before and after the haze. But we have no information upon which to base an analysis and so have to make certain assumptions. We have assumed that in the immediate and short term, supply curves for fish landings are very inelastic (see FIGURE 3.1). Using this assumption, fishermen and sellers would experience a gain in producer surplus (area OP_2BD – area OP_1CE) while consumers would incur a decline in consumer surplus (area AP_2B – area AP_1C). The decline in fish landings would therefore cause consumers to face a decline in consumer surplus estimated to be worth somewhere in the region of RM40.7 million (US$16.28 million). But a portion of this consumer loss was a gain for the fishermen through increased producer surplus

TABLE 3.12
Incremental Change in Quantity and Value of Fish Landings during the Period August–October in 1997 Compared with the Same Period in 1996

	Aug.–Oct. 1997[1]	Aug.–Oct. 1996	Difference
Fish landings[2] (tonnes)	191,794	207,719	–15,925
Average price[3]/tonne	RM2,650 (US$1,060)	RM2,446 (US$978)	
Value of fish landings	RM508,220,976 (US$203,288,390)	RM508,079,842 (US$203,231,936)	RM141,133 (US$56,453)
Consumer surplus[4]	RM235,413,395 (US$94,165,358)	RM276,130,349 (US$110,452,139)	–RM40,716,954 (–US$16,286,781)
Producer surplus[4]	RM508,220,976 (US$203,288,390)	RM508,079,842 (US$203,232,139)	RM141,133 (US$56,453)
Net surplus[4]	RM743,634,371 (US$297,453,748)	RM784,210,191 (US$313,684,076)	–RM40,575,821 (–US$16,230,328)

Note: All figures in the table are rounded up and may not tally with subsequent reported figures, which are based on non-rounded up data used in the analysis proper.
[1] Based on field visits to the states of Sarawak, Sabah, and Kedah. Fish landing data and newspaper reports for Perak indicate that a haze-related decline in fish landings occurred only during the month of September. The decline rate, after adjusting for trends during the months prior to and after August–October 1997, was estimated to be 23 per cent lower than landings in September 1996.
[2] It is assumed that fish landings off the coast of east Johor, Pahang, Kelantan, and Terengganu were not affected by the haze. Reported landing figures for 1996 and 1997 are for states affected by a decline in landings in 1997 only. Data for 1996 has not been published yet but a Fisheries Department Officer estimated the annual landings for 1996 to be 1.6 per cent higher than in 1995.
[3] Price-elasticity of demand for fish in Malaysia is –0.92 (Nik Mustapha R.A. 1995).
[4] Assuming that the short-run supply curve is perfectly inelastic (both immediately and in the short term), the incremental producer surplus can be measured by the change in value of fish landings. The difference between the net producer and consumer surpluses added together gives the net welfare effect of the loss of consumer surplus.

FIGURE 3.1
Welfare Effects of the Haze on the Fish Market



income due to the higher prices for fish, depending on the increased effort and expense incurred in landing the fish. The amount "gained" is not clear owing to the uncertain elasticity of the supply curves. But assuming a very inelastic supply curve, the decline in landings is estimated to raise producer surplus by RM140,000 (US$56,000) only. This would lead to a net welfare loss to society of about RM40.58 million (US$16.232 million).

CROP LOSS

According to Mohamad Nazli A.M., Director of the North Terengganu Agricultural Development Authority (KETARA), the haze reduced second harvest padi yields by about 10 per cent (*New Straits Times,* 27 October 1997). KETARA is concerned with 4,800 hectares of padi which can produce more than 21,000 tonnes of rice a season. The average production per acre is about 5 tonnes of rice, against the national average of 3.5 tonnes. The haze has affected levels of sunlight — important for photosynthesis —— thereby reducing KETARA's rice production to an average of 4.5 tonnes per acre. However, the extended period of dry weather caused by the haze enabled growers to maximize their harvest and increase the quality standards as the harvested grain contained less moisture than is usual for the time of year. Nevertheless, if there had been no haze the 10 per cent reduction in yield could have been avoided and the full quality-yield opportunity would have been realized.

The haze had additional effects on plant life. Leaden skies caused reduced flowering and fruiting in plants (Choong 1997) and crops including rice, fruit, and vegetables were also affected. With regard to the crop yield, the chain of events set into motion by the haze can best be illustrated by the following example. See TABLE 3.13 for a summary of the yield.

> An oil palm smallholder in Tawau, Sabah, owns a 60-hectare plot of oil palm which is expected to give high yields of 3.7 tonnes per hectare from reasonably aged palms (older than five, but less than fifteen, years old) during the months of March, April, August, and September. A yield of 2.5 tonnes per hectare is expected from young palms (aged between three and five years). TABLE 3.13 illustrates the yields that were recorded from this smallholding. One interesting observation is that haze has a delayed effect on oil palm crops. Fruit bunches were already in place on the crop, some matured, others still young, by the time the haze descended. Therefore, between September and early December a decline in the tonnes of fresh fruit bunches (FFB) was not obvious, other than the normal decline that begins once the high-yield season of August and Sep-

TABLE 3.13
Average Yield from a Smallholding in Tawau (tonnes)[1]

Month	Average Yield
June 1997	95
July 1997	95
August 1997	105
September 1997	105
October 1997	90
November 1997	85
December 1997	85
January 1998	60

[1] Yield is obtained from mixed age palms (young and matured). Oil palm crops are obtained from annual staggered planting, beginning 1990.
[2] Prices prior to October 1997 were around RM205 per tonne for fresh fruit bunches (FFB). But in January and February 1998, prices rose to RM340 per tonne for FFB. The nett effect of this price increase over the FFB yield decline is obvious when comparing the farmer's income for October 1997 to his income for January 1998 — an increase of RM1,125 (US$450) for the 60-hectare smallholding.

tember is over. The low yield of January and February 1998 is due to low fertilization rates in September of 1997. The economic impact is still unclear, as income gain or loss depends on price changes in response to market forces. A declining yield brings higher FFB prices.

OTHER TYPES OF DAMAGES

The haze caused poor visibility thereby increasing the chances of accidents, particularly road accidents in Sarawak and Sibu (*Borneo Post*, 23 September 1997).

AVERTIVE EXPENDITURE

In addition to lost income, businesses and the Malaysian government have incurred avertive expenditure.

COST TO MALAYSIAN MNCS

There are eighteen Malaysian joint ventures suspected of starting fires in Indonesia (Choong 1997). The Malaysian government is extracting a total of US$1.2 million from forty-three Malaysian corporations with plantation interests in Indonesia as a contribution towards paying for the pollution caused by the haze. Thirty-one companies have promised to pay and officials are planning to pursue the matter further with the remaining companies. By 10 December 1997, the National Disaster Fund (launched on 20 September) had collected RM2,587,870 or US$1,035,148 (Esther Tan, 10 December 1997).

FIRE-FIGHTING

In Kuala Lumpur water was sprinkled from high-rise buildings as a substitute for monsoon rains. Fifty fire-fighters sprayed water from 45-metre cranes in front of Merdeka Square and from the tops of several buildings and construction sites.

At the end of September 1997, 107 firemen from Sarawak and seventy-eight from Sabah travelled to West Kalimantan to join the 1,200 firemen from peninsular Malaysia already fighting fires. These firemen tackled pre-identified hotspots in an effort to prevent the spread of the fires. These firemen received an outstation allowance of RM215 (US$86) a day for food and lodging (Anonymous, *Sun*, 13 November). This

RM215 daily allowance had to pay for food (RM120 or US$48) and lodging (RM95 or US$38). The allowance was in addition to the RM2,000 (US$800) given to each fireman for being on duty for more than twenty-one days. Firemen who served for less than twenty-one days received RM80 (US$32) a day for each day they were on duty.

The Malaysian government is thought to have spent RM25 million on efforts to fight forest fires in Indonesia, to upgrade the Fire Services Department, and to purchase fire-fighting equipment. This figure does not include the cost of post-duty medical check-ups conducted on firemen sent to Indonesia (performed in several stages at government hospitals throughout the country). These check-ups, which included blood tests and X-rays, were undertaken in an effort to monitor serious health problems resulting from fighting the fires. Some firemen were warded for observation after they displayed symptoms such as coughing, chest pains, and sore throats. One fireman died seventeen days after returning from Indonesia.

The Malaysian government received 300 jet shooters, worth about RM443,000 (US$177,200), from the Japanese International Cooperation Agency (JICA) to aid the fight against the worsening haze situation within Malaysia. The jet shooters, portable air pressurized water extinguishers carried on the back, were also used by Malaysian fire-fighters operating in Sumatra and Kalimantan.

CLOUD SEEDING

The Malaysian government carried out 252 cloud-seeding operations during the haze period. Cloud seeding was implemented to encourage natural rain to fall, thus helping to damp down the haze. Cloud seeding uses a sodium nitrate (common salt) solution (50 kilograms of salt is dissolved into every 1,000 litres of water) which is dumped into cumulus cloud by Caribou and Charlie C130 carriers at about 5,000 metres above sea level. Each plane can carry 1,800 litres of the solution. A total of 118 trips were conducted between September and 4 November in Sarawak alone. Each trip requires about one hour and forty minutes to get from Kuching to the Batang Air Catchment Area and each flight operation costs about RM4,000 (US$1,600) an hour. Assuming that the loading of the cargo and preparation for the flight takes about two hours, each flight costs about RM8,000 (US$3,200) — so the total flight cost in Sarawak alone is in the region of RM520,000 (US$208,000). The Malaysian Meteorological Department spent about RM20,000

(US$8,000) on staff allowances, and RM6,300 (US$2,520) on creating the salt solution needed for seeding. The estimated cost of the cloud-seeding operation in Sarawak is RM970,000 (US$388,000). See TABLE 3.14. The total cost of the cloud-seeding operation to Malaysia is RM2.08 million, including an estimated thirty-nine operations in Indonesia.

TABLE 3.14
The Cost of Cloud-Seeding Operations,
8 September to 6 November 1997 versus 1996

	No. of Cloud Seedings[1]	Cost per Seeding	Total Cost
Malaysia	213	RM8,250 (US$3,300)	RM1,757,250 (US$702,900)
Indonesia	39	RM8,250 (US$3,300)	RM321,750 (US$128,700)
1997 total	252	RM8,250 (US$3,300)	RM2,079,000 (US$831,600)
1996	0	0	0
Increment	252		RM2,079,000 (US$831,600)

[1] National total, value added.

MASKS

The *Star* and Dupont Malaysia launched a campaign to create awareness among schoolchildren for the need to wear masks during the haze period. Under the auspices of this campaign, 20,000 masks were distributed to selected schools in areas where the API was the highest on the peninsula — Gombak, Nilai, Penang, Kuala Lumpur, and Petaling Jaya. Masks were sent to Sarawak (*Sarawak Tribune*, 25 September 1997); 300,000 masks were donated by the Federal Government, 20,000 by the United Nations Children's Fund, and 10,000 by the Japan International Cooperation Agency (JICA). The large number of masks donated to Sarawak is a reflection of the emergency situation in the state. See TABLE 3.15 for estimates of expenditure on masks.

It is not known how many masks were actually bought by the general population affected by the haze. The groups most likely to purchase masks were schoolchildren, pedestrians, and motorists who were forced to make their way along roads to schools, offices, and business centres. Some selected industries and businesses took action to reduce the impact of the haze on their employees such as the purchase of air and water

TABLE 3.15
Estimated Expenditure on Masks, September 1997

	Sarawak	Peninsular Malaysia	Total
No. of masks purchased	330,000	20,000	350,000
Price per mask	RM2.1 (US$0.84)	RM1.0 (US$0.40)	
Total expenditure	RM693,000 (US$277,200)	RM20,000 (US$8,000)	RM713,000 (US$285,200)

purifiers, air filters, and air-conditioning systems. A specific example once again best illustrates our point. See TABLE 3.16 for a summary.

> In Kuching, Sarawak, the Hilton Hotel took two major steps to ensure that the air quality within the hotel remained high despite the haze. During September, the month with the worst haze, the hotel management closed all the hotel's doors except one. At this one entrance an electrical air curtain, costing RM7,000 (US$2,800) was installed to prevent external air from freely entering the building. To prevent particulates from entering the hotel via air-conditioning, the management invested heavily in carbonated air filters for every air intake of the central air-conditioning system. A total of RM25,000 (US$10,000) was spent on these filters. The hotel's electricity bill increased by as much as RM50,000 (US$20,000) during September due to the need for round-the-clock air-conditioning throughout the hotel. To reduce the health impacts of the haze on the staff and hotel patrons when they ventured out of the hotel, 1,000 masks were distributed.

TABLE 3.16
Occupancy Rates at the Kuching Hilton, 1997
(percentages)

Month	Target Rate	Rate Achieved
August	80	80
September	86	61
October	82	57
November	84	67–70

Source: Interview with the General Manager.

The Kuching Hilton, which has 320 rooms, suffered further losses due to a decline in occupancy rates. In August 1997, the hotel's occupancy rate was unaffected as the haze had not yet reached Kuching. In September the occupancy rate was 61 per cent, far below the target rate of 86 per cent. Income from local reservations was reduced as bookings for banquets and seminars were cancelled. When the haze period ended the occupancy rates did not recover and reach normal target rates. The downward trend continued well into 1998 when the Kuching Hilton did not receive its usual package tour reservations in the first quarter of 1998.

But it should be noted that the Kuching Hilton's restaurant business did very well during the months of October and November owing to the air quality that the hotel could offer.

THE AGGREGATE VALUE OF THE HAZE

The estimated value of the haze damage to Malaysia from August to October 1997 is RM802 million or US$321 million (see TABLE 3.17). The per capita haze damage is RM37 (US$14.80) while the value of the haze damage is 0.30 per cent of the GDP (see TABLE 3.18).

The aggregate value of the cost of the haze is quite significant as various social projects could have been established within Malaysia if

TABLE 3.17
Aggregate Value of Haze Damage

Type of Damage[1]	RM Million	US$ Million	Percentage
Adjusted cost of illness	21.02	8.41	2.62
Productivity loss during the state of emergency	393.51	157.40	49.07
Decline in tourist arrivals	318.55	127.42	39.72
Flight cancellations	0.45	0.18	0.06
Decline in fish landings	40.58	16.23	5.00
Cost of fire-fighting	25.00	10.00	3.12
Cloud seeding	2.08	0.83	0.26
Expenditure on masks	0.71	0.28	0.09
Total damage cost	801.90	321.00	100.00

[1] Cost to Malaysian multinational corporations of RM2.5 million (US$1 million) is not included as this amount might have been used by the government to pay for various avertive expenditures.

TABLE 3.18
Indicators of Relative Economic Value of the Haze

Percentage of GDP	.30%
Per capita economic loss related to the haze	RM37 (US$14.80)
Percentage of per annum overall poverty alleviation allocation in the Sixth Malaysia Plan (1991–95)	29%
Percentage of per annum social programme in the Sixth Malaysia Plan (1991–95)	334%
Percentage of per annum infrastructure programme in the Sixth Malaysia Plan (1991–95)	251%
Number of protected area/biodiversity projects such as the KSNP[1] that could have been established	237

[1] A detailed breakdown of the KSNP project with development and maintenance costs is given in APPENDIX 3.2.

money had not been spent on the haze. Under the Sixth Malaysia Plan (1991–95), the total expenditure on poverty alleviation–related programmes was about RM14 billion (US$5.6 billion), which accounted for 27 per cent of the total development expenditure by Federal Government. Of the RM14 billion, RM1.2 billion (US$0.48 billion) and RM1.6 billion (US$0.64 billion) were slated for social and infrastructural programmes, respectively. The haze cost about 29 per cent of the country's annual expenditure on poverty alleviation. The haze cost 3.34 times and 2.51 times the annual expenditures on social and infrastructure programmes, respectively. In terms of budgeting for more specific programmes, it is thought that the economic loss from the haze could have financed the conservation and management of some 237 protected areas and biodiversity programmes such as the Kuala Selangor Nature Park (KSNP), which requires a total budget of RM3.4 million (US$1.36 million) for 1987–2000 (see APPENDIX 3.2).

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APPENDIX 3.1
Results of Dose-Response Estimations for Public Hospital Out-Patient Treatment and Admission Cases, Sarawak

Public hospital out-patient treatment

Data period: 5 August–22 October 1997
Dose-response coefficient per 10,000 population (DRC1) = 0.0125
(t statistic = 8.45)
$R^2 = 0.55$
Mean number of cases per 10,000 population = 4.89
Maximum API = 831
Minimum API = 27
Average daily API = 129

Public hospital admission

Data period: 5 August–22 October 1997
Dose-response coefficient per 10,000 population (DRC2) = 0.000055
(t statistic = 3.11)
$R^2 = 0.13$
Mean number of cases per 10,000 population = 0.03
Maximum API = 831
Minimum API = 27
Average daily API = 129

APPENDIX 3.2
Development and Maintenance Cost of the Kuala Selangor Nature Park, Malaysia

The Kuala Selangor Nature Park (KSNP) is a highly modified mangrove forest site of approximately 320 hectares, situated 65 km. from Kuala Lumpur. The park was established in 1987 and, in accordance with an agreement with the State Government of Selangor, is managed by the Malayan Nature Society (MNS). The park was established with financial support from the state government. The park is currently gazetted as a public park under the Local Government Act (1976). The KSNP was established to promote the conservation of mangrove and mudflats which are of biodiverse significance and for the re-establishment of indigenous plant species that may have been lost due to human intervention. There is considerable public interest in the park which is a well-known area for the observation of mangroves, water birds and wildlife species such as the silver-leaf monkey. The site is of global importance for migratory birds as Kuala Selangor forms a link in the migratory chain across Southeast Asia for waders. There is potential for the introduction of a milky stork (a CITES I bird) population into the KSNP's extensive mangrove forest and adjoining muddy shoreline. The milky storks are known to have bred along the Selangor coast during the 1930s, but they are now extinct. In the 1980s, the National Zoo imported seven stork chicks. With a breeding base in hand and a potential managed release site at the KSNP, the National Zoo embarked on captive breeding of the milky stork with sponsorship from the Malaysian Wildlife Conservation Foundation. The captive management programme has been successful with forty-eight milky storks and about five chicks at the aviary as of September 1995 (the date of the last study).

A breakdown of the streams of development and maintenance costs from 1987 to 2000 are reported in the table below. The development costs were budgeted for in two phases. The first phase has been directed at the design and excavation of a lake (as a roosting site) and the construction of a sluice gate and pumping facility, the construction of walking trails, a boardwalk, a tower and hides for bird watching, and the construction of chalets and an office to facilitate visits by nature enthusiasts. The second phase of the development began in 1997 and is of significance to the conservation of biodiversity as long as the second phase of the milky stork programme takes place at KSNP. Investment in a breeding aviary, to transfer the zoo-bred storks to the site and breed a second (F2) generation, is planned. Another roofless enclosure adjacent to the second aviary also has to be built to facilitate the transfer of the F2 young. These costs were discounted to 1987. The total discounted expenditure needed to conserve and establish the KSNP is as follows:

Value of Development and Maintenance of Kuala Selangor Nature Park, 1987–2000

Item	Total Value
Capital	RM945,663 (US$378,265)
Salaries and wages	RM921,306 (US$368,523)
Maintenance	RM300,113 (US$120,045)
General costs such as bird food	RM1,229,931 (US$491,973)
Total expenditure	RM3,397,013 (US$1,358,806)

Source: Mohd Shahwahid H.O. (1995).

4

SINGAPORE

Priscilla M.L. Hon

The haze is not a new phenomenon for Southeast Asia or for Singapore. It has been a yearly occurrence since 1994, though it has varied in severity and duration. During that time, most people saw the haze as an inconvenience, and a "passing event", lasting for about a fortnight at the most. The 1997 haze, however, changed these perceptions. The haze stayed for more than two months, and occupied the headlines with both government and public attention.

Even though there had been signs since the middle of 1997 that the haze would spread throughout the region, the haze only made it to the front page of the Singapore *Straits Times* on 23 August 1997. The Pollutants Standard Index (PSI) levels stayed at 91 for three hours that day. Previously, there had been only scattered reports of the haze in the Singapore media. As the PSI level went up and visibility worsened for the next few weeks, media coverage intensified and the haze occupied headlines and top broadcast spots. By early November, the air-quality had improved significantly. On 22 November the Ministry of the Environment declared the haze over and Television Corporation of Singapore (TCS) ended its hourly broadcast of PSI levels. (See APPENDIX 4.1 for PSI readings for August–November 1997 and APPENDIX 4.2 for the Ministry of the Environment's Haze Action Plan.)

The news coverage of the haze within the Singapore media can be categorized into three broad themes:

- the cause, or responsibility for the haze;
- how governments, at regional and national levels, dealt with the haze; and
- the losses incurred.

The purpose of this chapter is to produce a preliminary estimate of the economic losses of the 1997 haze within two affected areas: health and tourism. The state of the public's health gave much greater cause for concern throughout the 1997 haze than it had done during a previous serious haze episode in 1994. The impact of the haze on tourism, a US$7.8/S$11 billion industry, also caused alarm. Valuations are presented in both Singapore and U.S. currencies using the pre-financial crisis exchange rate of US$1:S$1.4.

THE MEASUREMENT OF AIR POLLUTION

Singapore's Ministry of the Environment uses the Pollutants Standard Index (PSI) to measure haze levels.

The PSI is an index developed by the United States Environmental Protection Agency (USEPA) to provide accurate, timely, and easily understandable information about the daily levels of air pollution. The Ministry of the Environment says it monitors air quality in Singapore via a network of fifteen air-monitoring stations using a telemetric air quality monitoring and management system. The air pollutants measured are: sulphur dioxide, oxides of nitrogen, ozone, carbon monoxide, and particulate matter (soot, dust particles, etc.). The PSI converts the measured pollutant concentration in a community's air to a number on a scale of 0 to 500.[1] Persons with chronic heart and lung problems are advised not to engage in outdoor activities if the PSI exceeds 100. The index used in Singapore is slightly different from the Malaysian Air Pollutant Index (API; see TABLE 4.1) and this difference has caused some confusion in terms of comparison; though a quick look at the list of pollutants measured under the API system shows that the basic polluting gases measured are similar.[2]

There are several points to note about using the PSI as a gauge of pollution levels and effects:

- The PSI places maximum emphasis on acute health effects occurring over very short time periods — twenty-four hours or less — rather than chronic effects occurring over months or years.
- The PSI cannot be used as the sole method for ranking the relative

TABLE 4.1
Pollutants Standard Index versus Air Pollutant Index

Pollutants Standard Index	Air Pollutant Index
500	522
400	428
300	353
200	286
100	100
0	0

Note: At the time of writing (14 February 1998), the Malaysian government ministry is revising its Air Pollutant Index calculations. Not much change is expected, but the Singapore Ministry of the Environment says that it might be brought closer in line with the PSI standard.

health of different cities. The number of people actually exposed to air pollution needs to be considered, along with transportation patterns, industrial composition, and the representativeness of the monitoring sites.

- The PSI also does not specifically take into account the damage air pollutants can do to animals, vegetation, and certain materials like building surfaces and statues.
- The PSI does not take into account the possible adverse effects associated with combinations of pollutants (synergism).[3]

DATA SOURCES AND PROBLEMS

The main sources of data for this chapter are:

- Ministry of the Environment (Strategic Planning and Research Department);
- Ministry of Health (MOH);
- Ministry of Labour (MOL); and
- Singapore Tourism Board (STB).

Additional data and supplementary commentary and information are collated from reports in the *Straits Times*, Singapore's English language daily newspaper.

The main obstacle in this chapter is in the analysis of the data collected. For a damages study, the underlying assumption is the causal relationship between the haze, health, and tourism. While it is fairly easy to argue that there is an impact, the exact effects in terms of numbers and dollars and cents are harder to pinpoint.

The health data indicates a correlation between the PSI levels and the number of persons seeking medical treatment. However, there are no specific health ailments classified as haze-related. The list used in this chapter is best described as a list of medical conditions attributed to the haze. We must also consider that with increased press coverage of the haze and its health effects, the public are more alert to subtle symptoms that might have gone unnoticed and unreported in a "normal" year; or the possibility that people who were affected may not have sought treatment as they may have perceived their discomfort as temporary. This feedback loop makes the data collated complex to analyse.

For tourism, the regional currency crisis that hit late in 1997 has complicated efforts to evaluate the impact of the haze on the industry. It is difficult to say with any certainty that fall in tourist arrivals can be linked predominantly to the haze.

To overcome these complexities, several assumptions have been made in the following calculations to factor out other causes and effects. Verification can only be done with further research and study.

HEALTH

During the haze period (August–October), the twenty-four-hour PSI daily readings indicated that Singapore experienced fourteen days when the PSI was in the "unhealthy" range. The remaining days were considered "moderate", though in the later months, the PSI levels hovered closer to the "unhealthy" range, with PSI levels above the 80s. Although these readings seem rather mild, they are daily averages. There were days when the PSI level was in the unhealthy range during the day but dropped in the evenings.

According to the Ministry of Health (MOH), there is a correlation between the PSI levels and the number of patients with respiratory and other haze-related ailments. During the weeks when PSI levels increased, the number of people seeking treatment increased as well. However, independent interviews with medical practitioners indicate that it is often difficult to relate an illness directly to the haze. People react differently to various levels of pollution. Groups that are at greater risk are children and the elderly and those who already suffer from medical problems such as asthma, skin allergies, or chronic lung diseases.

The MOH also issued a press release advising the public on how to cope with haze-induced health problems (see APPENDIX 4.3).

For the purposes of this chapter and to reflect as accurately as possible the number of people seeking treatment for haze-related ailments (HRA), the medical conditions are divided into two categories, HRA1 and HRA2 (see TABLE 4.2). The HRA1 grouping covers the less serious health reaction to the haze. It is assumed that these cases would be handled predominantly at government clinics, or polyclinics, and by private general practitioners. The Accident & Emergency (A&E) departments in both private and public hospitals dealt with more serious haze-related medical matters. The HRA2 grouping covers these medical conditions.[4]

The valuation of haze-health damages during the period of study has been calculated by estimating the cost of illness (COI) incurred by society. The COI includes the "real" medical treatment costs, and the cost of wages lost (either by the individual or the paying employer). However, studies indicate that the COI does not fully reflect the loss incurred by the individual, who has to endure the discomfort caused by the illness as well a loss of income. For that purpose, present health cost estimations include a willingness to pay (WTP) factor. WTP is a monetary measure of what an individual is willing to pay (or forego in other goods and services) to avoid experiencing the health effect of the haze.

TABLE 4.2
Levels of Seriousness of Haze-Related Medical Conditions

Less serious haze-related ailments (HRA1)
— in accordance with polyclinic surveillance
- Conjunctivitis
- Acute upper respiratory tract infection (URTI), including URTI
- Allergic rhinitis
- Acute bronchitis
- Asthma
- Eczema, including contact dermatitis

More serious haze-related ailments (HRA2)
— in accordance with A&E surveillance
- Asthma, bronchitis, emphysema
- Pneumonia
- Acute conjunctivitis
- Acute myocardial infarct
- Other ischaemic heart diseases

TABLE 4.3
Attendance for HRA1 at Polyclinics

Month	Conjunctivitis	Acute URTI Including URTI	Allergic Rhinitis	Acute Bronchitis	Asthma	Enzema Including Contact Dermatitis
August 1996	1,529	39,295	394	229	3,249	2,680
September 1996	1,442	34,701	511	239	3,373	2,771
October 1996	2,264	41,742	516	269	3,562	2,769
Sub-total	5,233	115,738	1,421	737	10,184	8,220
August 1997	983	31,167	428	298	3,183	2,701
September 1997	1,693	38,209	638	607	4,507	3,078
October 1997	1,719	46,760	629	551	4,436	3,407
Sub-total	4,395	116,136	1,695	1,456	12,126	9,186

Source: Ministry of Health.

INCREMENTAL NUMBER OF OUT-PATIENT TREATMENTS

The incremental number of out-patient treatments is estimated by looking at the "excess" number of cases of HRA1 and HRA2 recorded during August–October 1997 and a "normal" period (TABLES 4.3 and 4.4). (For HRA1, the 1996 data is available; for HRA2, only 1995 figures are available. There is little reason to believe that the 1996 figures would vary by more than 3 to 5 per cent.) Adjustment was made to factor in public-private medical treatment and those who practised self-treatment.

TABLE 4.4
Estimated "Excess" Attendance at Polyclinics

	August–October 1996	August–October 1997	Excess
Conjunctivitis	5,233	4,395	(838)
Acute URTI including URTI	115,738	116,136	398
Allergic rhinitis	1,421	1,696	274
Acute bronchitis	737	1,456	719
Asthma	10,184	12,126	1,942
Enzema including contact dermatitis	8,220	9,186	966
Total "excess" at polyclinics			3,461

The estimated private-to-public out-patient treatment ratio is 4:1[5] So the adjusted "excess" cases of HRA1 treated is 17,305.

To estimate "excess" admissions during August–October 1997, a comparison has been made between reported haze-related illnesses in 1997 and the same period in 1995 (1996 figures were not available). The available data for 1995 is the average weekly rate per 10,000 total population and it is this data that has been used to estimate the total number of cases that would have been treated between August and October 1997 had the population of Singapore been unaffected by the haze (TABLES 4.5 and 4.6).

Assuming that the ratio of private:public A&E attendance is 0.2:1,[6] the estimated "excess" number of attendance for HRA2 at A&E centres is 8,909 (see TABLE 4.7).

TABLE 4.5
Estimated Attendance at A&E Departments

Condition	August	September	October	Total
Asthma, bronchitis, emphysema	1,776	2,374	2,075	6,225
Pneumonia	630	864	716	2,210
Acute conjunctivitis	234	268	207	709
Acute myocardial infarct	94	170	141	405
Other ischeamic heart diseases	555	719	501	1,775

Note: The above data covers 13 weeks, from 3 August to 2 November 1997. The hospitals included government and restructured hospitals.

Source: Ministry of Health.

TABLE 4.6
Estimated Excess Attendance at A&E Departments

Condition	1995	1997	Excess Admissions
Asthma, bronchitis, emphysema	1,989	6,225	4,236
Pneumonia	858	2,210	1,352
Acute conjunctivitis	273	709	436
Acute myocardial infarct			
Other ischeamic heart diseases	780	2,180	1,400
Total "excess" attendances at A&E departments			3,461

Note: The hospitals included government and restructured hospitals.

TABLE 4.7
Estimated Excess HRA1 + HRA2

"Excess" number seeking out-patient treatment HRA1	17,305
Adjusted "excess" number seeking self-treatment HRA2	8,653
"Excess" number seeking treatment (A&E) HRA1 + HRA2	8,909
Estimated number hospitalized	(445)
HRA1 + HRA2	34,867

ADJUSTMENT TO INCLUDE SELF-TREATMENT AND HOSPITALIZATION

Random interviews and past research have shown that there is often a proportion of those who suffer discomfort opting for self-treatment. Their reasons could be a lack of medical funds, the inconvenience of going for consultation, or personal preference for alternative treatment (either home-cures or traditional medicine).

For HRA1 cases, the factor ratio adopted is 3:2 (treated:self-treated).[7] For HRA2 cases, where the illness is more serious, the factor ratio for self-treatment is assumed to be negligible. However, these cases have a greater tendency to lead to hospitalization. The ratio of the number of people seeking treatment at A&E departments to the number hospitalized is 1:0.05.

TREATMENT COSTS (OUT-PATIENT/SELF-TREATMENT AND HOSPITALIZATION)

Medical fees for government clinics (polyclinics) are:

1. consultation
   - S$8.00 (US$5.70) for adults
   - S$4.00 (US$2.80) for children under eighteen years of age and adults over sixty-five
2. treatment
   - S$4.00 (US$2.80) for adults
   - S$2.00 (US$1.40) for children under eighteen years of age and adults over sixty-five
3. prescription charges
   - S$1.20 (US$0.85) per item per week up to a maximum of S$600 per week (for adults)
   - S$0.60 (US$0.42) per item per week up to a maximum of S$300 per week (for children under eighteen years of age and adults over sixty-five)
4. the estimate per visit consultation and medication for a general practitioner (GP) in private practice: S$20–S$50 (US14–US35).

For polyclinics there are subsidies for treatment and consultation costs. There is no subsidy for people who seek treatment from GPs in private practice. The chapter will take the value of private medical health care as the real health cost incurred. This will factor in the "shadow price" of public health treatment and consultation. For the purposes of estimating the "real" treatment costs, the range of S$20–S$50 (US$14–US$35) has been used. The same price range will be used for those seeking self-treatment.

Hospitalization charges are much higher than treatment and self-treatment costs. The estimated average range is S$100–S$250 (US$71–US$178) per day. This is dependent on the type of ward requested by the patient, along with the treatment costs incurred during the stay. The length of stay varies from three to five days.

The estimated range of treatment costs for haze-related ailments is S$830,840–S$2,299,600 or US$593,457–US$1,642,571 (TABLE 4.8).

TABLE 4.8
Estimated Treatment Costs for HRA1 + HRA2

	Lower Bound	Upper Bound
Out-patient/self-treatment cost	S$697,340	S$1,743,350
Hospitalization cost	S$133,500	S$ 556,250
Treatment cost	S$830,840 (US$593,457)	S$2,299,600 (US$1,642,571)

Note: The lower boundary for HRA1 and HRA2 assumes S$20 (US$14) as the treatment cost; the upper boundary uses S$50 (US$35). For hospitalization, lower boundary = number of patients × S$100 (US$71) × 3 days; upper boundary = 445 × S$250 (US$178) × 5 days.

ESTIMATED WORKDAYS LOST

The number of adults affected but untreated during the haze period will be used as a proxy for workdays lost (TABLE 4.9). This number includes those hospitalized. The estimated ratio of adults to children affected during the haze is taken as 1:1.[8]

A random survey shows that the number of days of medical leave given was usually two to four days, depending on the severity of the illness and the PSI level.

The workdays lost are taken as "income forgone", which is paid for either by the patient, if self-employed, or by the company concerned. Although there is an argument for a patient not taking all the days off from work, but returning to work after one or two days, the incurred costs remain as the patient is "willing to accept" the income to compensate for the health discomfort while at work.

The average (real) daily wage for Singaporeans in 1996 was esti-

TABLE 4.9
Estimated Workdays Lost

	No. Affected	Cost	
		Lower Bound	Upper Bound
Total no. affected by HRA1 + HRA2	34,867		
Of which, no. of adults	17,434	S$60 (US$x)/day x 2	S$100/day x 4
Value of workdays lost		S$2,092,020	S$6,973,400
Total no. hospitalized	445		
Of which, no. of adults	223	S$60/day x 3	S$100/day x 5
Value of workdays lost		S$40,050	S$111,250
Total value of workdays lost		S$2,132,070 (US$1,522,907)	S$7,084,650 (US$5,060,464)

mated to be S$60–S$100 (US$42–US$71).[9]

The estimated cost of workdays lost attributed to the haze is about S$2,132,070–S$7,084,650 (US$1,522,907–US$5,060,464).

ADJUSTED COST OF ILLNESS

Studies have shown that the COI has seriously underestimated "total" damage from an illness, as measured by an individual's willingness to pay (WTP) to avoid it. The ratio used to for WTP:COI is 2:1.[10]

The adjusted COI for the 1997 haze is estimated to be S$6–S$19 million or US$4–US$13.5 million (TABLE 4.10). As a percentage of Singapore's total annual health care costs (assuming them to be S$200 million), the adjusted COI is approximately 3 to 9 per cent of the health care costs of 1997.

TABLE 4.10
Adjusted Cost of Illness

	Lower Bound		Upper Bound	
	S$	US$	S$	US$
Treatment costs	830,840	593,457	2,299,600	1,642,571
Value of workdays lost	2,132,070	1,522,907	7,084,650	5,060,464
Cost of illness (COI)	2,962,910	2,116,364	9,384,250	6,703,036
Adjusted COI	5,925,820	4,232,729	18,768,500	13,406,071

DISCUSSION

The estimated adjusted COI attributed to the haze is a conservative one. It only accounts for the short-term direct costs incurred during the three-month study period. Other costs are incurred, such as reduced activity, loss of productivity, or the loss of enjoyment of outdoor activities. Also, it is difficult to calculate the cost of the general discomfort suffered by the public during the haze, even if the symptoms are not obvious: an aesthetically pleasing environment can affect an individual's well-being. If the importance of an aesthetically pleasing environment is recognized then it is possible that the reduced visibility and lower air quality brought by the haze would have some impact on an individual's mental state. These indirect and often intangible costs cannot be estimated using available data.

Yet, from the number of people shown to suffer from asthma, rhinitis, or inflammation of the lining of the nose in recent studies it is possible to argue that health costs incurred are higher than the initial short-term estimate suggests.

About 140,000 Singaporeans suffer from asthma and as many as 300,000 (more than 10 per cent of the population) suffer from chronic rhinitis. These conditions are particularly susceptible to changes in air pollution levels. The impacts on both of these medical conditions vary from mild discomfort that can be controlled through medication, to more serious effects that can affect an individual's day-to-day functioning and cause physical, social, and emotional problems. During periods of high PSI levels, such costs will increase, along with the amount of money spent on medication, and a greater number of medical check-ups.

What is also not reflected in the COI estimates are the long-term effects and costs for higher-risk groups such as asthmatics, pregnant women, the elderly, and very young children.

However, based on current estimations, and information on the cost of health care in Singapore, long-terms costs will be relatively heavy. For example, the cost of going to an A&E department now includes a flat fee of S$65 (US$46) over and above the cost of consultation and treatment. Also, while health costs are subsidized, the philosophy of health care in Singapore favours personal responsibility. In other words, in order to encourage the individual to be more responsible for his or her own health, cost burdens are slowly being shifted from the government to the individual.

The above assumptions and explanations warrant further research that would require more detailed data and perhaps even a contingent valuation method to find out what people are willing to pay to avoid the discomfort of the haze, or how much compensation they would need to accept the damages.

Apart from showing the complexities in deciphering the information at hand, this short-term study also highlights the basic questions and problems of establishing a methodology that can best provide an economic value for environmental health damages.

TOURISM

The tourism industry was severely affected by the haze. The worsening haze, coupled with constant media coverage, both local and foreign, on the environmental disaster kept overseas visitors away.

> This is something people will remember for a long time. They might even say in the future, "Don't go to Singapore or Southeast Asia at this time of the year." (Andrew Hirst, General Manager of the Oriental Hotel, quoted in the *Straits Times*, 15 November 1997)

In a recent press report, the Singapore Tourism Board (STB) indicated that in 1997, for the first time since 1983, visitor arrivals to Singapore fell. Arrivals for the year as a whole fell by 1.3 per cent. The crucial period was the fourth quarter of 1997, when arrivals fell by 14.4 per cent. The previous three quarters were on target for the year's forecast growth of 3 to 4 per cent. The Singapore tourism industry covers hotels, restaurants, tourist attractions, the retail sector, and transportation. In addition to these considerations, Singapore is actively promoted as a convention hub so business travel is a major component of the tourism industry's development plans.

TOURIST ARRIVALS[11]

Tourist arrival figures have been worrying for the STB. From August to October 1997, tourist arrivals fell from around 650,000 to just below 500,000. In August 1997, arrivals fell by 1.5 per cent compared with August 1996. September saw a slight correction as arrivals were up 2.8 per cent. October witnessed a drastic fall of 17.6 per cent against the previous year's figure. (The downward trend continued into November and December, registering falls of 10.6 and 15 per cent, respectively. The latter part of the year is usually Singapore's peak tourist season.)

TABLE 4.11
Estimated Tourist Arrivals

	1996	1997	% Change	1997†	% Difference
August	655,108	645,092	–1.5	678,037	–5.1
September	548,865	564,372	2.8	568,075	–0.7
October	600,912	495,327	–17.6	621,944	–25.6
Total	1,804,885	1,704,791	–5.5	1,868,056	–9.6

1997† = expected visitor arrivals in 1997 (1996 × 1.035).
% difference = the percentage difference between expected (1997†) and actual (1997) arrivals.

The differences are even greater between actual arrivals and expected arrivals for 1997. Taking an average of the 3 to 4 per cent growth forecast (TABLE 4.11), expected visitor arrivals for 1997 (1997†) are estimated at 3.5 per cent higher than arrivals for 1996. The estimates in the differences between expected and actual arrivals show a percentage fall of 9.6 for the three-month period.

However, the haze is not the only cause of change in tourist arrivals. This period of study is complicated as it coincided with the onset of the regional financial crisis. The crisis affected tourist arrivals to Singapore as well as visitors from neighbouring Asian countries who suspended travel in order to cope with the economic situation at home. We need to look into the various characteristics of tourist arrivals to attain a fuller picture of the impact of the haze. This could also provide some insight into the variables at work.

The main characteristics to observe when analysing the impact of the haze on tourist arrivals are:

- where the visitors are from and
- purpose of visit.

ARRIVALS BY REGION

The regional financial crisis has affected tourism within and to the region. To account for the effect of the financial crisis, total tourist arrivals can be sub-divided into ASEAN and non-ASEAN markets (TABLE 4.12). ("Non-ASEAN" refers to all countries other than ASEAN members.) As South Korea was hard hit by the crisis and people were encouraged not to travel, a "non-ASEAN–minus–South Korea" category is useful in the analysis. South Korea was the fifth-largest tourist-generating market for Singapore in 1996.

TABLE 4.12
Arrivals, by Region

	August 1997	% Change	September 1997	% Change	October 1997	% Change
Total	645,092	–1.5	564,372	2.8	495,327	–17.6
ASEAN	180,651	–0.4	179,086	8.4	166,312	–12.6
Non-ASEAN	463,441	–2.0	385,268	0.4	329,015	–19.9
Non-ASEAN minus South Korea	432,254	–1.0	368,026	1.0	315,391	–20.1

Note: The 1997 figures for ASEAN provided by the Singapore Tourism Board included Myanmar and the People's Democratic Republic of Laos from August onwards. For purposes of comparison, the 1996 figures for ASEAN have been adjusted accordingly, and the percentage change calculated using the adjusted figure.

Throughout the months of August to October there was a consistent fall in tourist arrivals. Compared with the previous year's arrival figures, August witnessed a slight dip, while October's decrease was more dramatic. September seems an aberration, especially with ASEAN arrivals increasing by 8.4 per cent in comparison with September 1996. However, it is possible to argue that the ASEAN arrivals were a result of even worse haze conditions outside Singapore. Tourist volume from Indonesia and Malaysia was greater during this month.

While separating the tourist-generating markets by region would in part control the "financial crisis factor", some insight into the tourist arrival trends can be gained by looking at the next set of indicators.

PURPOSE OF VISIT

Holiday-makers tend to pay more attention to aesthetics, the weather, and the environment of their destination, whereas business travellers tend to have other priorities. These factors need to be considered when examining tourist arrival figures for the period under study.

Another possible factor is the frequency of visit. First-time visitors, it can be argued, might be more susceptible to reports of environmental crises and health warnings, than those more familiar with the location.

For an indication of the affected pattern of tourist arrivals turn to TABLES 4.13, 4.14, and 4.15. The change in trends for total tourist arrivals for ASEAN, South Korea (to factor in the financial crisis), and

TABLE 4.13
Purpose and Frequency of Tourist Visits, August 1997

	ASEAN		
Characteristics	No.	%	% Change
Arrivals	180,651	100.00	–0.4
Purpose of visit			
Holiday	59,268	32.81	–14.7
Business	26,455	14.64	9.1
Business & pleasure	4,940	2.73	–4.7
In transit	17,449	9.66	–7.3
Visiting*	12,513	6.93	24.8
Conventions**	6,556	3.63	208.4
Education	1,364	0.76	5.5
Others	17,998	9.96	14.9
Not stated	34,108	18.88	
Frequency			
First visit	16,578	9.18	–34.2
Repeat visit	104,142	57.65	–16.6
Not stated	59,931	33.17	

	South Korea		
Characteristics	No.	%	% Change
Arrivals	32,187	100.00	–13.4
Purpose of visit			
Holiday	20,859	64.81	–27.1
Business	2,480	7.70	17.4
Business & pleasure	640	1.99	3.1
In transit	1,205	3.74	–6.0
Visiting*	749	2.33	5.9
Conventions**	478	1.49	167.0
Education	236	0.73	110.7
Others	806	2.50	–24.3
Not stated	4,734	14.71	
Frequency			
First visit	15,614	48.51	–34.6
Repeat visit	6,620	20.57	–34.8
Not stated	9,953	30.92	

	Major Non-ASEAN Markets		
Characteristics	No.	%	% Change
Arrivals	297,411	100.00	–3.7
Purpose of visit			
Holiday	175,813	59.11	–13.2
Business	41,746	14.04	18.1
Business & pleasure	6,925	2.33	–1.2
In transit	20,987	7.06	–0.5
Visiting*	15,348	5.16	39.5
Conventions**	4,850	1.63	276.6
Education	759	0.26	71.7
Others	3,944	1.33	–7.3
Not stated	27,039	9.08	
Frequency			
First visit	105,020	35.31	–27.2
Repeat visit	125,864	42.32	–8.9
Not stated	66,527	22.37	

	Other Non-ASEAN Markets		
Characteristics	No.	%	% Change
Arrivals	134,843	100.00	3.6
Purpose of visit			
Holiday	64,810	48.06	–1.1
Business	18,976	14.07	17.4
Business & pleasure	4,241	3.15	12.5
In transit	17,212	12.76	9.3
Visiting*	9,247	6.86	30.2
Conventions**	2,878	2.13	183.0
Education	996	0.74	17.6
Others	5,090	3.77	–1.3
Not stated	11,393	8.46	
Frequency			
First visit	54,759	40.61	–11.3
Repeat visit	56,864	42.17	–5.1
Not stated	23,220	17.22	

	Total		
Characteristics	No.	%	% Change
Arrivals	645,092	100.00	–1.5
Purpose of visit			
Holiday	320,750	49.72	–12.3
Business	89,657	13.90	15.6
Business & pleasure	16,746	2.60	1.4
In transit	56,853	8.81	0.2
Visiting*	37,857	5.87	32.9
Conventions**	14,762	2.29	221.0
Education	3,355	0.52	26.4
Others	27,838	4.32	9.0
Not stated	77,274	11.97	
Frequency			
First visit	191,971	29.76	–24.5
Repeat visit	293,490	45.50	–11.5
Not stated	159,631	24.74	

Note:
* visiting — friends, relatives
** conventions — include exhibition, company meeting, company-paid holiday

TABLE 4.14
Purpose and Frequency of Tourist Visits, September 1997

	ASEAN		
Characteristics	No.	%	% Change
Arrivals	179,086	100.00	8.4
Purpose of visit			
Holiday	49,987	27.91	–10.9
Business	28,102	15.69	4.3
Business & pleasure	5,036	2.81	–5.3
In transit	19,922	11.12	14.2
Visiting*	11,793	6.59	26.6
Conventions**	7,709	4.30	152.3
Education	1,261	0.70	12.5
Others	18,042	10.07	19.4
Not stated	37,234	20.81	
Frequency			
First visit	13,483	7.53	–37.4
Repeat visit	98,926	55.24	–14.2
Not stated	66,677	37.23	

	South Korea		
Characteristics	No.	%	% Change
Arrivals	17,260	100.00	–10.5
Purpose of visit			
Holiday	9,516	55.13	–26.6
Business	2,350	13.62	10.5
Business & pleasure	449	2.60	–13.8
In transit	886	5.13	2.3
Visiting*	404	2.34	–8.8
Conventions**	674	3.90	146.0
Education	273	1.58	83.2
Others	517	3.00	–1.5
Not stated	2,191	12.70	
Frequency			
First visit	7,474	43.30	–37.1
Repeat visit	4,315	25.00	–26.9
Not stated	5,471	31.70	

	Major Non-ASEAN Markets		
Characteristics	No.	%	% Change
Arrivals	258,337	100.00	0.3
Purpose of visit			
Holiday	137,926	53.39	–11.0
Business	48,615	18.82	16.1
Business & pleasure	7,165	2.77	–4.4
In transit	19,743	7.64	–1.6
Visiting*	11,187	4.33	41.0
Conventions**	6,725	2.60	353.5
Education	719	0.28	115.3
Others	3,085	1.19	4.8
Not stated	23,172	8.98	
Frequency			
First visit	84,503	32.71	–27.1
Repeat visit	110,197	42.66	–9.9
Not stated	63,637	24.63	

	Other Non-ASEAN Markets		
Characteristics	No.	%	% Change
Arrivals	109,689	100.00	0.9
Purpose of visit			
Holiday	41,299	37.65	–10.0
Business	22,881	20.86	18.7
Business & pleasure	4,326	3.94	4.5
In transit	14,473	13.19	–1.4
Visiting*	7,153	6.52	25.8
Conventions**	4,333	3.95	247.8
Education	922	0.84	18.2
Others	4,375	3.99	4.7
Not stated	9,927	9.06	
Frequency			
First visit	38,826	35.40	–21.8
Repeat visit	47,659	43.45	–9.1
Not stated	23,204	21.15	

	Total		
Characteristics	No.	%	% Change
Arrivals	564,372	100.00	2.8
Purpose of visit			
Holiday	238,728	42.30	–11.5
Business	101,948	18.06	13.5
Business & pleasure	16,976	3.01	–2.5
In transit	55,024	9.75	4.2
Visiting*	30,537	5.41	32.4
Conventions**	19,441	3.44	221.9
Education	3,175	0.56	34.9
Others	26,019	4.61	16.2
Not stated	72,524	12.86	
Frequency			
First visit	144,286	25.57	–27.2
Repeat visit	261,097	46.26	–11.5
Not stated	158,989	28.17	

Note:
* visiting — friends, relatives
** conventions — include exhibition, company meeting, company-paid holiday

TABLE 4.15
Purpose and Frequency of Tourist Visits, October 1997

	ASEAN		
Characteristics	No.	%	% Change
Arrivals	166,321	100.00	–12.6
Purpose of visit			
Holiday	43,505	26.16	–40.9
Business	27,212	16.36	–7.7
Business & pleasure	4,629	2.78	–16.5
In transit	16,339	9.82	–13.0
Visiting*	11,301	6.80	20.6
Conventions**	6,510	3.91	55.4
Education	1,059	0.64	–16.5
Others	17,277	10.39	8.3
Not stated	38,480	23.14	
Frequency			
First visit	11,637	7.00	–59.0
Repeat visit	89,176	53.62	–31.3
Not stated	65,499	39.38	

	South Korea		
Characteristics	No.	%	% Change
Arrivals	13,624	100.00	–47.6
Purpose of visit			
Holiday	6,660	48.88	–64.9
Business	2,404	17.65	–5.9
Business & pleasure	392	2.88	–38.8
In transit	888	6.52	–4.3
Visiting*	328	2.41	–12.3
Conventions**	676	4.96	101.8
Education	170	1.25	–25.1
Others	457	3.35	–33.9
Not stated	1,649	12.10	
Frequency			
First visit	5,915	43.42	–63.6
Repeat visit	3,570	26.20	–49.6
Not stated	4,139	30.38	

	Major Non-ASEAN Markets		
Characteristics	No.	%	% Change
Arrivals	204,408	100.00	–23.0
Purpose of visit			
Holiday	100,162	49.00	–36.6
Business	45,478	22.25	–3.5
Business & pleasure	6,675	3.27	–18.8
In transit	17,872	8.74	–13.7
Visiting*	10,229	5.00	33.9
Conventions**	5,115	2.50	127.1
Education	735	0.36	14.0
Others	2,800	1.37	–10.2
Not stated	15,342	8.98	
Frequency			
First visit	61,506	30.09	–47.5
Repeat visit	94,501	46.23	–24.7
Not stated	48,401	18.74	

	Other Non-ASEAN Markets		
Characteristics	No.	%	% Change
Arrivals	110,983	100.00	–8.3
Purpose of visit			
Holiday	39,572	35.66	–25.1
Business	23,058	20.78	3.9
Business & pleasure	4,626	4.17	–3.3
In transit	15,494	13.96	–3.3
Visiting*	7,214	6.50	22.0
Conventions**	3,606	3.25	122.7
Education	1,274	1.15	69.2
Others	4,855	4.37	8.3
Not stated	11,284	10.16	
Frequency			
First visit	39,101	35.23	–30.1
Repeat visit	46,877	42.24	–18.4
Not stated	25,005	22.53	

	Total		
Characteristics	No.	%	% Change
Arrivals	495,327	100.00	–17.6
Purpose of visit			
Holiday	189,899	38.34	–37.4
Business	98,152	19.82	–2.8
Business & pleasure	16,322	3.30	–14.7
In transit	50,593	10.21	–10.0
Visiting*	29,072	5.87	26.2
Conventions**	15,907	3.21	89.8
Education	3,238	0.65	12.7
Others	25,389	5.13	7.1
Not stated	66,755	13.47	
Frequency			
First visit	118,159	23.85	–45.6
Repeat visit	234,124	47.27	–26.5
Not stated	143,044	28.88	

Note:
* visiting — friends, relatives
** conventions — include exhibition, company meeting, company-paid holiday

the top tourist-generating markets for Singapore — Japan, Taiwan, United States, Australia, the United Kingdom, and Germany is demonstrated in these tables.

In general, there is a drop in holiday-makers and those who combine business and pleasure on their visits to Singapore. The same trend is noted for first-time visitors to Singapore. The drop in holiday-makers is particularly severe at the height of the haze in the months of September and October where the negative percentage differences with the previous year range from around 30 per cent to over 50 per cent.

People who arrive for conventions and exhibitions off-set the decrease in tourist arrivals. Tourism industry professionals argue that business arrivals were sustained throughout the haze because conventions and exhibitions are booked months — sometimes up to a year — in advance and to change the date and location would be too costly to the overseas businesses involved. Also, conventions and exhibitions are usually held indoors, so are less affected by environmental factors.

THE ECONOMIC VALUE OF LOSSES TO THE TOURISM INDUSTRY[12]

According to the most recent available STB figures, each tourist spends around S$726[13] (US$519) per visit. (The range of tourist spending is from S$532 for the China market to S$918 for South Africa.) This figure is an average of the spending habits of tourists from various countries, and is based on the average length of stay per visitor ——3.2 days. This expenditure includes hotel accommodation, shopping, and dining (TABLE 4.16).

There is little to suggest that individual tourist expenditure will increase significantly. In fact, the STB is concerned that expenditure per tourist has begun a downward trend. Also, the haze might induce a reduction in tourist spending at outdoor attractions, such as dining at Boat Quay and Clarke Quay, or at shopping locations that require leaving the hotel or an air-conditioned shopping mall.

In order to calculate the impact of the haze and factor out the effects of the regional financial crisis, revenue earned has been segmented by region (TABLES 4.17, 4.18, 4.19, and 4.20). Within each category the average tourist expenditure for each region varies. The average spending for the ASEAN market is S$808 (US$577), for the non-ASEAN market (including South Korea) average spending is S$713 (US$509), and average spending for the non-ASEAN–minus–South Korea market is S$670 (US$478).

TABLE 4.16
Estimated Tourist Expenditure/Revenue (total),
Taking S$726 (US$518) as the Average Expenditure/Revenue per Visit

	1996	1997	1997†	Profits Foregone
August	S$475,608,408 (US$339,720,291)	S$468,336,792 (US$334,526,280)	S$492,254,702 (US$351,610,501)	S$23,917,910 (US$17,084,221)
September	S$398,475,990 (US$284,625,707)	S$409,734,072 (US$292,667,194)	S$412,422,650 (US$294,587,607)	S$2,688,578 (US$1,920,412)
October	S$436,262,112 (US$311,615,794)	S$359,607,402 (US$256,862,430)	S$451,531,286 (US$322,522,347)	S$91,923,884 (US$65,659917)
Total	S$1,310,346,510 (US$935,961,792)	S$1,237,678,266 (US$884,055,904)	S$1,356,208,638 (US$968,720,455)	S$188,530,372 (US$134,664,551)

† Expected figures.

TABLE 4.17
Tourist Expenditure, Market-by-Market, August 1997

	Tourist Arrivals			Revenue		
				Actual	Expected	Foregone
	1996	1997	1997†	1997 (S$)	1997† (S$)	(S$)
Total	655,108	645,092	678,037	468,336,792	492,254,702	23,917,910
ASEAN	181,186*	180,651	187,528	145,966,008	151,522,624	5,556,616
Non-ASEAN	473,922	464,441	490,509	331,146,433	349,732,917	18,586,484
Non-ASEAN minus South Korea	436,772	432,254	452,059	289,610,180	302,879,530	13,269,350

† Expected figures.
* This figure is taken from the 1996 tourist arrival numbers of "ASEAN + Myanmar". The figure for Laos is not available for 1996.
Actual revenue = 1997 × S$726/808/713/670.
Expected revenue = (1997†) S$726/808/713/670.
Revenue forgone = expected revenue – actual revenue.

TABLE 4.18
Tourist Expenditure, Market-by-Market, September 1997

	Tourist Arrivals			Revenue		
				Actual	Expected	Foregone
	1996	1997	1997†	1997 (S$)	1997† (S$)	(S$)
Total	548,865	564,372	568,075	409,734,072	412,422,650	2,688,578
ASEAN	165,098*	179,086	170,876	144,701,488	138,067,808	(6,633,680)
Non-ASEAN	383,767	385,286	397,199	274,708,918	283,202,776	8,493,858
Non-ASEAN minus South Korea	364,481	368,026	377,238	246,577,420	252,749,349	6,171,929

† Expected figures.
* This figure is taken from the 1996 tourist arrival numbers of "ASEAN + Myanmar". The figure for Laos is not available for 1996.

TABLE 4.19
Tourist Expenditure, Market-by-Market, October 1997

	Tourist Arrivals			Revenue		
	1996	1997	1997†	Actual 1997 (S$)	Expected 1997† (S$)	Foregone (S$)
Total	600,912	495,327	621,944	359,607,402	451,351,286	91,923,884
ASEAN	190,294*	166,312	196,954	134,380,096	159,138,832	24,758,736
Non-ASEAN	410,618	329,015	424,990	234,587,695	303,017,606	68,429,911
Non-ASEAN minus South Korea	394,623	315,391	408,435	211,311,970	273,651,319	62,339,349

† Expected figures.
* This figure is taken from the 1996 tourist arrival numbers of “ASEAN + Myanmar”. The figure for Laos is not available for 1996.

TABLE 4.20
Tourist Expenditure/Revenue Foregone for the Non-ASEAN–Minus–South Korea Market

	S$	US$
August 1997	13,269,350	9,478,031
September 1997	6,171,929	4,408,485
October 1997	62,339,349	44,527,750
Total	81,780,628	58,414,267

The loss in revenue sustained by the tourist industry during the 1997 haze is estimated to be around S$81.8 million (US$58.4 million).

AFFECTED HOTEL OCCUPANCY

The impact on hotel occupancy is less noticeable. The biggest change occurred in October 1997. The most probable explanation is that the extent of the haze in September led to room cancellations for the October period. The occupancy rate dropped from 78.8 per cent in October 1996 to 67.3 per cent during the same month in 1997 (TABLES 4.21 and 4.22).

The estimated loss in profits for the above hotels is: S$2,245,000–S$2,225,000 (US$1,603,571–US$1,589,285). The hotel room rates were held at an average of S$150 (US$107) between January and December 1997 (*Straits Times*, 8 January 1998).

However, more than other tourism components, the financial crisis played a huge part in reduced hotel occupancy. Comdex Asia, an exhibition and conference on computer systems held in October 1997, was supposed to have drawn in 35,000 visitors. Nearly 10 per cent of the projected visitors failed to show up, but organizers blame Southeast Asian currency problems, not the haze (*Straits Times*, 15 November 1997).

OTHER AFFECTED TOURIST ATTRACTIONS

Outdoor tourist attractions bore the brunt of the haze impact. Newspaper surveys conducted with restaurants and pubs that feature outdoor dining demonstrated a drop in takings. The Chairperson of the Restaurant Association of Singapore reported that business had fallen by 30 per cent for some members (*Straits Times*, 15 November 1997).

Visitor arrivals to the Jurong Bird Park were affected. However, when

TABLE 4.21
Gazetted Hotel Supply and Demand

	Arrivals	% Change	Paid Lettings* No.	Paid Lettings* % Change	Average Occupancy Rate Standard %	Average Occupancy Rate Nominal %
1997						
August	645,092	–1.5	681	1.6	79.5	72.8
September	564,372	2.8	688	7.3	82.5	76.3
October	495,327	–17.6	625	–10.1	73.6	67.3
1996						
August	655,108	–4.8	670	–3.2	81.7	76.2
September	548,865	–5.9	641	–6.7	81	75.2
October	600,912	2.1	695	2.7	83.9	78.8

* Paid lettings are for each room-night.
Standard average occupancy rate = gross lettings/available room-nights.
Nominal average occupancy rate = paid lettings/maximum room-nights.

Source: Singapore Tourism Board (STB).

TABLE 4.22
Hotel Survey, September–October 1997

Hotel	Room-Nights Cancelled	Loss (S$)
ANA Hotel	2,000	400,000
Conrad International Centennial	700	175,000
Mandarin Hotel	150	30,000
Oriental Hotel	1,200	220,000–240,000
Pan Pacific Hotel	400	300,000
Phoenix Hotel	1,000	250,000
Royal Crowne Plaza Singapore	100	200,000
Shangri-La's Rasa Sentosa Resort	4,000	650,000
Four CDL hotels — Orchard, King's Habour View, Novotel Orchid Inn	Almost 2,000 in October alone	See *Straits Times*, 15 November 1997

* Paid lettings are for each room-night.
Standard average occupancy rate = gross lettings/available room-nights.
Nominal average occupancy rate = paid lettings/maximum room-nights.

contacted, the Bird Park declined to provide data. Sentosa island was also affected. The Sentosa Development Corporation also declined to comment on its affected business. The Singapore Zoo and Night Safari saw a drop in visitor arrivals of about 10 per cent. In a press report, the Zoo said that visitor attendance between April and October 1997 was around 800,000, compared with 843,000 during the same period the previous year. The Zoo held the haze and the currency crisis responsible for the reduced attendance (*Straits Times*, 9 December 1997).

AFFECTED FLIGHTS

Poor visibility, due to the haze, affected some flight operations. Singapore's airport, Changi, did not suspend its daily operations but carriers under the SIA group, Singapore Airlines and SilkAir, cancelled over eighty flights and additional flight delays brought the number of disruptions to over 120 (TABLE 4.23).

The losses suffered by these two carriers are estimated to be around S$9.7 million (US$6.9 million).

As with the other loss indicators, this is a conservative estimate based on an early damage study conducted by SIA and an estimation of SilkAir losses.

A large number of passengers cancelled their Singapore Airlines bookings because of the haze. In addition, between mid-September and mid-October, eleven flights were cancelled: these were bound for Penang (four), Kuching (two), Kuala Lumpur (four), and Brunei (one). According to Singapore Airlines, a decline in passenger loads was only de-

TABLE 4.23
Affected SilkAir Flights

Destination	No. of Delays (more than 15 minutes)	No. of Cancellations
Padang	6	17
Pekanbaru	20	42
Tioman	4	7
Medan	8	7
Langkawi	1	2
Kuantan	1	—
Hadtyai	2	—
Total	42	75

Total number of flight disruptions: 117

tected in the later part of September when the international media and foreign governments began issuing advisories discouraging travel to haze-affected countries.

A preliminary study conducted by SIA (covering late September through to the end of October) showed that over 14,000 passenger bookings were cancelled. This is based on information supplied by the airline's office, and mainly considers group cancellations (TABLE 4.24).

Northeast Asia accounted for 83 per cent of flight cancellations. Japan and Taiwan contributed 45 and 26 per cent of the cancellations, respectively. Europe accounted for 12 per cent, Hong Kong for 7 per cent, South Korea 5 per cent, and Germany 4 per cent.

Being a regional airline, SilkAir faced a greater number of flight cancellations than trans-continental carriers. However, figures for cancellation of passenger bookings could not be accessed, so for the purposes of this chapter, the costs incurred have been taken as losses due to cancelled flights alone.

SilkAir made efforts to minimize passenger inconvenience by offering assistance in re-booking and transfers. SilkAir also provided telephone hotlines for passengers to check the status of their flights before leaving for the airport. This service was operated daily during office hours. Over

TABLE 4.24
Passenger Books Cancelled Due to the Haze, 25 September–31 October 1997

Station	Pax no.	Station	Pax no.	Station	Pax no.
Japan	6,328	Frankfurt	610	Sydney	201
Taiwan	3,694	London	334	Melbourne	75
Hong Kong	968	Zurich	278	Johannesburg	42
Korea	682	Paris	219	New York	40
Guangzhou	61	Rome	72	Auckland	22
Sub-total	11,733	Amsterdam	69	Mauritius	16
		Brussels	64	San Francisco	16
Singapore	137	Athens	50	Perth	13
Jakarta	66	Helsinki	50	Delhi	12
Manila	22	Oslo	15	Sub-total	437
Kuala Lumpur	10	Manila	22		
Sub-total	235	Sub-total	1,761		
Total	14,166				

Source: Singapore Airlines, Public Relations Department.

and above these operating costs, other excess expenditure might include monetary compensation for additional transport back home for local customers, or for hotel accommodation and meals for overseas customers. These costs, and the proportion of local:foreign customers could not be attained at the time of writing (March 1998). See TABLE 4.25 for a short-term valuation (assuming that the estimated ticket price for a regional flight with SilkAir is about S$280 (US$200); the passenger capacity for a Boeing 737-300 mixed class is 128; the estimated passenger seat factor is 74.4 per cent; and the break-even load factor is estimated at 65.9 per cent.[14]

TABLE 4.25
Estimated Flight Disruptions and Costs Foregone

Estimated number of passengers affected by cancelled flights	7,125
Estimated revenue lost (in terms of passenger tickets)	S$1,995,000 (US$1,425,000)
Estimated profit forgone	S$680,295 (US$485,925)

These are estimations of profit forgone by flights due to the haze. It is possible that passengers were re-booked on other flights but this information is not available. In addition, there are insufficient details to estimate the losses incurred by the airlines and the value of passenger inconvenience as a result of flight delays. Delayed flights also incur fuel costs, payment for the use of airport space, runway usage, and extra air traffic operation costs.

It should be noted that while airlines have incurred nominal profit losses due to the disruption caused by the haze, some market analysts argue that there may not be any real costs incurred. Regional flights tend to run at a loss, hence cancellations might actually reduce airline losses. However, losses incurred by running regional flights may be treated as "loss leaders" by an airline, that is, a loss knowingly incurred in order to gain future customers, in this case, SIA's international flights, or customers in other tourist-related markets.

At present, we will take the nominal losses at face value so as to be consistent with the other country chapters in this book. According to SIA, the revenue lost to flight cancellations are conservatively estimated to be S$9 million (US$6.4 million).

DISCUSSION

The impact of the 1997 haze on Singapore's tourism industry was tremendous. The industry sees itself as being exceedingly sensitive and vulnerable to any changes in the environment — natural, political, and economic. Subsequent to the 1997 haze the STB embarked on expensive damage-control plans and publicity blitzes to woo tourists.

At the beginning of 1998 there was concern among STB officials that:

- the media would continue to produce negative reports regarding Singapore's environment and by doing so will counter tourist-promotion efforts;
- the region as whole will suffer from a fall in tourist arrivals; and
- the period August–October may be "branded" a "haze period", thus leading to a chronic seasonal slow-down in the industry.

The haze, compounded by the financial crisis, compelled the STB to revise its 1998 forecast. Visitor arrivals for 1998 are expected to fall by 8–10 per cent. The Tourism 21 target of 10 million tourist arrivals by the year 2000 has been set back by between four and five years. Hotel occupancy rates are also expected to fall, along with the 1997 S$150-per-room-per-night rate (US$107). The 1997 troubles dragged hotel occupancy rates down to 79.5 per cent compared with 82.2 per cent[15] in 1996.

Retail and food outlets and taxi-drivers (who complained of a fall in income during the haze period)[16] are other economic sectors that have been hit.

For affected airlines the greatest impact was felt in the area of the most profitable flights — international ones. The losses registered by SIA during the haze period are conservative indicators of the economic impact of the haze on commercial aviation.

Due to austerity measures put in place throughout ASEAN and South Korea, regional arrivals are not expected to be recover their pre-haze volume soon. Instead, Europe, North America, and Oceania are perceived as potential growth markets. However, I would argue that the correction may not be significant as these markets tend to be more aware of environmental legislation and problems, and are perhaps more sensitive to an environmental issue such as the haze. For example, a 1996 APEC Tourism Working Group survey, published as *Impediments to Tourism Growth in the APEC Region*,[17] identified pollution as the single greatest emerging problem in the APEC region. Environmental legislation was another issue that could affect the future growth of tourism in the region. Other concerns were air traffic congestion, overcrowding at major tourist attractions, and political uncertainty.[18]

CONCLUSION

This chapter concentrates mainly on the effects of the haze on health and tourism in Singapore. Based on early estimations, the economic loss caused by the haze is between S$110.5 million and S$97.5 million or between US$78.8 million and US$69.3 million (TABLE 4.26).

This value is three times the funds generated by Singapore's Community Chest[19] which serviced over fifty charities during the 1997/98 financial year.

The tourist industry suffered the heaviest financial losses, between 75 and 85 per cent of the total estimated loss. Airline losses take up almost 10 per cent. Health costs appear to be less, but they are still substantial in absolute terms.

Other costs have not yet been taken into account. These would include items such as spending on public education, maintaining hotlines, the operating cost of offering technical aid to Indonesia, and the public's increased usage of fans and air-conditioning in an attempt to reduce exposure to the haze. The Ministry of the Environment, the Land Transport Authority, and the Traffic Police also stepped up enforcement actions against smoky vehicles to try to reduce the amount of air pollution in Singapore. Businesses and industries that require outdoor labour face lower productivity figures, and even clean industries, such as wafer fabrication plants, are assumed to have incurred economic costs due to

TABLE 4.26
Total Economic Losses Incurred as a Result of the Haze

	Upper Bound (million)			Lower Bound (million)		
	S$	US$	% of Total	S$	US$	% of Total
Health	19.0	13.5	17.2	6.0	4.0	6.2
Tourism	81.8	58.4	74.0	81.8	58.4	83.9
Airlines*	9.7	6.9	8.8	9.7	6.9	9.9
Total	110.5	78.8	100	97.5	69.3	100

* Nominal losses.

the haze. However, such figures are not available for analysis at the time of writing (March 1998).

In addition, this chapter does not account for the cost of the oil spill that took place in mid-1997. Although the spill was not attributed to the haze — it took place on a non-hazy day — clean-up efforts were hampered by the subsequent high haze levels, thus increasing the cost of the spill's impact on the environment and the fishing industry (some shrimp farms along the Malaysian coast incurred extra spending on preventative measures against the spill).

Furthermore, assuming that the price of products, such as fish and vegetables, increase in Malaysia as a result of the haze, it could be argued that this price increase has been transferred to Singapore as Singapore imports several of its essential food products from Malaysia.

Essentially, it should be remembered that the economic costs incurred throughout the period of this study should not be taken in isolation. Economic interdependence between the countries affected by the haze is very high.

The valuations provided in this chapter are merely a preliminary estimate. More details and data need to be collated and collected to provide a fuller picture. However, as a preliminary study, this chapter hopes to show that the impact of the haze on Singapore was, and continues to be, substantial. If the losses discussed in the preceding paragraphs are included, the value of haze-related economic losses could possibly increase by a factor of 2.

For Singapore, there are no standing visual reminders of the haze to draw upon — no charred forests, no villages suffering from drought, no cracked agricultural land. Most of these devastating reminders of environmental disaster are found outside Singapore. Lack of physical evidence could give Singapore the impression that the haze is "someone else's problem". This attitude has made it fairly difficult to draw public and official attention to the issues at stake. Up until now. Today, Singaporeans exhibit a high level of concern regarding the haze and the threat of its return.

NOTES

1. The scale does not go beyond 500. When asked how an over-500 situation might be translated into PSI numbers, the USEPA suggested that the figure be extrapolated from the provided scale. The USEPA does not have any numbers for scenarios beyond 500 PSI.

2. The API measures fine particles below 10 microns and gases such as carbon monoxide, sulphur dioxide, nitrogen oxide, and ozone.
3. *EPA Measuring Air Quality: The Pollutant Standards Index*, Office of Air Quality Planning & Standards, United States Environmental Protection Agency (EPA 451/k-94-001), February 1994, pp. 6–7.
4. The list of medical conditions has been provided by the Ministry of Health.
5. There are around 900 private general practice clinics in Singapore. Assuming that each clinic treats an average of thirty patients a day, the ratio of the number of patients treated relative to the number of patients treated at public family health services (polyclinics) is 4:1.

   Also, according to the Ministry of Health, the public sector takes care of 20 per cent of primary health care, with the remaining 80 per cent undertaken by the private sector (source: www.gov.sg/health).
6. The ratio is derived from private-sector admission to public-sector hospital admission (source: www.singstat.gov.sg).
7. This ratio is taken from the chapter on "Malaysia" in this volume. The ratio is used to adjust for self-treated people in peninsular Malaysia.
8. Taken from the chapter on "Malaysia" in this volume.
9. The 1997 figure was not available at the time of writing. This calculation is based on the range of average monthly earnings compiled from the payroll of Central Provident Fund (CPF) contributors (source: Ministry of Labour's annual publication, *1996 Singapore Yearbook of Labour Statistics*). The statistics on average monthly earnings have been taken from the payroll of CPF contributors. The real monthly wage is S$2,185.71.
10. Source: *ADB Workbook* (1996) where the range of WTP:COI for asthma symptoms is (1.6–1.3):1. The average of 2:1 is used in this chapter. The chapter acknowledges that the WTP value does vary for the range of illnesses that can be attributed to the haze.
11. Data for this section was supplied by the Singapore Tourism Board unless otherwise stated.
12. All economic values stated here are in Singapore dollars.
13. The figure was provided by the Singapore Tourism Board; also available in *STB Annual Report 1995–1996*.
14. The price of the ticket is an average ticket price for all SilkAir flights in the region, in both high and low season. The passenger seat factor and break-even load factor estimations were taken from SIA's 1997/98 financial report.
15. Fact sheets on visitor arrivals for 1997 are available at: www.cybrary.com.sg/pages/fact/html.
16. Random survey.
17. *Impediments to Tourism Growth in the APEC Region*, prepared for APEC Tourism Working Group by Dain Simpson Associates (APEC Document #97-TO-01.2) (Singapore: APEC Secretariat, 1996).
18. The 1997 haze involved several of these issues. Pollution levels were high; there is concern over the form and substance of environmental legislation in the region, and particularly in ASEAN countries; and some analysts argue that environmental

strain could lead to political uncertainty. Thomas F. Homer-Dixon in "On the Threshold: Environmental Changes as Causes of Acute Conflict", *International Security* 16, no. 2 (Fall 1991): 76–116, argues that there is a causal link between environmental changes and acute conflict. "Environmental degradation may cause countless often subtle changes in developing societies."

19. The Community Chest is the fund-raising division of the National Council of Social Services (NCSS). There are over fifty charities registered under the NCSS, and they help more than 178,973 people.

APPENDIX 4.1
24-Hour Pollution Index Reading, August–November 1997

Aug.	PSI	Sept.	PSI	Oct.	PSI	Nov.	PSI
1	52	1	57	1	72	1	55
2	51	2	5	2	112	2	54
3	45	3	69	3	121	3	73
4	45	4	71	4	68	4	76
5	54	5	62	5	95	5	94
6	51	6	4	6	73	6	51
7	58	7	76	7	83	7	49
8	59	8	80	8	55	8	62
9	53	9	72	9	47	9	51
10	59	10	61	10	75	10	36
11	55	11	67	11	69	11	41
12	63	12	88	12	92	12	61
13	52	13	106	13	108	13	62
14	60	14	107	14	81	14	42
15	62	15	93	15	74	15	43
16	51	16	73	16	77	16	42
17	62	17	71	17	83	17	41
18	54	18	70	18	65	18	37
19	54	19	138	19	83	19	32
20	63	20	73	20	95	20	33
21	59	21	81	21	81		
22	63	22	56	22	93		
23	64	23	68	23	130		
24	51	24	117	24	144		
25	56	25	113	25	108		
26	59	26	89	26	83		
27	59	27	89	27	66		
28	60	28	130	28	85		
29	71	29	92	29	73		
30	59	30	68	30	54		
31	51			31	60		

Source: Strategic Planning and Research Department, Ministry of the Environment.

APPENDIX 4.2
Haze Action Plan

Index Value	PSI	General Health Effects	Cautionary Statements	Response Plan for 24-Hour PSI
Up to 50	Good	None for the general public	None required	—
51–100	Moderate	None for the general public	None required	—
101–200	Unhealthy	Mild aggravation of symptoms among susceptible people, with irritation symptoms in the healthy population	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activities; the general population should reduce vigorous outdoor activity	ENV will continue to inform the public on PSI and give health advisories; outdoor physical education lessons, sports, and games to be cancelled
201–300	Very unhealthy	Significant aggravation of symptoms and decreased tolerance for persons with heart or lung disease; widespread symptoms in the healthy population	Elderly people and people with existing heart or lung disease should stay indoors and reduce physical activity; the general population should avoid vigorous outdoor activity	Fuel-burning industries and vehicle fleet owners to cut down on emissions The public to avoid unnecessary travel
301–400	Hazardous	Early onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons	The elderly, children, and persons with existing diseases should stay indoors and avoid physical exertion; the general population should avoid unnecessary outdoor activity	MOE and Sports Council to consider closing schools and sports complexes
Over 400	Hazardous	PSI levels above 400 may be life-threatening to ill and elderly persons; healthy people experience adverse symptoms that affect normal activity	All persons should remain indoors keeping windows and doors closed and minimize physical exertion	Civil defence sirens will be sounded and the public will have to tune in to the radio for announcements on air quality and health advisories; the public will be forewarned of additional measures to be taken

Source: www.gov.sg/env/sprd/H-A-P.htm.

APPENDIX 4.3
The Health Effects of Haze

The health effects of haze are mainly caused by the irritant effects of fine dust particles on the nose, throat, airways, skin, and eyes. The health effects of the haze depend on its severity as measured by the Pollutants Standard Index (PSI). There is also individual variation regarding the ability to tolerate air pollution. Most people would at most experience sneezing, running nose, eye irritation, dry throat and dry cough from the pollutants. They are mild and pose no danger to the health of the general public.

However, persons with medical problems such as asthma, chronic lung disease, chronic sinusitis, and allergic skin conditions are likely to be more affected by the haze and they may experience more severe symptoms. Children and the elderly in general are more likely to be affected. For some, symptoms may worsen with physical activity.

For persons under medical treatment, it is important that they take their medication regularly. Persons with chronic heart and lung problems are advised not to engage in outdoor activities if the PSI level is above 100. There is otherwise no need to take extraordinary precautions.

What do you do when you have a haze-related illness?

The current haze-related health problems are generally mild and can be treated easily. Eye irritation may be relieved by applying normal saline eyedrops which can be purchased from any pharmacy or medicine shop. Persons wearing contact lenses who experience eye irritation are advised to discontinue wearing contact lenses temporarily. Mild sneezing, running nose, dry throat, and dry cough can be relieved by cold tablets or cough mixture, obtainable from any pharmacy where the pharmacist's advice can be sought.

Persons whose symptoms do not improve or have worsened should see their GP or go to a government polyclinic.

In the case of breathlessness or asthma, the public are advised to seek treatment from their GPs or government polyclinics. For most people, there is no need to seek treatment at the A&E clinics of hospitals. Polyclinics and most GP clinics are equipped to treat even the more severe patients. Nebulizer treatment for acute asthmatic attacks is available. In polyclinics, very sick patients, e.g., those with severe breathlessness are given top treatment priority. If necessary, the polyclinic will make arrangements for an ambulance to send the patient to hospital.

Treatment at government polyclinics is heavily subsidized. Those who require hospitalization but have financial difficulty can request for financial assistance. No one will be denied treatment because of inability to pay.

The Ministry is monitoring the situation closely. There has been a slight increase in attendance at government polyclinics since the haze problem started. The Ministry wishes to assure the public that most GP clinics and polyclinics have the necessary expertise and resources to deal with medical problems arising from the haze.

The Ministry will make available additional treatment facilities and deploy more staff in polyclinics if the attendance increases significantly and there is a need to do so.

Source: Press Release, Ministry of Health, 24 September 1997.

APPENDIX 4.4
A Walk in the Haze: A Nature-Lover's Observations

The picture was pretty gloomy, with the PSI at about 169. There was a distinct lack of buzz around the MacRitchie Nature Trail at the edge of the reservoir. All was quiet. Even the cicadas had fallen silent.

A flock of Bee-Eaters sailed through the air, and close to the golf course, I encountered a Grey-Faced Buzzard which at once flew into a tree for cover. But on the whole, up in the sky, no raptors were to be seen — no White-Bellied Fish-Eagles, or Brahminy Kites — as might have been expected on a normal day. Even their keen eyesight would have had a hard time piercing the haze to spot any prey. They must have been suffering from a shortage of food as a result.

The smog-shrouded reservoir itself looked like a postcard from some foreign wintry land. The water levels were drastically down, with mudflats unusually exposed. Together the forest, the animals and myself, we all seemed to share in an overwhelming sense of unease, our biological clocks awry, with the sun nothing more than a dull orange glow. These are sad times.

Source: Goh Si Guim, *Nature News* (Nature Society Singapore), November–December 1997, p. 10.

5

INDONESIA

Jack Ruitenbeek

The purpose of this chapter on Indonesia is to identify and evaluate the economic costs to Indonesia of the fires and haze that occurred during mid- and late-1997. International coverage of the haze showed marked effects on a number of countries in the region. Singapore's skies were obscured for months. Evacuations and company shutdowns were reported in Malaysia. Sporadic cases of respiratory illness and discomfort were reported in the Philippines, southern Vietnam, and eastern parts of India.[1] Indonesia, however, received the brunt of the impacts. Media reports tie the fire and haze episodes to a wide array of damages including poor health, loss of standing timber and croplands, loss of traditional livelihoods, airline accidents, and potential orangutan extinction. These impacts, coupled with the recent financial crisis, have placed an onerous burden on Indonesia, both in terms of preventing further damage and in dealing with the damage that has already been inflicted.

While the general impacts of the fires and haze have been described, few attempts have been made to document the quantitative physical extent of the damages. Those attempts that do exist have been fraught with uncertainty, being hampered by incomplete data collection, institutional capacity constraints, and inability to assess impacts given that some areas are in remote locations where life-threatening fires are still burning. Also, few attempts have been made to assess the economic value of these physical damages, even if the physical impacts can be quantified. Media reports often provided inconsistent economic estimates that, for example, at times reported impacts on gross sales while on other occasions reported net profits.

Information contained in this chapter relied on a wide variety of government of Indonesia (GOI) information sources as well as on expert judgment regarding economic conditions. Sources included, for example, the Ministry of Forests, Ministry of Agriculture, Ministry of Health, Ministry of Tourism, Ministry of Environment, the Environmental Impact Agency (BAPEDAL), the Disaster Handling Unit (SATKORLAK), the Directorate General of Air Transportation, provincial offices of the Bureau of Statistics (BPS), and Planning Ministry (BAPPENAS and BAPPEDA), and the Meteorological and Geophysics Agency. As described in this chapter, health damage estimates relied on work conducted by the World Bank in 1994 as well as on a modified dose-response function based on primary investigations conducted by Shahwahid and Othman (1998) in Malaysia. Estimates of area burned relied on work conducted by the European Union Forest Fire Response Group (EUFFRG; 1998), the GOI, and the National University of Singapore's Centre for Remote Imaging, Sensing and Processing (CRISP, in Liew 1998). In all cases, the analysis used "conservative" assumptions relating to physical and economic impact measures; the resultant figures are therefore regarded as lower bound estimates of damages actually incurred. Also, as noted in Chapter 1, some of the impacts — both of the fire and the haze — are not quantifiable, although they may still take a significant toll.

Given that the haze episodes occurred at the same time as the financial crisis, it was important to use a consistent basis for expressing economic data. In all cases, pre-crisis exchange rates, labour values, and productivity levels were assumed. For example, the relevant exchange rate used for Indonesia is Rp2,500 per U.S. dollar, and average labour productivity was assessed to be US$6 per day or Rp15,000 per day. The U.S. dollar estimates derived in this chapter, however, permit comparison to results in the other countries and to other benchmark indicators such as gross domestic product (GDP).

THE HEALTH EFFECTS OF THE HAZE IN INDONESIA

Data on the health effects of the haze in Indonesia are limited. The best available data on the intensity of haze is the Haze Index (HI) map (see the endpapers of this book) compiled by the National Aeronautics and

Space Administration (NASA). This map indicates that the worst pollution occurred mainly in Sumatra and Kalimantan. Accordingly, the analysis here focuses on those areas. Java (as well as other areas) are excluded from the assessment. The total population affected is estimated to be in the order of 50 million.

Some information is available on the number of reported cases of illness associated with the haze in major provinces, but it is largely anecdotal. Estimation of the likely number of cases is thus undertaken by transferring a dose-response function for Malaysia to Indonesia. The dose-response function was estimated in Shahwahid and Othman (1998) and directly links hospitalizations and clinic visits to an Air Pollution Index (API) through a cross-sectional analysis. One difficulty here is that the Malaysian indicator of air pollution is the API whereas the NASA map uses a cumulative HI. This chapter therefore also provides an analysis that permits matching the HI scale to the API, and then transferring the dose-response functions.

Estimation of health effects in Indonesia therefore consists of two steps:

- the creation of a dose-response function that permits translation of haze density into population affected and resultant morbidity and
- the estimation of economic costs associated with treating the affected population, as well as productivity and other losses from high incidence of morbidity.

STEP 1: DOSE-RESPONSE FRAMEWORK

Health impacts for Indonesia are estimated by transferring the results of regression analysis conducted in Malaysia to the Indonesian situation. The steps required in this process are:

- Review the regression results for Malaysia relating the total number of reported cases of conjunctivitis, asthma, and upper respiratory tract (URT) ailments to values for the API.
- Estimate the number of reported cases in the base situation.
- Match the categories in the API to categories/scores for the HI.
- Estimate the incremental number of reported cases per day per 10,000 population for each category shift in the API and HI.
- Estimate the total number of reported cases in each province in Indonesia, attributable to the haze, based on the province's population, HI score, and number of days of exposure during the haze episode.

Matching the API and Haze Indices

The API is a composite index divided into five different categories of impact ranging from Good to Hazardous. Each category is equivalent to 100 points. The calculated index value may exceed 500 points, thus it is possible to add a sixth category. The HI used in the map compiled by NASA indicates the cumulative amount of haze from the beginning of September to mid-November 1997. The scale ranges from 1 (low pollution) to 6 (very high pollution). A matching of the two indices is shown in TABLE 5.1.

TABLE 5.1
Matching the Air Pollution Index (API) and Haze Index (HI)

API Category Description	API Value	HI Category (score)
Good	0–50	1
Moderate	51–100	2
Unhealthy	101–200	3
Very unhealthy	201–300	4
Hazardous	301–500	5
Extremely hazardous	>500	6

Transfer of Dose-Response Functions

Although it is possible to match the two indexes, there are still difficulties in transferring the statistical results for Malaysia to Indonesia. From the map of haze intensity, it is apparent that Malaysia incurred up to only three categories of haze. The HI values for Malaysia were 1 or 2 for most areas. Only in the vicinity of Kuching (Sarawak) are the HI values higher, with an upper limit of 3.

For Indonesia, the HI categories cover the full range from 1 to 6. Many provinces in Indonesia have HI values of 4 and 5. The value of 6 is evident in only two relatively small areas in Central Kalimantan.

Given that the HI values (or equivalent API values or categories) for Malaysia cover such a small range, it is clear that dose-response relationships for Malaysia can be derived only for the lower end of the pollution scales. Extrapolations of the Malaysian regression results to higher levels of pollution are thus more speculative. It is not possible to tell, from the available data, whether the dose-response relationship is linear for the full range of HI values or whether it is non-linear. In the absence of better data, a linear relationship is assumed in this chapter.

Base Situation

The base situation is defined as the conditions that would apply "without" the additional atmospheric haze resulting from the forest fires. This does not imply completely "clean" air, as some pollution would have existed without the fires and a certain number of cases of respiratory disease (per unit of population) would occur. It is assumed that an API of 0–50 or a HI score of 1 represents the base situation.

The expected number of reported cases per day per 10,000 population in the base situation is drawn from the data for Johor. The minimum API is 31, while the maximum API is 128 and the mean daily API is 68. The number of reported cases per day per 10,000 population is 3.7. If this is reduced proportionally to an API of 50, the expected number of cases would be approximately three (i.e., 3.7 × 50/68).

The expected number of cases per 10,000 in the base situation could be higher in large metropolitan areas because of emissions from motor vehicles and other sources of pollution. This appears to be borne out by the higher total number of cases per 10,000 for Kuala Lumpur where the minimum, maximum, and mean daily API readings are all higher than for Johor. The number of cases per day per 10,000 in the base situation for Kuala Lumpur may be four persons rather than three, for example, but this can only be assumed and is not verifiable with the existing information.

Incremental Cases Resulting from Haze

The incremental number of cases resulting from haze can be estimated in two ways:

- Method 1: By considering the observed number of additional cases per day per 10,000 population calculated as the increase in the number of cases per day per 10,000 divided by the number of category shifts in the API (i.e., an average increment over the base case).
- Method 2: By predicting the additional number of cases per day per 10,000 from the dose-response coefficient in the regression equation linking the total number of cases per 10,000 to the API. The dose-response coefficient indicates the number of additional cases per day per 10,000 for each one-point increase in the API.

Method 1 produces the relationships shown in TABLE 5.2. The results suggest that a one-category shift in the API or HI will lead to approximately one additional case per day per 10,000 population. This

TABLE 5.2
Changes in Number of Cases Compared with Category Shifts

Location	Base Situation (no./10,000)	Estimated Total (no./10,000)	Additional Cases (no./10,000)	No. of Category Shifts in API	No. of Category Shifts in HI
Sarawak	3	4.89	1.89	2	2
Selangor	3	3.84	0.84	1	1
Kuala Lumpur	4	5.38	1.38	1	1
Johor	3	3.7	0.7	<1	1
Penang	3	5.04	2.04	1	1

relationship holds true for most of the locations investigated, although they do not follow this pattern for Penang.

The results from Method 2 are shown in TABLE 5.3. Note that each category shift in the API is equivalent to a change of 100 points, so the number of additional cases per day per 10,000 per category shift will be 100 multiplied by the regression coefficient. The dose-response coefficients vary from 0.0038 (i.e., 0.38 additional cases per day per 10,000 per category shift in API) for Penang to 0.022 (i.e., 2.2 additional cases per day per 10,000 per category shift in API) for Johor. It is interesting to note that the coefficient for Kuala Lumpur is 0.005 (i.e., 0.5 additional cases per day per 10,000). One might have expected the response rate to have been higher, because of synergistic effects of pollutants from the forest fires, reacting with emissions from motor vehicles and other sources. The estimate for Johor using Method 2 is much higher than the estimate for Johor using Method 1.

The transfer of Malaysian dose-response regression results to Indonesia thus enables estimates to be made for the expected additional number of cases resulting from the haze.

TABLE 5.3
Estimates of Additional Cases per 10,000 per Category Shift in the API

Location	Dose-Response Coefficient	Additional Cases per 10,000 per Category Shift in API
Sarawak	0.012	1.2
Selangor	0.012	1.2
Kuala Lumpur	0.008	0.8
Johor	0.022	2.2
Penang	0.0038	0.38

The method requires mapping of the HI zones against populations at risk. This was conducted using the NASA maps and district level population data for the areas affected by haze (see the annex to this chapter).

STEP 2: ESTIMATION OF HEALTH COSTS

Although the dose-response relationships used transfer functions from Malaysia, all other health cost and morbidity impacts for Indonesia have been estimated based on country-specific data. Much of these data were extrapolated from "transfer techniques" by using 1994 World Bank studies as a preliminary basis. The World Bank studies permitted disaggregation, for example, of hospitalized treatments from short-term respiratory treatments, and also permitted estimates of length of illness. Significantly, these estimates also provided detailed information on the number of people that may have "self-treated" as opposed to those "seen" at clinics. Finally, cost estimates based on surveys undertaken for the World Bank work were escalated to present-day terms (1997) to provide order-of-magnitude unit costs for treatment.

Specific costs for each area of Indonesia are shown in the annex to this chapter. In each case, the specific health impacts for Indonesia may be translated into estimates of health costs by means of the following steps:

- Estimate total medical costs based on data for the treatment cost per case and the estimated number of cases. Allow for unreported cases and self-treatment.
- Estimate the number of days of illness incurred, using data for the average length of illness per case.
- Estimate the number of productive days lost. This is informed by typical child:adult morbidity ratios in Indonesian clinics.
- Estimate total wages lost at current productivity levels. Allow for unreported cases.
- Calculate the total cost of treatment and lost wages.

A spreadsheet model was constructed to carry out these steps, and results are summarized in this chapter's annex. The following should be noted:

- The calculations performed refer only to the direct costs of health (i.e., medical costs and the value of lost wages) and do not include possible long-term health impacts.

- The number of days lost per case is assumed to be the same for self-treatment as for reported cases, and it is also assumed that all adult cases would involve employed persons (i.e., it would include housewives, retired persons, and the unemployed). This may overstate the productivity losses.
- No attempt has been made to estimate the effects on productivity of reduced work performance by those who remain employed but who do not become ill enough to be classified as "a case". This will lead to an understatement of the true costs. It may be that the overstatement and understatement of costs are self-cancelling. A more accurate assessment could be made only with a more detailed analysis.
- The literature on health impacts suggests that the willingness to pay to prevent adverse effects exceeds the direct costs by a factor of 2:1. This has been included as an additional estimate of lost consumer surplus.

RESULTS

The haze impact model results illustrate the following:

- A total population of 47.6 million fell within the analysed "haze zone", of which 12.2 million fell inside Haze Zone 1. This implies that 35.4 million people were subject to "above normal" levels of haze during the three months of the haze.
- Within this zone, an incremental 267,000 hospitalizations, 623,000 unhospitalized treatments, and 9.78 million self-treatment cases were estimated to occur. This results in a total of 11.6 million cases as a consequence of the haze.
- Workdays lost as a result of these cases are estimated to be 27.9 million workdays — approximately equivalent to 100,000 person years of employment.
- Total medical costs are estimated to be US$295 million, while productivity losses are estimated to be an additional US$167 million. An "indirect cost" of lost consumer surplus (associated with a WTP factor of 2:1) accounts for an additional US$462 million in costs.
- The total economic impact of the short-term health damages is US$924 million.

HAZE IMPACTS ON TOURISM LOSSES AND AIRPORT CLOSURES IN INDONESIA

Tourism is an important sector in all of the ASEAN economies. Moreover, economic losses associated with drops in tourism are often felt acutely throughout the economy. Businesses suffer, but employment also suffers. Tourism typically has one of the greatest employment:output ratios of any sector in the economy. As tourism declines, job losses escalate considerably. In the case of Indonesia, this chapter estimates both tourism losses and the impacts of airport closures. Results are summarized here, with detailed calculations shown in the annex to this chapter.

METHODS FOR ESTIMATING TOURISM LOSSES

The basic approach taken here is to start by estimating a projected number of (international) tourism visits "without" the fires and haze. This projection is used to estimate the number of visits that could have been expected during September to mid-November 1997 without the fires.

The average expenditure per tourist is then calculated from data on total tourism expenditure and the number of visits. This is applied to September, October, and November to estimate the expected expenditure during that period.

An assumption is then made about the percentage reduction in visits (hence gross expenditure) resulting from the forest fires. Elsewhere in the region, the reductions ranged from 10 to 30 per cent. While this can be transferred to Indonesia, a "High/Low" sensitivity range was established that corresponded to a minimum 30 per cent reduction in total visitors and a maximum 45 per cent reduction. This was then further adjusted to reflect that approximately half of these would have been ASEAN visitors who, because of the economic crisis, would have chosen not to come. As a consequence, the increment attributable to haze is a minimum 15 per cent reduction and a maximum 22.5 per cent reduction. Indeed, the reduction could be higher for some parts of Indonesia, as the HI scores reach higher levels than in Malaysia. But some reports indicated that tourists going to Indonesia simply changed their destinations within the country as a result of the haze; Bali, for example, was untouched by the haze and may have captured some of the tourists originally bound for other destinations. It must be understood that the main effect on potential tourists is one of perception — i.e., regardless of pollution levels, the existence of the phenomenon on a regional scale would be sufficient to cancel planned visits.

Losses in net returns are estimated on the assumption that producer margins in the tourism industry would be 20 per cent. However, considering that the episode is essentially short term, the real losses would be closer to the losses in gross rather than net revenue. The reason is that many costs (labour, hotel overheads, etc.) would still be borne, so the percentage loss to producers would be much greater than 20 per cent. It is only if factors of production displaced in an industry are able to find alternative employment (and hence make a contribution to GDP in other activities) that the normal 20 per cent margin would be relevant. For reporting purposes, however, here the impacts are shown to assume a 20 per cent margin. Again, this approach is likely to understate the total impacts.

Data Limitations

Only limited data were available to apply the above methodology. A confidential document to Cabinet contains information on monthly visits at seven airports from January 1994 to September 1997. While the seven airports would account for most of the visits to Indonesia, it is not clear what is meant by a "visit". The intent of the traveller is not recorded, and many visits may be for business rather than for tourism. Even if the numbers refer to "tourism" ticked on the entry cards, many visitors state that the purpose of their visit is tourism, to avoid possible complications associated with "business" visits.

A second uncertainty is what is covered by "tourism expenditure". Ministry of Tourism surveys suggest that average visitor expenditure is approximately US$1,250 but little information is available regarding the breakdown of these expenditures, or on the potential impact of the financial crisis on such expenditures. This gross expenditure level is, however, used as the basis for estimating tourism losses in this chapter.

Growth Calculations

A linear regression model is fitted to the time trend. Projected visits in September, October, and November 1997 are estimated using the regression equation. This suggests that without the fires 1,138,000 visits would have been made over the three-month period.

An alternative method is to estimate the average increment per month, from 290,000 to 401,000 from the column of observations. This suggests that 6,000 extra visitors would have been expected per month. This estimate is used to calculate the total expected number of visits for 1997 based on actual data for the months January–August with projected estimates (using the increment of 6,000 visits per month) for September–December. The method also indicates that 1,248,000 visits would have been made during September–November.

These two methods provide similar estimates — approximately 1.2 million visits during the haze period. For the purposes of reporting, the trend estimate is used, resulting in a base case forecast of 1.25 million visitors.

Results

The haze episode resulted in the following:

- between 187,000 and 281,000 visitor losses during the three-month period and
- economic losses of US$46.90–US$70.35 million (mean estimate US$58.63 million).

AIRPORT CLOSURES

Data from major airlines show that a total of 1,108 flights were cancelled in the period 1 August to 31 October 1997. Private, charter-basis DAS airlines suffered most, with 532 flights cancelled because of the haze. The second-highest number of flights cancelled were on the government-owned airline Garuda Indonesia, which had 412 flights cancelled. Accordingly, a total loss of US$7.54 million (Rp18.9 billion) was declared by major airlines in relation to haze problems in Indonesia (see TABLE 5.4).

It should be noted that two of the major airlines: Garuda Indonesia and Merpati Nusantara are either state-owned or state-controlled. Therefore, the public has to bear any such company losses.

In addition to the economic losses of major airlines, local airport authorities in Kalimantan, Sumatra, and Sulawesi also incurred losses. In Indonesia, the airport authority is managed by PT Angkasa Pura, a state-owned company. Airport closures affected its revenue. For example, local airports in Kalimantan lost US$0.56 million (Rp1.4 billion) due to flight cancellations; while in Sumatra losses were nearly US$0.2 million (Rp0.5 billion).

Some airports in the haze-affected regions also experienced losses because flights had to return to their initial base. According to the Directorate General of Air Transportation (DGAT), the losses related to return-to-base phenomena were about US$0.9 million (Rp2.3 billion).

TABLE 5.4
Flights Cancelled and Economic Losses by Airlines in Indonesia

Major Airlines	No. of Flights Cancelled	Losses	
		Rp Million	US$ Million
Mandala	164	2,826	1.13
DAS	532	1,283	0.51
Bouraq	n.a.	1,990	0.80
Garuda Indonesia	412	1,056	0.42
Sempati	n.a.	n.a.	n.a.
Merpati Nusantara	n.a.	10,698	4.28
Total	1,108	18,853	7.54

n.a. = Not available.

Source: Directorate General of Air Transportation, Indonesia, 1997.

The total of all such losses, for all areas, resulted in lost income to PT Angkasa Pura of nearly US$10 million (Rp25 billion).

AREA BURNED ESTIMATES

Data on area burned by the fires in Indonesia are among the most difficult to assess reliably. Accurate estimation of this area has been hampered by a number of factors. First, on-the-ground conditions have made ground-truthing difficult; remoteness and continued fires often make it inadvisable or costly to mount extensive surveys to verify estimates. Second, interpretation of remote imaging has been hampered by the complexities of image-processing. Third, local government authorities have often downplayed damages because government policies have themselves been cited as contributing to the fires. Finally, even though total areas may be estimated, estimating the specific types of land-use within these areas has been similarly problematic: few reliable land-use maps exist for many of these areas.

Nonetheless, many of the economic estimates rely on an accurate assessment of the areas burned. We here, therefore, provide a discussion of the various estimates, culminating with our own judgment and assumptions relating to areas affected.

GOI ESTIMATE — 263,992 HECTARES

The government of Indonesia (GOI) very rapidly provided a detailed breakdown of its estimate of land affected by the fires. By January 1998, the GOI had compiled extensive statistics of land affected, with an overall estimate that some quarter of a million hectares of forest were damaged. The areas excluded agricultural and other "non-forest" areas.

The GOI estimated that 163,000 hectares were in production forest, and the remaining 100,000 hectares were in some form of conservation forest; some of this conservation forest qualified for limited timber extraction. Vegetation types affected were calculated to be 21 per cent grassland or barren land, 24 per cent secondary forest, 24 per cent secondary forest and plantation, and 31 per cent industrial plantation forestry. Of the total, 54,000 hectares were in National Parks.

Distribution of the burned areas showed impacts on many of the major islands. While Kalimantan and Sumatra suffered most of the damage, the GOI estimated that 49,000 hectares were affected on Sulawesi, as well as 63,000 hectares on Maluku and Irian Jaya.

At the time of writing, no ground verification has been made of these areas.

EUFFRG ESTIMATE — >2 MILLION HECTARES

The European Union Forest Fire Response Group (EUFFRG) conducted a survey and estimate of land areas affected in mid-October 1997. Detailed studies were conducted on Sumatra and extrapolations to the rest of Indonesia were based on these studies. The studies were based on hot spot assessments from National Oceanic and Atmospheric Administration (NOAA) weather satellites, coarse resolution images from European Satellite Pour l'Observation de la Terra (SPOT), similar images from American Landsat satellites, and other interpretive products from the United States Forest Service, and the National Forest Inventory in Indonesia's Ministry of Forest.

Findings suggested that some 1 million hectares were scarred on Sumatra, and that considerable burns had occurred on Kalimantan, although no detailed survey was conducted for Kalimantan. EUFFRG estimated, through extrapolation, that the total area affected for Indonesia was in excess of 2 million hectares.

Forest area was estimated to comprise 15 per cent of this total. Actual land-use maps suggested that forest cover may be as high as 36.4 per cent, but ground-truthing suggested that many of these forest areas (as much as one-half) had already been converted to agriculture.

The EUFFRG noted that considerable burning was occurring in Irian Jaya, but no clear estimate of area burned could be made for this region.

SNU/CRISP ESTIMATE — 4.56 MILLION HECTARES

Detailed analyses of quicklook SPOT images permitted CRISP analysts (Liew et al. 1998) to complete a more comprehensive assessment of burn scars in Kalimantan and Sumatra. The work relied on the generation of two composite mosaic images — before and after the fires — through the use of 766 imagery scenes. Delineation of burn scars was done through visual inspection, and differentiation from cloud shadows and inland water masses. Land was also visually classified through the distinguishing characteristics of forest, agricultural, and other land types.

Results of the analysis suggest that 1.50 million hectares were affected on Sumatra, and 3.06 million hectares on Kalimantan. Of this, 20 per cent was estimated to be in forest, 50 per cent in agriculture, and 30 per cent in other land classes.

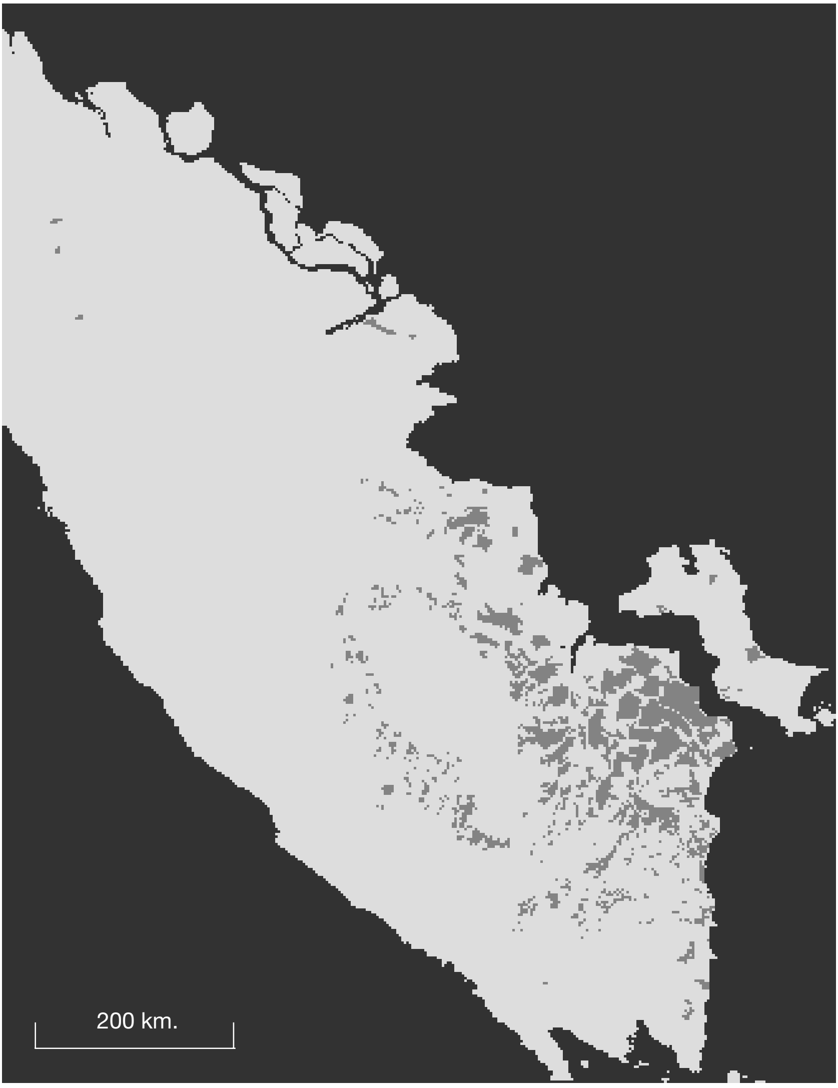
In addition, the work estimated greenhouse gas emissions from CO_2 and CH_4 assuming a burn factor of 50 per cent of dry biomass; in total, CO_2 release was estimated to be 90×10^{12} grams while CH_4 release was estimated to be 0.36×10^{12} grams.

EEPSEA/WWF ESTIMATE — 5 MILLION HECTARES

At this point in time (November 1998), the CRISP estimates are thought to be the most comprehensive assessment of fire damage to date. But lessons from the GOI and EUFFRG estimates also suggest that substantial tracts of land elsewhere in Indonesia were affected. Moreover, some of the limitations of the quicklook SPOT imagery — both in coverage and in resolution — suggest that the CRISP estimates represent the minimum level of scarring caused by fires.

For analytical purposes, therefore, this chapter assumes that a total of 5 million hectares was affected in Indonesia, distributed as follows among land-use classes: 20 per cent forest, 50 per cent agriculture/plantation, and 30 per cent other (unproductive). This implies that 1 million hectares of forest lands, and 2.5 million hectares of agricultural and plantation lands were burned.

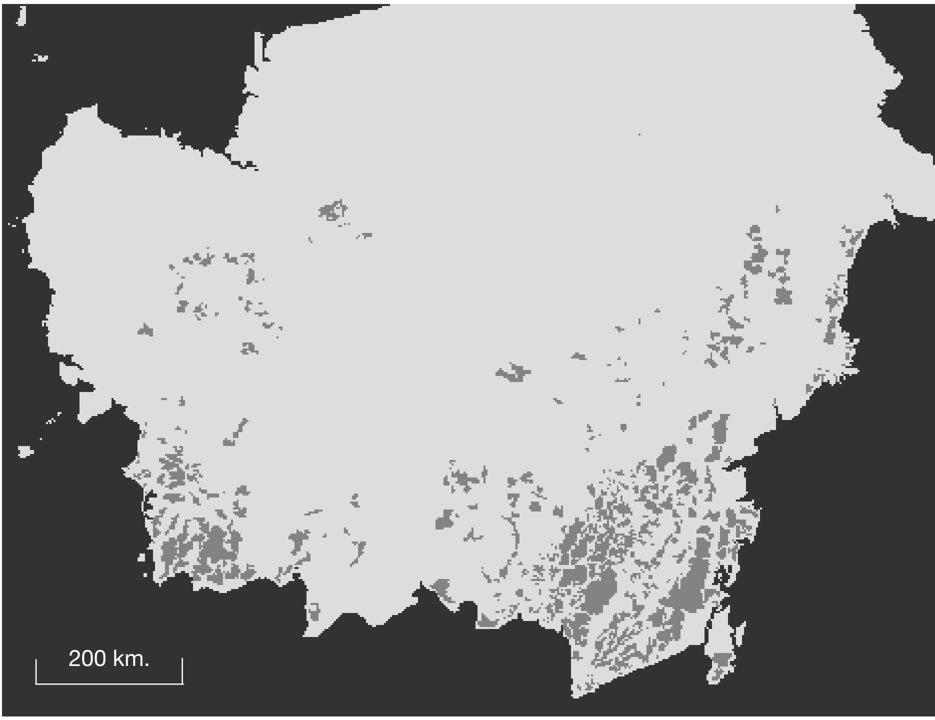
FIGURE 5.1
Map of Fire Burn Scars in Sumatra, Derived from the August–December 1997 SPOT Quicklook Mosiac (© 1998 IEEE)



FIGURES 5.1 and 5.2 represent CRISP's findings as of May 1998 and formed the basis of EEPSEA/WWF's valuation of fire damages. Subsequent refinements by CRISP — available only after this book had gone to press — include burn areas missed in the preliminary study; exclude some swamp areas that had been misclassified as burn scars; and include areas in Riau province that had been burned during early 1997. If these refinements are taken into account, the total burned area is about one million hectares more than the figure used in this book.

(These maps were produced by the Centre for Remote Imaging, Sensing and Processing [CRISP], National University of Singapore and were first published in Liew Soo Chin, Lim Oo Kaw, Kwoh Leong Keong, and Lim Hock, "A Study of the 1997 Forest Fires in South East Asia Using SPOT Quicklook Mosaics", *International Geoscience and Remote Sensing Symposium Proceedings* 2 (1998): 879–81. The co-operation of CRISP and the permission of the Institute of Electrical and Electronics Engineer (IEEE) to reproduce the maps are gratefully acknowledged.)

FIGURE 5.2
Map of Fire Burn Scars in Kalimantan, Derived from
the August–December 1997 SPOT Quicklook Mosaic (© 1998 IEEE)



METHODOLOGICAL IMPLICATIONS

In the economic valuations, it is noted that all forest lands are treated equivalently and, similarly, all agricultural and plantation lands are treated equivalently. To provide a comprehensive economic analysis, a detailed breakdown of individual land-uses would be required. Information currently available does not permit such a breakdown to be made. Land-use maps are, as noted by EUFFRG, typically out-dated and do not even remotely reflect "pre-fire" land-use because of recent conversion efforts. Estimates of forest land breakdowns from the GOI are taken from provincial averages and do not necessarily bear any relation to the areas actually affected by fires. Recent consolidation of smallholder lands into larger parcels, through purchases by larger firms, complicates the assessment of farm sizes or crop types. In brief, disaggregation to such "sub-unit" levels is not yet possible and attempts to do so based on current information are likely to result in inaccurate results with unknown biases.

For economic valuation, therefore, the following methodological assumptions are used to ensure consistency with the nature of the available land area information:

- Per unit economic values for forest and agricultural lands should represent "average" values for typical land-uses. For example, prices of timber should reflect typical timber prices, as opposed to those that might be obtained through high-grading of forest stands.
- Per unit production from forests and agricultural lands should represent average values. For example, stocking or inventory rates for forests should be averaged over a wide range of forest types, including low productivity forest scrublands. This implies that the inventory rates that appear in this chapter may be lower than those shown for typical commercial forest stands in the tropics.
- Forest land should be treated as a "multi-purpose" asset that is capable of concurrently providing a multitude of benefits if managed on a sustainable basis. This implies, for example, that an average hectare of forest land can concurrently support some level of sustainable timber production, while still also providing flows of other direct benefits (such as non-timber forest products), indirect services (such as erosion control), and climate control and biodiversity maintenance.

Analyses in the following section reflect these methodological requirements.

FIRE DAMAGE IN INDONESIA

TIMBER — US$494 MILLION

Timber values take into account estimates of average timber inventory and productivity by the GOI, as well as growth estimates of forests and net international prices. A net price of US$50 per cubic metre was used, consistent with GOI Ministry of Forest estimates. This corresponds to gross prices of approximately US$100 per cubic metre and a cost of cutting and transport of about US$50 per cubic metre.

Timber stocking rates differ throughout the country. Typical inventory rates for Kalimantan are 49 cubic metres per hectare in the >50 cm. age class and 74 cubic metres per hectare in the >20 cm. age class. For Sumatra, average stocking rates are 32 cubic metres per hectare in the >50 cm. age class and 53 cubic metres per hectare in the >20 cm. age class. Growth curves suggest that the immature (20–50 cm.) age class on average matures in approximately ten years to the harvestable (>50 cm.) age class.

For the purpose of this chapter, an average stocking rate was used, which is 40.5 cubic metres per hectare in the >50 cm. age class and 63.5 cubic metres per hectare in the >20 cm. age class. It was further assumed that the immature age class took ten years to grow into the mature age class, and that each cubic metre of immature wood thus had an equivalent physical value of 0.386 cubic metres of mature wood.[2] Using this procedure, a standardized commercial stocking rate of 49.37 cubic metres per hectare was derived for all forested lands.

It was further assumed that the cutting period of this "average" forest stand would occur over a twenty-five-year period. This is slightly less than the Indonesian standard rotation of thirty-five years, but reflects common practice to manage forests through cutting at somewhat accelerated rates. It is noted that under such assumptions, harvesting would be regarded as "sustainable" by most international standards and would thus permit continued provision of other forest direct and indirect benefits, such as provision of non-timber forest products (NTFPs), maintenance of biodiversity functions, and provision of important ecological services.

Under these conditions, the present (November 1998) value loss of timber resources is almost US$500 million.

It is noted that, as an independent verification, this procedure was cross-checked with an alternative estimation method based on land values and found to yield consistent results. The pricing and valuation model used for this chapter was benchmarked using the typical Kalimantan stocking rates (which are higher than the Indonesian average). The result of this procedure was that land values for forest of about US$1,200/hectare were estimated for Kalimantan. By comparison, GOI estimates (BAPEDAL, personal communication to the WWF; published in *Jakarta Post*, 21 April 1998) for commercial stock damage on Kalimantan in early 1998 (from 400,000 hectares of fires in January–April) resulted in gross implied land values averaging US$2,400 per hectare. Accounting for a 50 per cent margin for costs, this corresponds precisely to the land valuation of US$1,200 per hectare implied by the EEPSEA/WWF model estimates for Kalimantan.

AGRICULTURE — US$470 MILLION

Agricultural losses were estimated based on lost production in terms of years of output. Productivity values are assumed to be reflected in land values, which are taken to be at an average of US$1,000 per hectare. This average value is informed by a number of sources.

First, large-scale oil palm plantations typically have productive land values in the order of US$2,000–US$4,000 per hectare within the region (for Malaysia) and approximately US$1,000 per hectare for Indonesia. Increased investment in such land in Indonesia suggests that values will likely increase above current levels: closer to those in the rest of the region.

By contrast, smallholders are typically quoted as having land values of about US$400 per hectare (Indonesia Consortium, 1997). The 1997 fires have destroyed smallholder and transmigration lands, which are the most valuable assets for villagers to depend on. The land values may understate the effects, given that the smallholders mostly rely on these very lands for their daily lives, and loss of these lands may require them to relocate or incur additional expenses.

Finally, the estimate is consistent with forestry land value estimates. The EEPSEA/WWF model of forest values at average stocking rates implies a forest value of US$987 per hectare. The near equivalence of this to the agricultural values is what one would anticipate at the margin in an economic equilibrium (or for average values on large tracts of marginal lands such as many of those that were burned). If these two were grossly different, one would have expected either that all forest lands would have been cleared by now or that no clearing would be taking place at all.

The US$1,000 per hectare is therefore a judgemental average, used for analytical purposes, which is consistent with empirical observations. This land value translates into an annual net value of US$100 per hectare per year at a 10 per cent discount rate.

Next, the analysis assumes that, after burning, full agricultural productivity would be re-established in three years, with partial productivity being re-established in years one and two after the burns. This is consistent with the average productive cycles of mixed crops (combination of annuals and perennials and tree-crops). As a precise breakdown of damage to various land-use classes is unavailable, this figure may be open to future revision. If future assessments show that much of the area burned was mature pre-harvest plantation, then damages may be considerably higher. A sensitivity test that increased the recovery time to six years, for example, increased agricultural losses from US$470 million to US$754 million.

DIRECT FOREST ECOSYSTEM PRODUCTION — US$705 MILLION

In addition to timber, forests produce a wide variety of other direct and indirect benefits through tangible (though often unmarketed) goods and critical ecosystem services.

The approach taken here is to use a benefit transfer approach from average world values of tropical rain forest ecosystems, applying these only to the forest area in the sample (i.e., 1 million hectares). This is therefore a conservative estimate, but the resultant damages are large relative to estimates of timber or agriculture losses. The base estimates were derived from Costanza et al. (1997), escalated by 5 per cent a year from 1994 to 1997 (TABLE 5.5). Values for "culture" were removed from the Costanza estimates, as were values for "timber", climate control/regulation, and genetic resources to avoid double counting with other independent estimates conducted here. Specific direct uses valued in this procedure thus included food, raw materials, NTFPs, and recreation.

It was further assumed that the losses applied only to the area "effectively burned" of forest which, consistent with the "combustion factor" in the CRISP estimates, was 50 per cent of actual forested area.

A related part of this estimating procedure required an estimate of years of loss. For this analysis, it was assumed that NTFP and similar product production would be re-established (linearly) over a period of

TABLE 5.5
Ecosystem Production and Function Losses

Use or Function	Value (US$/hectare/year)
Direct use	530
Food, raw materials, non-timber forest products	401
Recreation	129
Indirect use	1,481
Disturbance regulation	5
Water supply/regulation	15
Erosion control	283
Soil formation	11
Nutrient cycling	1,067
Waste treatment	100

Source: Mean values taken from Costanza et al. (1997) for tropical forest systems, escalated by 5 per cent per year to obtain 1997 U.S. dollar equivalence.

five years. This reflects the idea that local users will likely place priority on other areas (timber and agriculture) before turning their attention to rehabilitating and using NTFPs and similar products.

INDIRECT FOREST ECOSYSTEM FUNCTIONS — US$1,077 MILLION

Indirect uses include functions of erosion control, disturbance regulation, water supply and regulation, soil formation, nutrient cycling, and waste treatment. Estimation of the value of these functions is generally methodologically more complicated than estimating the direct benefits.

For example, the short-run economic consequence of erosion damage is a decrease in agricultural productivity. Under a constant price, this will lead to a decline in the farmer's income. However, it is not so easy to assess how the soil erosion brought about by forest damage has affected crop productivity and farmers' income in most parts of the developing world. A fundamental difficulty is in generalizing the relationship between soil erosion and crop productivity because of the location-specific nature of soil erosion. The scale and heterogeneity of studies of the erosion-productivity relationship vary greatly. The range includes highly technical studies of physical processes of erosion and their effects on soil properties, small-scale test plot studies to estimate the effects on crop yields of varying amounts of erosion, and wide-ranging discussion of erosion policies. As erosion involves changes in the availability and relative concentration of nutrients for plant growth, and changes in soil structure, soil erosion will influence root growth and affect the availability of water.

For Indonesia, no major studies on future damages of forest fire and erosion-related productivity decline have been undertaken. Some information is available from soil erosion plots, but these refer to relatively minor soil losses occurring within plots under a range of crop treatments. Studies in several experimental sites of Indonesian upland areas show that the ultimate effect of erosion on yields differs by soil type, by crop, and by management practices. No major economic-policy efforts have been focused in the soil-productivity relationship.

As a consequence, a benefit transfer approach is again used to assess erosion and similar damages. As with the direct benefits described above, this estimate relied on international estimates summarized by Costanza et al. (1997).

For the purpose of these analyses, it was assumed that indirect functions would be re-established linearly over two years. This estimate of functional rehabilitation reflects average conditions; it is likely to result in an underestimate of damages in some severely burned parts, while in some areas it may overstate the damages. For example, flooding is likely to be above normal in 1998 because of the end of the El Niño cycle, but may well return to normal levels by 1999.

CAPTURABLE BIODIVERSITY — US$30 MILLION

The approach used here is to value "capturable biodioversity" from the GOI perspective. It is not the full international value of biodiversity. It does not reflect the intrinsic value of species whose extinction has been hastened; the potential value of ecotourism or internationally marketed pharmaceuticals; the human cultural diversity of indigenous forest-based cultures; or other benefits too difficult to value. Such additional losses would be shared by Indonesia and the rest of the world.

Amounts that have been paid for tropical biodiversity conservation vary considerably from country to country, falling into a range of US$30–US$3,000 per square km. per year for tropical moist forests (Ruitenbeek 1992; Costanza et al. 1997). The high values are generally reserved for small areas of high quality, while the lower values are generally associated with large areas of diverse habitats. In the case of the areas considered in this chapter, values would be anticipated to fall near the lower

TABLE 5.6
Financial Assistance and International Response to the Fires

Source	Description	Amount Rp Million	Amount US$
1. Domestic donors			
Ministry of Forestry	Cash and programme expenses	25,900	10,360,000
BPPT	Cloud seeding	2,353	941,200
Other agencies		913	365,200
Domestic sub-total		29,166	11,666,400
2. Foreign donors			
U.N. system			
• DHA	Dispatch of UNDAC team emergency grants	1,250	500,000
• UNICEF	Provision of 210 face masks	50	20,000
• WHO	Cash	500	200,000
	Provision of health adviser (3 months)*	75	30,000
OPEC	Cash through DHA	500	200,000
Governments			
• Australia	Cash	1,800	720,000
	Cash to provide a package of aerial water bombing	1,800	720,000
• Canada	Dispatched forest fire control specialists to assist the BAPPEDAL (environmental impact agency)	135	53,956
• Japan	Dispatched a six-member disaster relief team	362	145,193
	Provision of 300 portable fire extinguishers	368	147,372
	Cash contribution by Japanese embassy to Indonesia's Red Cross	188	75,000
• Republic of Korea	Cash	250	100,000
• United Kingdom	Cash through DHA	225	90,000
	Provision of one UNDAC team member (3 months)*	75	30,000
• United States	Cash to meet the immediate relief needs of victims of ongoing forest fires and drought, through DHA	63	25,000
• Russia	Two fire-fighter airplanes	800	320,000
• Malaysia	Dispatch of 1,257 fire-fighters to Sumatra and 196 fire-fighters to Kalimantan, plus medical personnel and instruments**	25,000	10,000,000
• Norway	Provision of one UNDAC team member (3 months)	75	30,000
• Switzerland	Provision of one UNDAC team member (3 months)*	75	30,000
• Sweden	Dispatch of fire-fighting/management expert (3 months)*	75	30,000
Foreign sub-total		33,666	13,466,521
Total		62,832	25,132,921

* Imputed values assuming deployment costs of expatriate staff at US$10,000 per month.
** Costs to Malaysia of RM25 million (US$10 million) are included here based on Shahwahid and Othman (1998).
BPPT = Agency for Technology Assessment and Application.
DHA = U.N. Department of Humanitarian Affairs.
UNICEF = United Nations International Children's Emergency Fund.
UNDAC = U.N. Disaster Assessment and Coordination.
OPEC = Organization of Petroleum-Exporting Countries.
WHO = World Health Organization.

Sources: Southeast Asia: Environmental Emergency DHA, *Geneva Situation Report* no. 54 (October 1997).

part of this range because of the large areas involved. For analyses undertaken here, it is assumed that values would be US$300 per square km. per year, which is applied in perpetuity to the entire area of forest, unadjusted for burn factors. The absence of this adjustment reflects the fact that people are generally not willing to pay half as much for a half burned area.

FIRE-FIGHTING — US$25 MILLION

Fire-fighting costs were borne through a collaborative effort between the Indonesian government and the international community (TABLE 5.6). Domestic financial assistance consisted mainly of support from the Ministry of Forestry and the Agency for Technology Assessment and Application (BPPT) in the form of cloud seeding. Foreign assistance from international organizations and foreign governments ranged from cash assistance to the dispatch of fire-fighting experts and instruments.

CARBON RELEASE — US$272 MILLION

Carbon dioxide and methane emission estimates in the CRISP study were increased by the ratio of total area burned (5 million hectares) to area assessed by CRISP (4.56 million hectares). Carbon shares within these were then calculated, based on a 12/44 ratio for CO_2 and a 12/16 ratio for CH_4. The net result is an estimated emission of 27.21 tonnes carbon, which corresponds to an emission of 99.77 tonnes carbon dioxide.

Such emissions increase global warming, which in turn is assumed to cause economic damage. Previous studies for the Intergovernmental Panel on Climate Change (Watson et al. 1996) have put a value of up to US$30 on the damage caused by a tonne of carbon emitted; figures up to this amount are commonly used in international negotiations. In this chapter, a conservative figure of US$10 per tonne carbon is used; this results in a cost of US$272 million to the global community.

SUMMARY

Short-term haze impacts resulted in over US$1 billion in damages (TABLE 5.7). This impact occurred during the three-month haze episode in 1997, and excludes long-term health-related losses. In addition, fire impacts resulted in more than US$3 billion in damages. No estimate is yet possible of the long-term consequences for investor confidence, or

TABLE 5.7
Summary of Indonesia's Haze and Fire Impacts, 1997

Impacts	Economic Costs (US$ million)
1. Haze impacts	
• Medical costs	294.70
• Productivity	167.30
• Indirect impacts	462.00
Sub-total of health impacts	924.00
• Tourism impacts (maximum)	70.35
• Airline impacts	7.54
• Airport closures	10.00
Sub-total of tourism/airline/airport impacts	87.89
Total haze impacts	1,011.89
2. Fire impacts	
• Timber losses	493.67
• Agriculture/plantation losses	470.39
• Direct forest ecosystem production losses	704.97
• Indirect forest ecosystem function losses	1,077.09
• Domestic (capturable) biodiversity losses	30.00
• Fire-fighting costs	11.67
Sub-total of impacts on Indonesia	2,787.79
• Carbon release	272.10
• Global biodiversity losses	not estimated
• Fire-fighting costs	13.46
Sub-total of global impacts	285.56
Total fire impacts	3,073.36
Total overall impacts	4,085.25

the tourism trade. It is conceivable that inclusion of these losses would increase the total costs by an order of magnitude.

Total haze and fire impacts thus exceed US$4 billion. How do these losses relate to other economic factors in the country? The following comparisons place these losses in perspective:

- It takes about US$25 per capita to provide basic sanitation, water, and sewer service to the rural poor. US$1 billion could thus provide basic services to 40 million people. US$3 billion could thus provide basic services to 120 million people, or all of the "rural poor" in Indonesia.

- It takes about US$30,000 to provide basic levels of village sanitation, water, and health infrastructure. US$4 billion could therefore be distributed to over 100,000 rural villages or *kampung*.
- Public spending on health in Indonesia is about US$1.5 billion annually, or about 0.7 per cent of its GDP. Private spending on health in Indonesia is about US$1.7 billion annually, or about 0.8 per cent of GDP. Total fire damages are equivalent to total annual health spending by both the private and public sectors.
- The economic losses from the haze are equivalent to about 0.5 per cent of the annual GDP.
- The economic losses from fire are equivalent to about 1.5 per cent of the annual GDP.

NOTES

1. Full reports for Singapore and Malaysia are detailed in Chapters 2 and 3. Analyses by Francisco (1998) for the Philippines suggest that while there were some documented complaints of respiratory illness, no incremental economic damage costs could be identified. Reports in Vietnam and India were not pursued because in both instances they involved under 1,000 people and haze maps prepared for this chapter suggested that haze levels in those areas were little different from historical norms.
2. This procedure involves a physical discounting of future quantities to arrive at a present value equivalent of future volumes. In this case, a ten-year discounting at 10 per cent per year discount rate provides a multiplier of 0.386.

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APPENDIX 5.1
Indonesia's Haze Model Results

The summary sheets include model results for the base case analysis of haze damages in Indonesia. The model consists of the following three sets of worksheets.

Worksheet set 1 — summary assumptions and output

This sheet summarizes main model parameters and outcomes. Reference haze level and admissions are derived as described in the text of this chapter. Dose-response coefficients are taken from Shahwahid and Othman, normalized for the HI:API transfer function as described in this chapter. All ratios for self-treatment and duration of stays are taken from the World Bank (1994). Unit costs for treatment are taken from the World Bank (1994), escalated to 1997. The average wage rate is taken as US$6 (Rp15,000) per day, consistent with average productivity in rural Indonesia. This wage rate, as well as the exchange rate of US$1:Rp2,500 are used as pre-economic-crisis parameters. The tourism submodel assumptions are consistent with those described in the chapter's main text.

Worksheet set 2 — population impacts

This section of the model shows a district-by-district enumeration of population and damages. It was created by overlaying the NOAA maps with a map of Indonesian district boundaries using Geographic Information System (GIS) overlay techniques. Inspection of the sheets will show that some districts fall in multiple haze zones, in which cases it was assumed that the proportion of the population falling within each zone was proportional to the areas of the relevant polygons. A manual audit of the GIS overlays was undertaken and errors were subsequently estimated to be less than 1 per cent of total populations. Upon assignation of each district's population to various Haze Index zones, the dose-response coefficient is applied to that population base and the sheet shows incremental morbidity, costs, productivity losses, and other indicators for each district. The last sheets show the summary impacts for each Haze Zone, which are also repeated on the main summary sheet.

Worksheet set 3 — tourism impacts

The final sheet shows historical data on visitors as well as linear regression and trend analysis of these data to project "baseline" visitors (in the absence of haze) for the September–November 1997 period.

WORKSHEET SET 1
Summary Assumptions and Output

Indonesia Haze Model - 1997 Damage Estimates (Health & Tourism)

SUMMARY (million USD)			
Medical Costs	$ 294.70		29.5%
Lost Productivity Costs	$ 167.30		16.7%
Indirect Costs (WTP increment)	$ 462.00		46.2%
Sub-total Medical		$ 924.00	92.4%
Average Tourism Losses (mean of range)	$ 58.63		5.9%
Airline Reported Losses	$ 7.54		0.8%
Airport Closures	$ 10.00		1.0%
Sub-total Tourism		$ 76.17	7.6%
Total Haze Damages		$ 1,000.17	100.0%

Health Submodel	INPUT	OUTPUT	KEY RESULTS	
Reference Haze Level (ID)	1			
Reference Admissions (cases/haze-day/10,000 population)	3.00		Population Affected	47,632,205
DR Coefficient 'Patients Reported Seen' (#/Unit Shift in ID Level)	1.00		Hospitalizations	266,698
- note (implied DR/API equivalent) within ID 1		0.020	Unhospitalized Treatments	622,295
- note (implied DR/API equivalent) within ID 2		0.020	Self-treatments	9,778,926
- note (implied DR/API equivalent) within ID 3		0.010	Total Cases	11,556,912
- note (implied DR/API equivalent) within ID 4		0.010	Work-days Lost	27,883,274
- note (implied DR/API equivalent) within ID 5		0.005	Medical Costs	$ 294.70
Exposure Period (days)	91		Lost Productivity Impacts	$ 167.30
Ratio of Reported Cases Requiring Long-Term Hospitalization	30%		Total Direct Costs	$ 462.00
Ratio of Self-treated to Reported Cases	11.0			
Duration of Stay for Hospitalized Cases (days)	10		Total WTP Adjusted Costs	$ 924.00
Duration of Incident for Unhospitalized Cases (days)	5			
Duration of Incident for Self-treated Cases (days)	5		Total Costs/Population	$ 19.40
Proportion of Cases as Adults	51%			
Cost of Hospitalization (entire incident) US$	$ 325.00	Rp812,500		
Cost of Unhospitalized Treatment (entire incident) US$	$ 20.00	Rp50,000		
Cost of Self-Treatment (entire incident) US$	$ 20.00	Rp50,000		
Average Wage Rate (Rp/day)	Rp15,000	$ 6.00		
Normal Pre-crisis Exchange Rate (Rp/US$)	2,500			
WTP Factor	2.00			

DETAILED RESULTS

	Population	Total Cases	Med Costs	Wages	Total	Adj COI
			Rp million			
Zone ID1	12,189,039	0	0	0	0	0
Zone ID2	5,584,758	660,677	42,118	23,910	66,028	132,057
Zone ID3	8,160,785	1,930,842	123,091	69,878	192,969	385,938
Zone ID4	11,121,072	3,946,868	251,613	142,839	394,452	788,903
Zone ID5	10,460,731	4,950,018	315,564	179,143	494,707	989,413
Zone ID6	115,820	68,508	4,367	2,479	6,847	13,693
TOTAL INDONESIA	47,632,205	11,556,912	736,753	418,249	1,155,002	2,310,005

			US$ million			
			Med Costs	Wages	Total	Adj COI
Zone ID1			0.00	0.00	0.00	0.00
Zone ID2			16.85	9.56	26.41	52.82
Zone ID3			49.24	27.95	77.19	154.38
Zone ID4			100.65	57.14	157.78	315.56
Zone ID5			126.23	71.66	197.88	395.77
Zone ID6			1.75	0.99	2.74	5.48
TOTAL INDONESIA			294.70	167.30	462.00	924.00

Tourism Submodel

Tourism Submodel	INPUT	OUTPUT	KEY RESULTS			
Normal Pre-crisis Exchange Rate (Rp/US$)		2,500				
Estimation Method Used (1=Trend;2=Regression)	*1*				Minimum Visitor Losses	187,200
1997 3-month Visitor Forecast by Trend		1,248,000			Maximum Visitor Losses	280,800
Tour Operator Profit Margins	*20%*					
Minimum Visitor Loss from Haze - Unadjusted	*30%*				Minimum Tourism Losses	$ 46.90
Maximum Visitor Loss from Haze - Unadjusted	*45%*				Maximum Tourism Losses	$ 70.35
Visitor Loss Adjustment - Proportion ASEAN Related to Ec Crisis*	*50%*				Airline Losses	$ 7.54
Minimum Visitor Loss from Haze - Adjusted		15%			Airport Losses	$ 10.00
Maximum Visitor Loss from Haze - Adjusted		23%				
Declared Airline Losses (manual) Rp million	*Rp18,853*	$ 7,541,200			Minimum Total Losses	$ 64.44
PT Angkasa Pura Losses (Airport Closings) Rp million	*Rp25,000*	$ 10,000,000			Maximum Total Losses	$ 87.89

* This corresponds to the proportion of losses that are attributable to Economic crisis; as a proxy one can use proportion of ASEAN visitors.

This model is a 'working model' with inputs from WWF Indonesia, David James, and Jack Ruitenbeek.

Version 16-February-1998.

WORKSHEET SET 2
Population Impacts

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	*Population*	*People_affected*	*Haze Index*	*Base*	No HI	Cases/day	Total Cases
			Category	*HI*	Categories	per 10,000	per day
			Score	*Score*	Over Base	in Base	in Base
District				1		3.00	
Aceh Selatan	395,992	166,973	1	1	0	3	50
Aceh Tenggara	209,458	11,497	1	1	0	3	3
Aceh Timur	627,708	72,353	1	1	0	3	22
Asahan	918,332	537,452	1	1	0	3	161
Berau	97,409	85,547	1	1	0	3	26
Bulongan	291,573	177,023	1	1	0	3	53
Dairi	288,902	288,902	1	1	0	3	87
Deli Serdang	1,698,209	1,698,209	1	1	0	3	509
Karo	269,509	258,235	1	1	0	3	77
Kepulauan Riau	495,654	52,634	1	1	0	3	16
Kodya Bandar Lampung	651,968	651,968	1	1	0	3	196
Kodya Binjai	182,728	182,728	1	1	0	3	55
Kodya Medan	1,628,946	1,628,946	1	1	0	3	489
Kodya Pematang Siantar	210,038	210,038	1	1	0	3	63
Kodya Sibolga	74,479	74,479	1	1	0	3	22
Kodya Tanjung Balai	15,737	1,120	1	1	0	3	0
Kodya Tebing Tinggi	115,356	115,356	1	1	0	3	35
Kutai	716,854	52,699	1	1	0	3	16
Lampung Barat	347,407	130,580	1	1	0	3	39
Lampung Selatan	1,886,907	1,791,579	1	1	0	3	537
Lampung Tengah	1,971,881	1,336,238	1	1	0	3	401
Lampung Utara	1,643,122	23,176	1	1	0	3	7
Langkat	854,877	707,245	1	1	0	3	212
Nias	573,714	441,032	1	1	0	3	132
Simalungun	840,138	840,138	1	1	0	3	252
Tapanuli Tengah	344,854	247,198	1	1	0	3	74
Tapanuli Utara	710,709	405,694	1	1	0	3	122
Sub_Total_ID_1							
Asahan	918,332	378,664	2	1	1	3	114
Bengkalis	1,096,376	27,428	2	1	1	3	8
Bengkulu Selatan	355,384	43,023	2	1	1	3	13
Berau	97,409	11,862	2	1	1	3	4
Bulongan	291,573	40,543	2	1	1	3	12
Kapuas Hulu	179,859	11,039	2	1	1	3	3
Kepulauan Riau	495,654	306,684	2	1	1	3	92
Kodya Batam	199,069	199,069	2	1	1	3	60
Kodya Samarinda	448,547	359,904	2	1	1	3	108
Kodya Tanjung Balai	15,737	14,611	2	1	1	3	4
Kota Baru	377,345	12,051	2	1	1	3	4
Kutai	716,854	255,823	2	1	1	3	77
Labuhan Batu	796,565	569,589	2	1	1	3	171
Lampung Barat	347,407	216,820	2	1	1	3	65
Lampung Selatan	1,886,907	95,369	2	1	1	3	29
Lampung Tengah	1,971,881	635,620	2	1	1	3	191
Lampung Utara	1,643,122	1,142,965	2	1	1	3	343
Nias	573,714	113,005	2	1	1	3	34
Ogan Komering Ilir	923,630	67,442	2	1	1	3	20
Ogan Komering Ulu	1,953,645	348,894	2	1	1	3	105
Tabalong	159,783	30,886	2	1	1	3	9
Tanah Laut	201,504	2,836	2	1	1	3	1
Tapanuli Selatan	1,057,891	162,643	2	1	1	3	49
Tapanuli Tengah	344,854	97,656	2	1	1	3	29
Tapanuli Utara	710,709	305,015	2	1	1	3	92
Tapin	135,317	135,317	2	1	1	3	41
Sub_Total_ID_2							
Bangka	537,273	536,872	3	1	2	3	161
Banjar	482,772	59,352	3	1	2	3	18
Barito Kuala	239,713	57,727	3	1	2	3	17
Barito Utara	167,155	33,736	3	1	2	3	10
Belitung	199,366	1,618	3	1	2	3	0
Bengkalis	1,096,376	538,776	3	1	2	3	162
Bengkulu Selatan	355,384	267,857	3	1	2	3	80
Hulu Sungai Selatan	192,960	46,099	3	1	2	3	14
Hulu Sungai Tengah	231,528	149,618	3	1	2	3	45
Hulu Sungai Utara	295,871	87,116	3	1	2	3	26
Indragiri Hilir	542,507	73,943	3	1	2	3	22
Kampar	722,805	38,479	3	1	2	3	12
Kapuas Hulu	179,859	77,193	3	1	2	3	23
Kepulauan Riau	495,654	136,335	3	1	2	3	41
Kodya Balikpapan	268,428	268,428	3	1	2	3	81
Kodya Banjarmasin	516,099	16,371	3	1	2	3	5
Kodya Pangkal Pinang	122,379	122,379	3	1	2	3	37
Kodya Samarinda	448,547	88,643	3	1	2	3	27
Kota Baru	377,345	135,657	3	1	2	3	41

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	Cases/day per 10,000 per Category	Total Est. Additional Cases/day	No Days Exposure Sep-Nov	Additional Reported Cases	Cases Hospitalized	Cases Outpatient	Cases Self Treated
District	1		91		30%		11
Aceh Selatan	1	0	91	0	0	0	0
Aceh Tenggara	1	0	91	0	0	0	0
Aceh Timur	1	0	91	0	0	0	0
Asahan	1	0	91	0	0	0	0
Berau	1	0	91	0	0	0	0
Bulongan	1	0	91	0	0	0	0
Dairi	1	0	91	0	0	0	0
Deli Serdang	1	0	91	0	0	0	0
Karo	1	0	91	0	0	0	0
Kepulauan Riau	1	0	91	0	0	0	0
Kodya Bandar Lampung	1	0	91	0	0	0	0
Kodya Binjai	1	0	91	0	0	0	0
Kodya Medan	1	0	91	0	0	0	0
Kodya Pematang Siantar	1	0	91	0	0	0	0
Kodya Sibolga	1	0	91	0	0	0	0
Kodya Tanjung Balai	1	0	91	0	0	0	0
Kodya Tebing Tinggi	1	0	91	0	0	0	0
Kutai	1	0	91	0	0	0	0
Lampung Barat	1	0	91	0	0	0	0
Lampung Selatan	1	0	91	0	0	0	0
Lampung Tengah	1	0	91	0	0	0	0
Lampung Utara	1	0	91	0	0	0	0
Langkat	1	0	91	0	0	0	0
Nias	1	0	91	0	0	0	0
Simalungun	1	0	91	0	0	0	0
Tapanuli Tengah	1	0	91	0	0	0	0
Tapanuli Utara	1	0	91	0	0	0	0
Sub_Total_ID_1							
Asahan	1	38	91	3,446	1,034	2,412	37,904
Bengkalis	1	3	91	250	75	175	2,746
Bengkulu Selatan	1	4	91	392	117	274	4,307
Berau	1	1	91	108	32	76	1,187
Bulongan	1	4	91	369	111	258	4,058
Kapuas Hulu	1	1	91	100	30	70	1,105
Kepulauan Riau	1	31	91	2,791	837	1,954	30,699
Kodya Batam	1	20	91	1,812	543	1,268	19,927
Kodya Samarinda	1	36	91	3,275	983	2,293	36,026
Kodya Tanjung Balai	1	1	91	133	40	93	1,463
Kota Baru	1	1	91	110	33	77	1,206
Kutai	1	26	91	2,328	698	1,630	25,608
Labuhan Batu	1	57	91	5,183	1,555	3,628	57,016
Lampung Barat	1	22	91	1,973	592	1,381	21,704
Lampung Selatan	1	10	91	868	260	608	9,546
Lampung Tengah	1	64	91	5,784	1,735	4,049	63,626
Lampung Utara	1	114	91	10,401	3,120	7,281	114,411
Nias	1	11	91	1,028	309	720	11,312
Ogan Komering Ilir	1	7	91	614	184	430	6,751
Ogan Komering Ulu	1	35	91	3,175	952	2,222	34,924
Tabalong	1	3	91	281	84	197	3,092
Tanah Laut	1	0	91	26	8	18	284
Tapanuli Selatan	1	16	91	1,480	444	1,036	16,281
Tapanuli Tengah	1	10	91	889	267	622	9,775
Tapanuli Utara	1	31	91	2,776	833	1,943	30,532
Tapin	1	14	91	1,231	369	862	13,545
Sub_Total_ID_2							
Bangka	1	107	91	9,771	2,931	6,840	107,482
Banjar	1	12	91	1,080	324	756	11,882
Barito Kuala	1	12	91	1,051	315	735	11,557
Barito Utara	1	7	91	614	184	430	6,754
Belitung	1	0	91	29	9	21	324
Bengkalis	1	108	91	9,806	2,942	6,864	107,863
Bengkulu Selatan	1	54	91	4,875	1,462	3,412	53,625
Hulu Sungai Selatan	1	9	91	839	252	587	9,229
Hulu Sungai Tengah	1	30	91	2,723	817	1,906	29,954
Hulu Sungai Utara	1	17	91	1,586	476	1,110	17,441
Indragiri Hilir	1	15	91	1,346	404	942	14,803
Kampar	1	8	91	700	210	490	7,703
Kapuas Hulu	1	15	91	1,405	421	983	15,454
Kepulauan Riau	1	27	91	2,481	744	1,737	27,294
Kodya Balikpapan	1	54	91	4,885	1,466	3,420	53,739
Kodya Banjarmasin	1	3	91	298	89	209	3,277
Kodya Pangkal Pinang	1	24	91	2,227	668	1,559	24,500
Kodya Samarinda	1	18	91	1,613	484	1,129	17,746
Kota Baru	1	27	91	2,469	741	1,728	27,159

HEALTH IMPACTS FROM HAZE IN INDONESIA						
Note: cells with headings in italics require data input; all others are derived results						
Location	Cases Total	Medical Cost Hospitalized million R	Medical Cost Outpatient million R	Medical Cost Self Treated million R	Medical Cost Total million R	Days Hospitalized
District		0.8125	0.0500	0.0500		10
Aceh Selatan	0	0	0	0	0	0
Aceh Tenggara	0	0	0	0	0	0
Aceh Timur	0	0	0	0	0	0
Asahan	0	0	0	0	0	0
Berau	0	0	0	0	0	0
Bulongan	0	0	0	0	0	0
Dairi	0	0	0	0	0	0
Deli Serdang	0	0	0	0	0	0
Karo	0	0	0	0	0	0
Kepulauan Riau	0	0	0	0	0	0
Kodya Bandar Lampung	0	0	0	0	0	0
Kodya Binjai	0	0	0	0	0	0
Kodya Medan	0	0	0	0	0	0
Kodya Pematang Siantar	0	0	0	0	0	0
Kodya Sibolga	0	0	0	0	0	0
Kodya Tanjung Balai	0	0	0	0	0	0
Kodya Tebing Tinggi	0	0	0	0	0	0
Kutai	0	0	0	0	0	0
Lampung Barat	0	0	0	0	0	0
Lampung Selatan	0	0	0	0	0	0
Lampung Tengah	0	0	0	0	0	0
Lampung Utara	0	0	0	0	0	0
Langkat	0	0	0	0	0	0
Nias	0	0	0	0	0	0
Simalungun	0	0	0	0	0	0
Tapanuli Tengah	0	0	0	0	0	0
Tapanuli Utara	0	0	0	0	0	0
Sub_Total_ID_1						
Asahan	44,796	840	120.604484	1,895	2,856	10337.5272
Bengkalis	3,245	61	8.735818	137	207	748.7844
Bengkulu Selatan	5,090	95	13.7028255	215	324	1174.5279
Berau	1,403	26	3.778047	59	89	323.8326
Bulongan	4,796	90	12.9129455	203	306	1106.8239
Kapuas Hulu	1,306	24	3.5159215	55	83	301.3647
Kepulauan Riau	36,281	680	97.678854	1,535	2,313	8372.4732
Kodya Batam	23,550	442	63.4034765	996	1,501	5434.5837
Kodya Samarinda	42,577	798	114.629424	1,801	2,714	9825.3792
Kodya Tanjung Balai	1,728	32	4.6536035	73	110	398.8803
Kota Baru	1,426	27	3.8382435	60	91	328.9923
Kutai	30,264	567	81.4796255	1,280	1,929	6983.9679
Labuhan Batu	67,382	1,263	181.4140965	2,851	4,296	15549.7797
Lampung Barat	25,650	481	69.05717	1,085	1,635	5919.186
Lampung Selatan	11,282	212	30.3750265	477	719	2603.5737
Lampung Tengah	75,194	1,410	202.44497	3,181	4,794	17352.426
Lampung Utara	135,213	2,535	364.0343525	5,721	8,620	31202.9445
Nias	13,368	251	35.9920925	566	852	3085.0365
Ogan Komering Ilir	7,978	150	21.480277	338	509	1841.1666
Ogan Komering Ulu	41,274	774	111.122739	1,746	2,631	9524.8062
Tabalong	3,654	69	9.837191	155	233	843.1878
Tanah Laut	335	6	0.903266	14	21	77.4228
Tapanuli Selatan	19,241	361	51.8017955	814	1,227	4440.1539
Tapanuli Tengah	11,553	217	31.103436	489	736	2666.0088
Tapanuli Utara	36,083	677	97.1472775	1,527	2,300	8326.9095
Tapin	16,008	300	43.0984645	677	1,021	3694.1541
Sub_Total_ID_2						
Bangka	127,024	2,382	341.987464	5,374	8,098	29313.2112
Banjar	14,043	263	37.807224	594	895	3240.6192
Barito Kuala	13,658	256	36.772099	578	871	3151.8942
Barito Utara	7,982	150	21.489832	338	509	1841.9856
Belitung	383	7	1.030666	16	24	88.3428
Bengkalis	127,474	2,390	343.200312	5,393	8,126	29417.1696
Bengkulu Selatan	63,375	1,188	170.624909	2,681	4,040	14624.9922
Hulu Sungai Selatan	10,907	205	29.365063	461	695	2517.0054
Hulu Sungai Tengah	35,400	664	95.306666	1,498	2,257	8169.1428
Hulu Sungai Utara	20,612	386	55.492892	872	1,314	4756.5336
Indragiri Hilir	17,495	328	47.101691	740	1,115	4037.2878
Kampar	9,104	171	24.511123	385	580	2100.9534
Kapuas Hulu	18,264	342	49.171941	773	1,164	4214.7378
Kepulauan Riau	32,257	605	86.845395	1,365	2,056	7443.891
Kodya Balikpapan	63,510	1,191	170.988636	2,687	4,049	14656.1688
Kodya Banjarmasin	3,873	73	10.428327	164	247	893.8566
Kodya Pangkal Pinang	28,955	543	77.955423	1,225	1,846	6681.8934
Kodya Samarinda	20,973	393	56.465591	887	1,337	4839.9078
Kota Baru	32,096	602	86.413509	1,358	2,046	7406.8722

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	Days Outpatient	Days Self Treated	Days Total	Days Total Adults	Total Wages Lost million R	Total Est. Health million R	WTP adj COI million R
District	5	5		51%	0.015000		2
Aceh Selatan	0	0	0	0	0	0	0
Aceh Tenggara	0	0	0	0	0	0	0
Aceh Timur	0	0	0	0	0	0	0
Asahan	0	0	0	0	0	0	0
Berau	0	0	0	0	0	0	0
Bulongan	0	0	0	0	0	0	0
Dairi	0	0	0	0	0	0	0
Deli Serdang	0	0	0	0	0	0	0
Karo	0	0	0	0	0	0	0
Kepulauan Riau	0	0	0	0	0	0	0
Kodya Bandar Lampung	0	0	0	0	0	0	0
Kodya Binjai	0	0	0	0	0	0	0
Kodya Medan	0	0	0	0	0	0	0
Kodya Pematang Siantar	0	0	0	0	0	0	0
Kodya Sibolga	0	0	0	0	0	0	0
Kodya Tanjung Balai	0	0	0	0	0	0	0
Kodya Tebing Tinggi	0	0	0	0	0	0	0
Kutai	0	0	0	0	0	0	0
Lampung Barat	0	0	0	0	0	0	0
Lampung Selatan	0	0	0	0	0	0	0
Lampung Tengah	0	0	0	0	0	0	0
Lampung Utara	0	0	0	0	0	0	0
Langkat	0	0	0	0	0	0	0
Nias	0	0	0	0	0	0	0
Simalungun	0	0	0	0	0	0	0
Tapanuli Tengah	0	0	0	0	0	0	0
Tapanuli Utara	0	0	0	0	0	0	0
Sub_Total_ID_1							
Asahan	12060.4484	189521.332	211,919	108,079	1,621	4,477	8,954
Bengkalis	873.5818	13727.714	15,350	7,829	117	324	649
Bengkulu Selatan	1370.28255	21533.0115	24,078	12,280	184	509	1,017
Berau	377.8047	5936.931	6,639	3,386	51	140	280
Bulongan	1291.29455	20291.7715	22,690	11,572	174	479	959
Kapuas Hulu	351.59215	5525.0195	6,178	3,151	47	131	261
Kepulauan Riau	9767.8854	153495.342	171,636	87,534	1,313	3,626	7,252
Kodya Batam	6340.34765	99634.0345	111,409	56,819	852	2,354	4,707
Kodya Samarinda	11462.9424	180131.952	201,420	102,724	1,541	4,255	8,510
Kodya Tanjung Balai	465.36035	7312.8055	8,177	4,170	63	173	345
Kota Baru	383.82435	6031.5255	6,744	3,440	52	142	285
Kutai	8147.96255	128039.4115	143,171	73,017	1,095	3,025	6,049
Labuhan Batu	18141.40965	285079.2945	318,770	162,573	2,439	6,734	13,468
Lampung Barat	6905.717	108518.41	121,343	61,885	928	2,563	5,127
Lampung Selatan	3037.50265	47732.1845	53,373	27,220	408	1,128	2,255
Lampung Tengah	20244.497	318127.81	355,725	181,420	2,721	7,515	15,030
Lampung Utara	36403.43525	572053.9825	639,660	326,227	4,893	13,513	27,026
Nias	3599.20925	56559.0025	63,243	32,254	484	1,336	2,672
Ogan Komering Ilir	2148.0277	33754.721	37,744	19,249	289	797	1,595
Ogan Komering Ulu	11112.2739	174621.447	195,259	99,582	1,494	4,125	8,250
Tabalong	983.7191	15458.443	17,285	8,816	132	365	730
Tanah Laut	90.3266	1419.418	1,587	809	12	34	67
Tapanuli Selatan	5180.17955	81402.8215	91,023	46,422	696	1,923	3,846
Tapanuli Tengah	3110.3436	48876.828	54,653	27,873	418	1,155	2,309
Tapanuli Utara	9714.72775	152660.0075	170,702	87,058	1,306	3,606	7,212
Tapin	4309.84645	67726.1585	75,730	38,622	579	1,600	3,200
Sub_Total_ID_2							
Bangka	34198.7464	537408.872	600,921	306,470	4,597	12,695	25,390
Banjar	3780.7224	59411.352	66,433	33,881	508	1,403	2,807
Barito Kuala	3677.2099	57784.727	64,614	32,953	494	1,365	2,730
Barito Utara	2148.9832	33769.736	37,761	19,258	289	798	1,595
Belitung	103.0666	1619.618	1,811	924	14	38	77
Bengkalis	34320.0312	539314.776	603,052	307,557	4,613	12,740	25,480
Bengkulu Selatan	17062.4909	268124.857	299,812	152,904	2,294	6,334	12,667
Hulu Sungai Selatan	2936.5063	46145.099	51,599	26,315	395	1,090	2,180
Hulu Sungai Tengah	9530.6666	149767.618	167,467	85,408	1,281	3,538	7,076
Hulu Sungai Utara	5549.2892	87203.116	97,509	49,730	746	2,060	4,120
Indragiri Hilir	4710.1691	74016.943	82,764	42,210	633	1,748	3,497
Kampar	2451.1123	38517.479	43,070	21,965	329	910	1,820
Kapuas Hulu	4917.1941	77270.193	86,402	44,065	661	1,825	3,651
Kepulauan Riau	8684.5395	136471.335	152,600	77,826	1,167	3,224	6,448
Kodya Balikpapan	17098.8636	268696.428	300,451	153,230	2,298	6,347	12,694
Kodya Banjarmasin	1042.8327	16387.371	18,324	9,345	140	387	774
Kodya Pangkal Pinang	7795.5423	122501.379	136,979	69,859	1,048	2,894	5,788
Kodya Samarinda	5646.5591	88731.643	99,218	50,601	759	2,096	4,192
Kota Baru	8641.3509	135792.657	151,841	77,439	1,162	3,208	6,415

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	*Population*	*People_affected*	*Haze Index*	*Base*	No HI	Cases/day	Total Cases
			Category	*HI*	Categories	per 10,000	per day
			Score	*Score*	Over Base	in Base	in Base
District				1		3.00	
Kutai	716,854	338,180	3	1	2	3	101
Labuhan Batu	796,565	190,396	3	1	2	3	57
Lahat	639,577	109,568	3	1	2	3	33
Lampung Utara	1,643,122	476,994	3	1	2	3	143
Muara Enim	688,012	105,671	3	1	2	3	32
Musi Banyu Asin	1,070,912	1,933	3	1	2	3	1
Nias	573,714	17,692	3	1	2	3	5
Ogan Komering Ilir	923,630	597,442	3	1	2	3	179
Ogan Komering Ulu	1,953,645	1,604,751	3	1	2	3	481
Padang Pariaman	525,924	225,426	3	1	2	3	68
Pasaman	496,486	70,529	3	1	2	3	21
Pasir	234,458	151,876	3	1	2	3	46
Sambas	824,162	599,588	3	1	2	3	180
Tabalong	159,783	36,271	3	1	2	3	11
Tanah Laut	201,504	120,110	3	1	2	3	36
Tapanuli Selatan	1,057,891	778,159	3	1	2	3	233
Sub_Total_ID_3							
Agam	443,207	214,470	4	1	3	3	64
Bangka	537,273	405	4	1	3	3	0
Banjar	482,772	415,072	4	1	3	3	125
Barito Kuala	239,713	124,267	4	1	3	3	37
Barito Selatan	171,614	45,174	4	1	3	3	14
Barito Utara	167,155	103,879	4	1	3	3	31
Belitung	199,366	197,749	4	1	3	3	59
Bengkalis	1,096,376	530,177	4	1	3	3	159
Bengkulu Selatan	355,384	44,504	4	1	3	3	13
Bengkulu Utara	551,285	287,686	4	1	3	3	86
Hulu Sungai Selatan	192,960	60,552	4	1	3	3	18
Hulu Sungai Tengah	231,528	59,226	4	1	3	3	18
Hulu Sungai Utara	295,871	147,347	4	1	3	3	44
Indragiri Hilir	542,507	418,652	4	1	3	3	126
Indragiri Hulu	423,940	78,737	4	1	3	3	24
Kampar	722,805	449,880	4	1	3	3	135
Kapuas Hulu	179,859	83,142	4	1	3	3	25
Kodya Banjarmasin	516,099	3,762	4	1	3	3	1
Kodya Bengkulu	232,752	232,752	4	1	3	3	70
Kodya Palembang	1,170,061	1,170,061	4	1	3	3	351
Kodya Pekan Baru	488,048	488,048	4	1	3	3	146
Kodya Pontianak	398,341	398,341	4	1	3	3	120
Kota Baru	377,345	133,755	4	1	3	3	40
Kutai	716,854	35,695	4	1	3	3	11
Lahat	639,577	530,008	4	1	3	3	159
Muara Enim	688,012	569,189	4	1	3	3	171
Musi Banyu Asin	1,070,912	589,820	4	1	3	3	177
Musi Rawas	1,491,809	555,538	4	1	3	3	167
Ogan Komering Ilir	923,630	258,747	4	1	3	3	78
Padang Pariaman	525,924	232,827	4	1	3	3	70
Pasaman	496,486	356,161	4	1	3	3	107
Pasir	234,458	82,582	4	1	3	3	25
Pesisir Selatan	413,888	3,890	4	1	3	3	1
Pontianak	846,876	614,221	4	1	3	3	184
Rejang Lebong	447,633	309,823	4	1	3	3	93
Sambas	824,162	224,575	4	1	3	3	67
Sanggau	582,756	374,646	4	1	3	3	112
Sintang	413,976	135,512	4	1	3	3	41
Solok	455,548	9,401	4	1	3	3	3
Tabalong	159,783	92,624	4	1	3	3	28
Tanah Datar	362,800	3,737	4	1	3	3	1
Tanah Laut	201,504	78,572	4	1	3	3	24
Tanjung Jabung	399,946	258,780	4	1	3	3	78
Tapanuli Selatan	1,057,891	117,086	4	1	3	3	35
Sub_Total_ID_4							
Agam	443,207	228,737	5	1	4	3	69
Banjar	482,772	8,351	5	1	4	3	3
Barito Kuala	239,713	57,716	5	1	4	3	17
Barito Selatan	171,614	126,440	5	1	4	3	38
Barito Utara	167,155	29,539	5	1	4	3	9
Bengkulu Utara	551,285	263,590	5	1	4	3	79
Bungo Tebo	403,049	403,049	5	1	4	3	121
Hulu Sungai Selatan	192,960	86,323	5	1	4	3	26
Hulu Sungai Tengah	231,528	22,664	5	1	4	3	7
Hulu Sungai Utara	295,871	61,387	5	1	4	3	18
Indragiri Hilir	542,507	49,914	5	1	4	3	15
Indragiri Hulu	423,940	345,203	5	1	4	3	104

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	Cases/day per 10,000 per Category	Total Est. Additional Cases/day	No Days Exposure Sep-Nov	Additional Reported Cases	Cases Hospitalized	Cases Outpatient	Cases Self Treated
District	1		91		30%		11
Kutai	1	68	91	6,155	1,846	4,308	67,704
Labuhan Batu	1	38	91	3,465	1,040	2,426	38,117
Lahat	1	22	91	1,994	598	1,396	21,936
Lampung Utara	1	95	91	8,681	2,604	6,077	95,494
Muara Enim	1	21	91	1,923	577	1,346	21,155
Musi Banyu Asin	1	0	91	35	11	25	387
Nias	1	4	91	322	97	225	3,542
Ogan Komering Ilir	1	119	91	10,873	3,262	7,611	119,608
Ogan Komering Ulu	1	321	91	29,206	8,762	20,445	321,271
Padang Pariaman	1	45	91	4,103	1,231	2,872	45,130
Pasaman	1	14	91	1,284	385	899	14,120
Pasir	1	30	91	2,764	829	1,935	30,406
Sambas	1	120	91	10,913	3,274	7,639	120,038
Tabalong	1	7	91	660	198	462	7,261
Tanah Laut	1	24	91	2,186	656	1,530	24,046
Tapanuli Selatan	1	156	91	14,162	4,249	9,914	155,787
Sub_Total_ID_3							
Agam	1	64	91	5,855	1,757	4,099	64,405
Bangka	1	0	91	11	3	8	122
Banjar	1	125	91	11,331	3,399	7,932	124,646
Barito Kuala	1	37	91	3,392	1,018	2,375	37,317
Barito Selatan	1	14	91	1,233	370	863	13,566
Barito Utara	1	31	91	2,836	851	1,985	31,195
Belitung	1	59	91	5,399	1,620	3,779	59,384
Bengkalis	1	159	91	14,474	4,342	10,132	159,212
Bengkulu Selatan	1	13	91	1,215	364	850	13,365
Bengkulu Utara	1	86	91	7,854	2,356	5,498	86,392
Hulu Sungai Selatan	1	18	91	1,653	496	1,157	18,184
Hulu Sungai Tengah	1	18	91	1,617	485	1,132	17,786
Hulu Sungai Utara	1	44	91	4,023	1,207	2,816	44,248
Indragiri Hilir	1	126	91	11,429	3,429	8,000	125,721
Indragiri Hulu	1	24	91	2,150	645	1,505	23,645
Kampar	1	135	91	12,282	3,685	8,597	135,099
Kapuas Hulu	1	25	91	2,270	681	1,589	24,968
Kodya Banjarmasin	1	1	91	103	31	72	1,130
Kodya Bengkulu	1	70	91	6,354	1,906	4,448	69,895
Kodya Palembang	1	351	91	31,943	9,583	22,360	351,369
Kodya Pekan Baru	1	146	91	13,324	3,997	9,327	146,561
Kodya Pontianak	1	120	91	10,875	3,262	7,612	119,622
Kota Baru	1	40	91	3,652	1,095	2,556	40,167
Kutai	1	11	91	974	292	682	10,719
Lahat	1	159	91	14,469	4,341	10,128	159,161
Muara Enim	1	171	91	15,539	4,662	10,877	170,927
Musi Banyu Asin	1	177	91	16,102	4,831	11,271	177,123
Musi Rawas	1	167	91	15,166	4,550	10,616	166,828
Ogan Komering Ilir	1	78	91	7,064	2,119	4,945	77,702
Padang Pariaman	1	70	91	6,356	1,907	4,449	69,918
Pasaman	1	107	91	9,723	2,917	6,806	106,955
Pasir	1	25	91	2,254	676	1,578	24,799
Pesisir Selatan	1	1	91	106	32	74	1,168
Pontianak	1	184	91	16,768	5,030	11,738	184,451
Rejang Lebong	1	93	91	8,458	2,537	5,921	93,040
Sambas	1	67	91	6,131	1,839	4,292	67,440
Sanggau	1	112	91	10,228	3,068	7,159	112,506
Sintang	1	41	91	3,699	1,110	2,590	40,694
Solok	1	3	91	257	77	180	2,823
Tabalong	1	28	91	2,529	759	1,770	27,815
Tanah Datar	1	1	91	102	31	71	1,122
Tanah Laut	1	24	91	2,145	644	1,502	23,595
Tanjung Jabung	1	78	91	7,065	2,119	4,945	77,712
Tapanuli Selatan	1	35	91	3,196	959	2,238	35,161
Sub_Total_ID_4							
Agam	1	91	91	8,326	2,498	5,828	91,586
Banjar	1	3	91	304	91	213	3,344
Barito Kuala	1	23	91	2,101	630	1,471	23,109
Barito Selatan	1	51	91	4,602	1,381	3,222	50,627
Barito Utara	1	12	91	1,075	323	753	11,827
Bengkulu Utara	1	105	91	9,595	2,878	6,716	105,541
Bungo Tebo	1	161	91	14,671	4,401	10,270	161,381
Hulu Sungai Selatan	1	35	91	3,142	943	2,200	34,564
Hulu Sungai Tengah	1	9	91	825	247	577	9,075
Hulu Sungai Utara	1	25	91	2,234	670	1,564	24,579
Indragiri Hilir	1	20	91	1,817	545	1,272	19,986
Indragiri Hulu	1	138	91	12,565	3,770	8,796	138,219

HEALTH IMPACTS FROM HAZE IN INDONESIA						
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Location	Cases	Medical Cost	Medical Cost	Medical Cost	Medical Cost	Days
	Total	Hospitalized	Outpatient	Self Treated	Total	Hospitalized
		million R	million R	million R	million R	
District		0.8125	0.0500	0.0500		10
Kutai	80,013	1,500	215.42066	3,385	5,101	18464.628
Labuhan Batu	45,048	845	121.282252	1,906	2,872	10395.6216
Lahat	25,924	486	69.794816	1,097	1,653	5982.4128
Lampung Utara	112,857	2,116	303.845178	4,775	7,195	26043.8724
Muara Enim	25,002	469	67.312427	1,058	1,594	5769.6366
Musi Banyu Asin	457	9	1.231321	19	29	105.5418
Nias	4,186	78	11.269804	177	267	965.9832
Ogan Komering Ilir	141,355	2,650	380.570554	5,980	9,011	32620.3332
Ogan Komering Ulu	379,684	7,119	1022.226387	16,064	24,205	87619.4046
Padang Pariaman	53,336	1,000	143.596362	2,257	3,400	12308.2596
Pasaman	16,687	313	44.926973	706	1,064	3850.8834
Pasir	35,934	674	96.745012	1,520	2,291	8292.4296
Sambas	141,863	2,660	381.937556	6,002	9,044	32737.5048
Tabalong	8,582	161	23.104627	363	547	1980.3966
Tanah Laut	28,418	533	76.51007	1,202	1,812	6558.006
Tapanuli Selatan	184,112	3,452	495.687283	7,789	11,737	42487.4814
Sub_Total_ID_3						
Agam	76,115	1,427	204.926085	3,220	4,852	17565.093
Bangka	144	3	0.3869775	6	9	33.1695
Banjar	147,309	2,762	396.601296	6,232	9,391	33994.3968
Barito Kuala	44,102	827	118.7371185	1,866	2,812	10177.4673
Barito Selatan	16,032	301	43.163757	678	1,022	3699.7506
Barito Utara	36,867	691	99.2563845	1,560	2,350	8507.6901
Belitung	70,181	1,316	188.9491695	2,969	4,474	16195.6431
Bengkalis	188,160	3,528	506.5841235	7,961	11,995	43421.4963
Bengkulu Selatan	15,794	296	42.523572	668	1,007	3644.8776
Bengkulu Utara	102,100	1,914	274.883973	4,320	6,509	23561.4834
Hulu Sungai Selatan	21,490	403	57.857436	909	1,370	4959.2088
Hulu Sungai Tengah	21,019	394	56.590443	889	1,340	4850.6094
Hulu Sungai Utara	52,293	981	140.7900585	2,212	3,334	12067.7193
Indragiri Hilir	148,580	2,786	400.021986	6,286	9,472	34287.5988
Indragiri Hulu	27,944	524	75.2332035	1,182	1,781	6448.5603
Kampar	159,662	2,994	429.86034	6,755	10,178	36845.172
Kapuas Hulu	29,507	553	79.442181	1,248	1,881	6809.3298
Kodya Banjarmasin	1,335	25	3.594591	56	85	308.1078
Kodya Bengkulu	82,604	1,549	222.394536	3,495	5,266	19062.3888
Kodya Palembang	415,255	7,786	1117.993286	17,568	26,472	95827.9959
Kodya Pekan Baru	173,208	3,248	466.329864	7,328	11,042	39971.1312
Kodya Pontianak	141,371	2,651	380.6148255	5,981	9,012	32624.1279
Kota Baru	47,470	890	127.8029025	2,008	3,026	10954.5345
Kutai	12,668	238	34.1065725	536	808	2923.4205
Lahat	188,100	3,527	506.422644	7,958	11,991	43407.6552
Muara Enim	202,005	3,788	543.8600895	8,546	12,878	46616.5791
Musi Banyu Asin	209,327	3,925	563.57301	8,856	13,345	48306.258
Musi Rawas	197,160	3,697	530.816559	8,341	12,569	45498.5622
Ogan Komering Ilir	91,829	1,722	247.2327585	3,885	5,854	21191.3793
Padang Pariaman	82,630	1,549	222.4661985	3,496	5,268	19068.5313
Pasaman	126,402	2,370	340.3118355	5,348	8,058	29169.5859
Pasir	29,308	550	78.907101	1,240	1,868	6763.4658
Pesisir Selatan	1,381	26	3.716895	58	88	318.591
Pontianak	217,987	4,087	586.8881655	9,223	13,897	50304.6999
Rejang Lebong	109,956	2,062	296.0358765	4,652	7,010	25374.5037
Sambas	79,702	1,494	214.5814125	3,372	5,081	18392.6925
Sanggau	132,962	2,493	357.974253	5,625	8,476	30683.5074
Sintang	48,093	902	129.481716	2,035	3,066	11098.4328
Solok	3,336	63	8.9826555	141	213	769.9419
Tabalong	32,872	616	88.502232	1,391	2,096	7585.9056
Tanah Datar	1,326	25	3.5707035	56	85	306.0603
Tanah Laut	27,885	523	75.075546	1,180	1,778	6435.0468
Tanjung Jabung	91,841	1,722	247.26429	3,886	5,855	21194.082
Tapanuli Selatan	41,554	779	111.875673	1,758	2,649	9589.3434
Sub_Total_ID_4						
Agam	108,238	2,029	291.410938	4,579	6,900	24978.0804
Banjar	3,952	74	10.639174	167	252	911.9292
Barito Kuala	27,311	512	73.530184	1,155	1,741	6302.5872
Barito Selatan	59,831	1,122	161.08456	2,531	3,814	13807.248
Barito Utara	13,978	262	37.632686	591	891	3225.6588
Bengkulu Utara	124,731	2,339	335.81366	5,277	7,952	28784.028
Bungo Tebo	190,723	3,576	513.484426	8,069	12,159	44012.9508
Hulu Sungai Selatan	40,848	766	109.975502	1,728	2,604	9426.4716
Hulu Sungai Tengah	10,725	201	28.873936	454	684	2474.9088
Hulu Sungai Utara	29,048	545	78.207038	1,229	1,852	6703.4604
Indragiri Hilir	23,619	443	63.590436	999	1,506	5450.6088
Indragiri Hulu	163,350	3,063	439.788622	6,911	10,414	37696.1676

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	Days Outpatient	Days Self Treated	Days Total	Days Total Adults	Total Wages Lost million R	Total Est. Health million R	WTP adj COI million R
District	5	5		51%	0.015000		2
Kutai	21542.066	338518.18	378,525	193,048	2,896	7,997	15,993
Labuhan Batu	12128.2252	190586.396	213,110	108,686	1,630	4,502	9,004
Lahat	6979.4816	109677.568	122,639	62,546	938	2,591	5,182
Lampung Utara	30384.5178	477470.994	533,899	272,289	4,084	11,279	22,558
Muara Enim	6731.2427	105776.671	118,278	60,322	905	2,499	4,997
Musi Banyu Asin	123.1321	1934.933	2,164	1,103	17	46	91
Nias	1126.9804	17709.692	19,803	10,099	151	418	837
Ogan Komering Ilir	38057.0554	598039.442	668,717	341,046	5,116	14,127	28,254
Ogan Komering Ulu	102222.6387	1606355.751	1,796,198	916,061	13,741	37,946	75,892
Padang Pariaman	14359.6362	225651.426	252,319	128,683	1,930	5,330	10,661
Pasaman	4492.6973	70599.529	78,943	40,261	604	1,668	3,335
Pasir	9674.5012	152027.876	169,995	86,697	1,300	3,591	7,182
Sambas	38193.7556	600187.588	671,119	342,271	5,134	14,178	28,356
Tabalong	2310.4627	36307.271	40,598	20,705	311	858	1,715
Tanah Laut	7651.007	120230.11	134,439	68,564	1,028	2,840	5,680
Tapanuli Selatan	49568.7283	778937.159	870,993	444,207	6,663	18,400	36,801
Sub_Total_ID_3							
Agam	20492.6085	322026.705	360,084	183,643	2,755	7,607	15,214
Bangka	38.69775	608.1075	680	347	5	14	29
Banjar	39660.1296	623230.608	696,885	355,411	5,331	14,722	29,444
Barito Kuala	11873.71185	186586.9005	208,638	106,405	1,596	4,408	8,815
Barito Selatan	4316.3757	67828.761	75,845	38,681	580	1,602	3,205
Barito Utara	9925.63845	155974.3185	174,408	88,948	1,334	3,684	7,369
Belitung	18894.91695	296920.1235	332,011	169,325	2,540	7,014	14,028
Bengkalis	50658.41235	796060.7655	890,141	453,972	6,810	18,805	37,610
Bengkulu Selatan	4252.3572	66822.756	74,720	38,107	572	1,579	3,157
Bengkulu Utara	27488.3973	431960.529	483,010	246,335	3,695	10,204	20,408
Hulu Sungai Selatan	5785.7436	90918.828	101,664	51,849	778	2,148	4,295
Hulu Sungai Tengah	5659.0443	88927.839	99,437	50,713	761	2,101	4,201
Hulu Sungai Utara	14079.00585	221241.5205	247,388	126,168	1,893	5,226	10,452
Indragiri Hilir	40002.1986	628605.978	702,896	358,477	5,377	14,849	29,698
Indragiri Hulu	7523.32035	118223.6055	132,195	67,420	1,011	2,793	5,585
Kampar	42986.034	675494.82	755,326	385,216	5,778	15,957	31,913
Kapuas Hulu	7944.2181	124837.713	139,591	71,192	1,068	2,949	5,898
Kodya Banjarmasin	359.4591	5648.643	6,316	3,221	48	133	267
Kodya Bengkulu	22239.4536	349477.128	390,779	199,297	2,989	8,255	16,511
Kodya Palembang	111799.3286	1756846.592	1,964,474	1,001,882	15,028	41,501	83,001
Kodya Pekan Baru	46632.9864	732804.072	819,408	417,898	6,268	17,310	34,621
Kodya Pontianak	38061.48255	598109.0115	668,795	341,085	5,116	14,129	28,257
Kota Baru	12780.29025	200833.1325	224,568	114,530	1,718	4,744	9,488
Kutai	3410.65725	53596.0425	59,930	30,564	458	1,266	2,532
Lahat	50642.2644	795807.012	889,857	453,827	6,807	18,799	37,598
Muara Enim	54386.00895	854637.2835	955,640	487,376	7,311	20,188	40,377
Musi Banyu Asin	56357.301	885614.73	990,278	505,042	7,576	20,920	41,840
Musi Rawas	53081.6559	834140.307	932,721	475,687	7,135	19,704	39,409
Ogan Komering Ilir	24723.27585	388508.6205	434,423	221,556	3,323	9,177	18,355
Padang Pariaman	22246.61985	349589.7405	390,905	199,361	2,990	8,258	16,516
Pasaman	34031.18355	534775.7415	597,977	304,968	4,575	12,633	25,265
Pasir	7890.7101	123996.873	138,651	70,712	1,061	2,929	5,858
Pesisir Selatan	371.6895	5840.835	6,531	3,331	50	138	276
Pontianak	58688.81655	922252.8315	1,031,246	525,936	7,889	21,786	43,571
Rejang Lebong	29603.58765	465199.2345	520,177	265,290	3,979	10,989	21,978
Sambas	21458.14125	337199.3625	377,050	192,296	2,884	7,965	15,931
Sanggau	35797.4253	562530.969	629,012	320,796	4,812	13,288	26,577
Sintang	12948.1716	203471.268	227,518	116,034	1,741	4,806	9,613
Solok	898.26555	14115.6015	15,784	8,050	121	333	667
Tabalong	8850.2232	139074.936	155,511	79,311	1,190	3,285	6,571
Tanah Datar	357.07035	5611.1055	6,274	3,200	48	133	265
Tanah Laut	7507.5546	117975.858	131,918	67,278	1,009	2,787	5,574
Tanjung Jabung	24726.429	388558.17	434,479	221,584	3,324	9,179	18,357
Tapanuli Selatan	11187.5673	175804.629	196,582	100,257	1,504	4,153	8,306
Sub_Total_ID_4							
Agam	29141.0938	457931.474	512,051	261,146	3,917	10,817	21,635
Banjar	1063.9174	16718.702	18,695	9,534	143	395	790
Barito Kuala	7353.0184	115547.432	129,203	65,894	988	2,729	5,459
Barito Selatan	16108.456	253132.88	283,049	144,355	2,165	5,980	11,959
Barito Utara	3763.2686	59137.078	66,126	33,724	506	1,397	2,794
Bengkulu Utara	33581.366	527707.18	590,073	300,937	4,514	12,466	24,931
Bungo Tebo	51348.4426	806904.098	902,265	460,155	6,902	19,061	38,122
Hulu Sungai Selatan	10997.5502	172818.646	193,243	98,554	1,478	4,082	8,165
Hulu Sungai Tengah	2887.3936	45373.328	50,736	25,875	388	1,072	2,144
Hulu Sungai Utara	7820.7038	122896.774	137,421	70,085	1,051	2,903	5,806
Indragiri Hilir	6359.0436	99927.828	111,737	56,986	855	2,361	4,721
Indragiri Hulu	43978.8622	691096.406	772,771	394,113	5,912	16,325	32,651

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	*Population*	*People_affected*	*Haze Index*	*Base*	No HI	Cases/day	Total Cases
			Category	*HI*	Categories	per 10,000	per day
			Score	*Score*	Over Base	in Base	in Base
District				1		3.00	
Kampar	722,805	234,448	5	1	4	3	70
Kapuas	486,847	437,208	5	1	4	3	131
Kapuas Hulu	179,859	8,485	5	1	4	3	3
Kerinci	293,273	293,273	5	1	4	3	88
Ketapang	388,980	388,980	5	1	4	3	117
Kodya Banjarmasin	516,099	495,988	5	1	4	3	149
Kodya Bukit Tinggi	88,213	88,213	5	1	4	3	26
Kodya Jambi	367,489	367,489	5	1	4	3	110
Kodya Padang	678,750	678,750	5	1	4	3	204
Kodya Padang Panjang	38,358	38,358	5	1	4	3	12
Kodya Palangkaraya	136,767	125,354	5	1	4	3	38
Kodya Payakumbuh	102,429	102,429	5	1	4	3	31
Kota Baru	377,345	95,891	5	1	4	3	29
Kota Waringin Barat	197,215	197,215	5	1	4	3	59
Kota Waringin Timur	448,753	393,980	5	1	4	3	118
Lima Puluh Koto	318,532	318,532	5	1	4	3	96
Muara Enim	688,012	13,153	5	1	4	3	4
Musi Banyu Asin	1,070,912	479,158	5	1	4	3	144
Musi Rawas	1,491,809	936,271	5	1	4	3	281
Padang Pariaman	525,924	67,671	5	1	4	3	20
Pasaman	496,486	69,797	5	1	4	3	21
Pesisir Selatan	413,888	409,993	5	1	4	3	123
Pontianak	846,876	232,655	5	1	4	3	70
Rejang Lebong	447,633	137,818	5	1	4	3	41
Sanggau	582,756	208,110	5	1	4	3	62
Sarolangon Bangko	414,410	414,410	5	1	4	3	124
Sawah Lunto	319,358	319,358	5	1	4	3	96
Sintang	413,976	278,464	5	1	4	3	84
Solok	455,548	446,147	5	1	4	3	134
Tanah Datar	362,800	359,057	5	1	4	3	108
Tanjung Jabung	399,946	141,163	5	1	4	3	42
Sub_Total_ID_5							
Kapuas	486,847	49,640	6	1	5	3	15
Kodya Palangkaraya	136,767	11,406	6	1	5	3	3
Kota Waringin Timur	448,753	54,774	6	1	5	3	16
Sub_Total_ID_6							
Location	Population	People_affected	Haze Index	Base	No HI	Cases/day	Total Cases
			Category	HI	Categories	per 10,000	per day
			Score	Score	Over Base	in Base	in Base
TOTAL ALL ID		47,632,205					14,290
ID1		12,189,039					3,657
ID2		5,584,758					1,675
ID3		8,160,785					2,448
ID4		11,121,072					3,336
ID5		10,460,731					3,138
ID6		115,820					35
			Rp million	Rp million	Rp million	Rp million	
Summary	Population	Total Cases	Med Costs	Wages	Total	Adj COI	
Zone ID1	12,189,039	0	0	0	0	0	
Zone ID2	5,584,758	660,677	42,118	23,910	66,028	132,057	
Zone ID3	8,160,785	1,930,842	123,091	69,878	192,969	385,938	
Zone ID4	11,121,072	3,946,868	251,613	142,839	394,452	788,903	
Zone ID5	10,460,731	4,950,018	315,564	179,143	494,707	989,413	
Zone ID6	115,820	68,508	4,367	2,479	6,847	13,693	
TOTAL	47,632,205	11,556,912	736,753	418,249	1,155,002	2,310,005	
			USD million	USD million	USD million	USD million	
			Med Costs	Wages	Total	Adj COI	
Zone ID1			0.00	0.00	0.00	0.00	
Zone ID2			16.85	9.56	26.41	52.82	
Zone ID3			49.24	27.95	77.19	154.38	
Zone ID4			100.65	57.14	157.78	315.56	
Zone ID5			126.23	71.66	197.88	395.77	
Zone ID6			1.75	0.99	2.74	5.48	
TOTAL			294.70	167.30	462.00	924.00	

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	Cases/day per 10,000 per Category	Total Est. Additional Cases/day	No Days Exposure Sep-Nov	Additional Reported Cases	Cases Hospitalized	Cases Outpatient	Cases Self Treated
District	1		91		30%		11
Kampar	1	94	91	8,534	2,560	5,974	93,873
Kapuas	1	175	91	15,914	4,774	11,140	175,058
Kapuas Hulu	1	3	91	309	93	216	3,397
Kerinci	1	117	91	10,675	3,203	7,473	117,427
Ketapang	1	156	91	14,159	4,248	9,911	155,748
Kodya Banjarmasin	1	198	91	18,054	5,416	12,638	198,594
Kodya Bukit Tinggi	1	35	91	3,211	963	2,248	35,320
Kodya Jambi	1	147	91	13,377	4,013	9,364	147,143
Kodya Padang	1	272	91	24,707	7,412	17,295	271,772
Kodya Padang Panjang	1	15	91	1,396	419	977	15,359
Kodya Palangkaraya	1	50	91	4,563	1,369	3,194	50,192
Kodya Payakumbuh	1	41	91	3,728	1,119	2,610	41,013
Kota Baru	1	38	91	3,490	1,047	2,443	38,395
Kota Waringin Barat	1	79	91	7,179	2,154	5,025	78,965
Kota Waringin Timur	1	158	91	14,341	4,302	10,039	157,750
Lima Puluh Koto	1	127	91	11,595	3,478	8,116	127,540
Muara Enim	1	5	91	479	144	335	5,266
Musi Banyu Asin	1	192	91	17,441	5,232	12,209	191,855
Musi Rawas	1	375	91	34,080	10,224	23,856	374,883
Padang Pariaman	1	27	91	2,463	739	1,724	27,095
Pasaman	1	28	91	2,541	762	1,778	27,947
Pesisir Selatan	1	164	91	14,924	4,477	10,447	164,161
Pontianak	1	93	91	8,469	2,541	5,928	93,155
Rejang Lebong	1	55	91	5,017	1,505	3,512	55,182
Sanggau	1	83	91	7,575	2,273	5,303	83,327
Sarolangon Bangko	1	166	91	15,085	4,525	10,559	165,930
Sawah Lunto	1	128	91	11,625	3,487	8,137	127,871
Sintang	1	111	91	10,136	3,041	7,095	111,497
Solok	1	178	91	16,240	4,872	11,368	178,637
Tanah Datar	1	144	91	13,070	3,921	9,149	143,766
Tanjung Jabung	1	56	91	5,138	1,541	3,597	56,522
Sub_Total_ID_5							
Kapuas	1	25	91	2,259	678	1,581	24,845
Kodya Palangkaraya	1	6	91	519	156	363	5,709
Kota Waringin Timur	1	27	91	2,492	748	1,745	27,414
Sub_Total_ID_6							
Location	Cases/day per 10,000 per Category	Total Est. Additional Cases/day	No Days Exposure Sep-Nov	Additional Reported Cases	Cases Hospitalized	Cases Outpatient	Cases Self Treated
TOTAL ALL ID		9,769		888,993	266,698	622,295	9,778,926
ID1		0		0	0	0	0
ID2		558		50,821	15,246	35,575	559,034
ID3		1,632		148,526	44,558	103,968	1,633,789
ID4		3,336		303,605	91,082	212,524	3,339,658
ID5		4,184		380,771	114,231	266,539	4,188,477
ID6		58		5,270	1,581	3,689	57,968
Summary							
Zone ID1							
Zone ID2							
Zone ID3							
Zone ID4							
Zone ID5							
Zone ID6							
TOTAL							
Zone ID1							
Zone ID2							
Zone ID3							
Zone ID4							
Zone ID5							
Zone ID6							
TOTAL							

HEALTH IMPACTS FROM HAZE IN INDONESIA						
Note: cells with headings in italics require data input; all others are derived results						
Location	Cases Total	Medical Cost Hospitalized million R	Medical Cost Outpatient million R	Medical Cost Self Treated million R	Medical Cost Total million R	Days Hospitalized
District		0.8125	0.0500	0.0500		10
Kampar	110,941	2,080	298.686752	4,694	7,072	25601.7216
Kapuas	206,887	3,879	557.002992	8,753	13,189	47743.1136
Kapuas Hulu	4,015	75	10.80989	170	256	926.562
Kerinci	138,777	2,602	373.629802	5,871	8,847	32025.4116
Ketapang	184,065	3,451	495.56052	7,787	11,734	42476.616
Kodya Banjarmasin	234,702	4,401	631.888712	9,930	14,962	54161.8896
Kodya Bukit Tinggi	41,742	783	112.383362	1,766	2,661	9632.8596
Kodya Jambi	173,896	3,261	468.180986	7,357	11,086	40129.7988
Kodya Padang	321,185	6,022	864.7275	13,589	20,476	74119.5
Kodya Padang Panjang	18,151	340	48.868092	768	1,157	4188.6936
Kodya Palangkaraya	59,318	1,112	159.700996	2,510	3,781	13688.6568
Kodya Payakumbuh	48,469	909	130.494546	2,051	3,090	11185.2468
Kota Baru	45,376	851	122.165134	1,920	2,893	10471.2972
Kota Waringin Barat	93,322	1,750	251.25191	3,948	5,949	21535.878
Kota Waringin Timur	186,431	3,496	501.93052	7,887	11,885	43022.616
Lima Puluh Koto	150,729	2,826	405.809768	6,377	9,609	34783.6944
Muara Enim	6,224	117	16.756922	263	397	1436.3076
Musi Banyu Asin	226,738	4,251	610.447292	9,593	14,455	52324.0536
Musi Rawas	443,043	8,307	1192.809254	18,744	28,244	102240.7932
Padang Pariaman	32,022	600	86.212854	1,355	2,041	7389.6732
Pasaman	33,028	619	88.921378	1,397	2,106	7621.8324
Pesisir Selatan	194,009	3,638	522.331082	8,208	12,368	44771.2356
Pontianak	110,092	2,064	296.40247	4,658	7,018	25405.926
Rejang Lebong	65,215	1,223	175.580132	2,759	4,157	15049.7256
Sanggau	98,478	1,846	265.13214	4,166	6,278	22725.612
Sarolangon Bangko	196,099	3,677	527.95834	8,296	12,501	45253.572
Sawah Lunto	151,120	2,834	406.862092	6,394	9,634	34873.8936
Sintang	131,769	2,471	354.763136	5,575	8,400	30408.2688
Solok	211,117	3,958	568.391278	8,932	13,459	48719.2524
Tanah Datar	169,906	3,186	457.438618	7,188	10,831	39209.0244
Tanjung Jabung	66,798	1,252	179.841662	2,826	4,258	15414.9996
Sub_Total_ID_5						
Kapuas	29,362	551	79.0517	1,242	1,872	6775.86
Kodya Palangkaraya	6,747	126	18.164055	285	430	1556.919
Kota Waringin Timur	32,399	607	87.227595	1,371	2,065	7476.651
Sub_Total_ID_6						
Location	Cases Total	Medical Cost Hospitalized million R	Medical Cost Outpatient million R	Medical Cost Self Treated million R	Medical Cost Total million R	Days Hospitalized
TOTAL ALL ID	11,556,912	216,692	31,115	488,946	736,753	2,666,980
ID1	0	0	0	0	0	0
ID2	660,677	12,388	1,779	27,952	42,118	152,464
ID3	1,930,842	36,203	5,198	81,689	123,091	445,579
ID4	3,946,868	74,004	10,626	166,983	251,613	910,816
ID5	4,950,018	92,813	13,327	209,424	315,564	1,142,312
ID6	68,508	1,285	184	2,898	4,367	15,809
Summary						
Zone ID1						
Zone ID2						
Zone ID3						
Zone ID4						
Zone ID5						
Zone ID6						
TOTAL						
Zone ID1						
Zone ID2						
Zone ID3						
Zone ID4						
Zone ID5						
Zone ID6						
TOTAL						

HEALTH IMPACTS FROM HAZE IN INDONESIA							
Note: cells with headings in italics require data input; all others are derived results							
Location	Days	Days	Days	Days	Total	Total Est.	WTP adj
	Outpatient	Self Treated	Total	Total	Wages Lost	Health	COI
				Adults	million R	million R	million R
District	5	5		51%	0.015000		2
Kampar	29868.6752	469364.896	524,835	267,666	4,015	11,087	22,175
Kapuas	55700.2992	875290.416	978,734	499,154	7,487	20,676	41,353
Kapuas Hulu	1080.989	16986.97	18,995	9,687	145	401	803
Kerinci	37362.9802	587132.546	656,521	334,826	5,022	13,869	27,739
Ketapang	49556.052	778737.96	870,771	444,093	6,661	18,396	36,791
Kodya Banjarmasin	63188.8712	992967.976	1,110,319	566,263	8,494	23,456	46,912
Kodya Bukit Tinggi	11238.3362	176602.426	197,474	100,712	1,511	4,172	8,344
Kodya Jambi	46818.0986	735712.978	822,661	419,557	6,293	17,379	34,758
Kodya Padang	86472.75	1358857.5	1,519,450	774,919	11,624	32,099	64,199
Kodya Padang Panjang	4886.8092	76792.716	85,868	43,793	657	1,814	3,628
Kodya Palangkaraya	15970.0996	250958.708	280,617	143,115	2,147	5,928	11,856
Kodya Payakumbuh	13049.4546	205062.858	229,298	116,942	1,754	4,844	9,688
Kota Baru	12216.5134	191973.782	214,662	109,477	1,642	4,535	9,070
Kota Waringin Barat	25125.191	394824.43	441,485	225,158	3,377	9,327	18,653
Kota Waringin Timur	50193.052	788747.96	881,964	449,801	6,747	18,632	37,264
Lima Puluh Koto	40580.9768	637701.064	713,066	363,664	5,455	15,064	30,128
Muara Enim	1675.6922	26332.306	29,444	15,017	225	622	1,244
Musi Banyu Asin	61044.7292	959274.316	1,072,643	547,048	8,206	22,660	45,320
Musi Rawas	119280.9254	1874414.542	2,095,936	1,068,927	16,034	44,278	88,556
Padang Pariaman	8621.2854	135477.342	151,488	77,259	1,159	3,200	6,401
Pasaman	8892.1378	139733.594	156,248	79,686	1,195	3,301	6,602
Pesisir Selatan	52233.1082	820805.986	917,810	468,083	7,021	19,389	38,779
Pontianak	29640.247	465775.31	520,821	265,619	3,984	11,003	22,005
Rejang Lebong	17558.0132	275911.636	308,519	157,345	2,360	6,518	13,035
Sanggau	26513.214	416636.22	465,875	237,596	3,564	9,842	19,684
Sarolangon Bangko	52795.834	829648.82	927,698	473,126	7,097	19,598	39,196
Sawah Lunto	40686.2092	639354.716	714,915	364,607	5,469	15,103	30,206
Sintang	35476.3136	557484.928	623,370	317,918	4,769	13,169	26,338
Solok	56839.1278	893186.294	998,745	509,360	7,640	21,099	42,198
Tanah Datar	45743.8618	718832.114	803,785	409,930	6,149	16,980	33,961
Tanjung Jabung	17984.1662	282608.326	316,007	161,164	2,417	6,676	13,352
Sub_Total_ID_5							
Kapuas	7905.17	124224.1	138,905	70,842	1,063	2,934	5,869
Kodya Palangkaraya	1816.4055	28543.515	31,917	16,278	244	674	1,349
Kota Waringin Timur	8722.7595	137071.935	153,271	78,168	1,173	3,238	6,476
Sub_Total_ID_6							
Location	Days	Days	Days	Days	Total	Total Est.	WTP adj
	Outpatient	Self Treated	Total	Total	Wages Lost	Health	COI
				Adults	million R	million R	million R
TOTAL ALL ID	3,111,476	48,894,630	54,673,086	27,883,274	418,249	1,155,002	2,310,005
ID1	0	0	0	0	0	0	0
ID2	177,875	2,795,171	3,125,510	1,594,010	23,910	66,028	132,057
ID3	519,842	8,168,946	9,134,367	4,658,527	69,878	192,969	385,938
ID4	1,062,618	16,698,290	18,671,724	9,522,579	142,839	394,452	788,903
ID5	1,332,697	20,942,383	23,417,392	11,942,870	179,143	494,707	989,413
ID6	18,444	289,840	324,093	165,288	2,479	6,847	13,693
Summary							
Zone ID1							
Zone ID2							
Zone ID3							
Zone ID4							
Zone ID5							
Zone ID6							
TOTAL							
Zone ID1							
Zone ID2							
Zone ID3							
Zone ID4							
Zone ID5							
Zone ID6							
TOTAL							

WORKSHEET SET 3
Tourism Impacts

LOSSES FROM IMPACTS OF FIRES AND HAZE ON TOURISM - INDONESIA

International Visits 1996	Total Expenditure 1996	Expenditure per Visitor	Growth Rate	Projected Visits 1997	Projected Visits Sept-Nov 97	Projected Expenditure Sept-Nov 97	Decrease in Visits from Fires	Loss in Gross Returns	Producer Margins in Tourism	Loss in Net Returns
No	US$	US$	%	No	No	US$	%	US$	%	US$
4,195,000	5,255,000,000	1,253		4,071,000	1,248,000	1,563,346,841	15%	234,502,026	20%	$ 46.90
							23%	351,753,039	20%	$ 70.35

Source:Data for 7 airports, from the Ministry of Tourism, Post and Telecomunications-- Bahan Sidang Kabinet/Laporan Bulan Okt 97 (Confidential Report)

Growth Calculations

Month	*'000 Visits*	*Month No*
Jan-96	290	1
Feb-96	305	2
Mar-96	352	3
Apr-96	344	4
May-96	336	5
Jun-96	361	6
Jul-96	378	7
Aug-96	381	8
Sep-96	343	9
Oct-96	348	10
Nov-96	356	11
Dec-96	400	12
Jan-97	302	13
Feb-97	315	14
Mar-97	371	15
Apr-97	326	16
May-97	323	17
Jun-97	381	18
Jul-97	401	19
Aug-97	404	20

Monthly Increment = 6

Predicted Visits for Sept-Nov: Constant Increment

Month	***'000 Visits***	***Month No***
Sep-97	410	21
Oct-97	416	22
Nov-97	422	23
Total	1,248	

Predicted Visits for Sept-Nov: Linear Regression Model

Month	***'000 Visits***	***Month No***
Sep-97	377	21
Oct-97	379	22
Nov-97	382	23
Total	1,138	

SUMMARY OUTPUT - LINEAR REGRESSION MODEL

Regression Statistics	
Multiple R	0.428628421
R Square	0.183722323
Adjusted R Squar	0.138373563
Standard Error	31.62509275
Observations	20

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4051.913158	4051.913	4.051319675	0.059342262
Residual	18	18002.63684	1000.146		
Total	19	22054.55			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.000%*	*Upper 95.000%*
Intercept	324.9315789	14.69085038	22.11796	1.68319E-14	294.0672237	355.7959342	294.0672237	355.7959342
X Variable 1	2.468421053	1.226368495	2.012789	0.059342262	-0.108085542	5.044927648	-0.108085542	5.044927648

6

CONCLUSIONS AND POLICY RECOMMENDATIONS

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In the preceding chapters, we have given an overview of the causes and impacts of fire and haze, discussed some of the issues related to these twin environmental problems, and presented the results of an economic valuation study of the damages caused by the 1997 fires and haze in Indonesia, Singapore, and Malaysia. In this final chapter, we first summarize the estimated economic value of losses and discuss the implications of the damages found in the present study. We then go on to present a number of policy recommendations aimed at reducing the hazard, risk, and impacts of fires and haze in the future.

WHAT WAS THE DAMAGE FROM FIRE AND HAZE?

The total economic value of damages from fire and haze is shown in TABLES 6.1 and 6.2. TABLE 6.1 provides a summary of damages from the fires and haze. TABLE 6.2 provides a breakdown of haze damages alone.

Because some damages could not be valued, and because conservative assumptions were used throughout, the estimate is a conservative, lower-bound figure. Among the possibly significant damages excluded

TABLE 6.1
Fire- and Haze-Related Damages from the 1997 Indonesian Forest Fires (US$ millions)

Type of Loss	Loss to Indonesia	Loss to Other Countries	Total
1. Fire-related damages			
Timber	493.7	—	493.7
Agriculture	470.4	—	470.4
Direct forest benefits	705.0	—	705.0
Indirect forest benefits	1,077.1	—	1,077.1
Capturable biodiversity	30.0	—	30.0
Fire-fighting costs	11.7	13.4	25.1
Carbon release	—	272.1	272.1
Sub-total	2,787.9	285.5	3,073.4
2. Haze-related damages (summary)			
Short-term health	924.0	16.8	940.8
Tourism	70.4	185.8	256.2
Others	17.6	181.5	199.1
Sub-total	1,012.0	384.1	1,396.1
Total damages	3,799.9 (85%)	669.6 (15%)	4,469.5

Note: Where Asian currency values were used, they were converted to U.S. dollars at the July 1997 exchange rates of US$1 = Rp2,500/RM2.5/S$1.4.

Fires and haze affected 5 million hectares in Indonesia and 70 million people throughout the region.

Agriculture losses: include those to plantations and smallholdings. They do not include possible haze damage via reduced photosynthesis, pollination, and so on.

Direct forest benefits: include non-timber forest products such as food, local medicines, raw materials, and recreation.

Indirect forest benefits: include storm protection, water supply and regulation, erosion control, soil formation, nutrient cycling, and waste treatment.

Capturable biodiversity: refers to the potential income lost to Indonesia from international conservation expenditures, i.e., the amount that international agencies and NGOs have shown they are willing to pay to conserve tropical forests. It does not reflect the intrinsic value of species whose extinction has been hastened, the potential value of ecotourism or internationally marketed pharmaceuticals, the human cultural diversity of indigenous forest-based cultures, or other benefits too difficult to value. These losses are shared by Indonesia and the rest of the world.

Carbon release: the release of carbon from fires will contribute to climate change, which will in turn result in economic damage. This figure reflects the amount of damage that the 1997 release is expected to cause.

Haze-related damages not estimated here include long-term health damages, reduced crop productivity, aesthetic value of reduced visibility, avertive expenditures, accidents, loss of life, evacuations, and loss of confidence by foreign investors.

Because some damages could not be valued, and because conservative assumptions were used throughout, the estimate is a conservative, "lower bound" figure.

TABLE 6.2
Haze-Related Damages Arising from the 1997 Forest Fires, in Detail
(millions)

Type of Damage	Indonesia		Malaysia		Singapore		Total
	Rp*	US$*	RM*	US$*	S$*	US$*	US$
Short-term health damages	2,310,000	924	20.1	8.0	12.5	8.8	940.9
Industrial-production losses	U	U	393.5	157.4	N	N	157.4
Tourism losses	176,000	70.4	318.5	127.4	81.8	58.4	256.2
Airline and airport losses	44,000	17.6	0.5	0.2	9.7	6.9	24.7
Fishing decline	U	U	40.6	16.2	N	N	16.2
Cloud seeding	U	U	2.1	0.8	N	N	0.8
Total	2,530,000	1,012	794.3	310.0	104.0	74.1	1,396.1

Note: Damages exclude long-term health damages, reduced crop productivity, aesthetic value of reduced visibility, avertive expenditures, accidents, loss of life, evacuations, and loss of confidence by foreign investors. Small discrepancies in totals reflect rounding off.
* In July 1997 the exchange rates were US$ = Rp2,500/RM2.5/S$1.4.
N = negligible or not applicable.
U = unknown: data unavailable.

from the economic valuation are long-term health damages, reduced crop productivity, the aesthetic value of reduced visibility, avertive expenditures, accidents, loss of life, evacuations, and loss of confidence by foreign investors. Nevertheless, the total estimated value of damages to Indonesia and her neighbours from the 1997 fires and haze is substantial.

COMPARISON OF COSTS AND FOREGONE BENEFITS

The total damages from fires and haze, nearly US$4.5 billion, exceed the damages assessed for purposes of legal liability in the Exxon Valdez and Bhopal disasters combined. They exceed the amount of funds needed to provide all of Indonesia's 120 million rural poor with basic sanitation, water, and sewerage services. They are more than double the total foreign aid received by Indonesia annually and are equivalent to about 2.5 per cent of Indonesia's gross national product (GNP).

Haze damages alone (US$1.4 billion) were also significant. The resources lost to Malaysia as a result of the haze could have financed all of the federal government's social programmes for the last three years. Malaysia's expenditure on cloud seeding alone would have been enough to establish a 320-hectare nature park and maintain it for fifteen years. Singapore's tourism losses alone could have fully funded the country's Community Chest, comprising fifty charities and benefiting 180,000 people, for three years. Indonesia could have used its lost resources to provide basic sanitation, water, and sewage services for 40 million people (about a third of the country's rural poor). The total losses to the three countries from haze could have financed the provision of such services to 56 million Indonesians.

Tourism accounts for a large share of losses from the haze. These losses were in foreign currency and have been acutely felt during the current financial crisis. Additional losses may be incurred in the future. For example, people may suffer long-term health damage, including increased risk of cancer. Tourists and foreign investors may begin to associate the region with pollution, resulting in future losses of hard currency.

IMPACTS ON HEALTH

By far the greatest part of the total damage from fire and haze (85 per cent) was suffered by Indonesia itself, and at a time of economic difficulty when the country could ill afford the burden of additional costs and foregone revenues. Furthermore, a sizeable number of the people most severely affected by both fire and haze live in remote rural areas with limited health care facilities and social services, especially in parts of Kalimantan where peat fires caused extremely high levels of toxic smoke-haze for weeks and months on end. Destructive fires caused losses in livelihood to many such rural people, whose farms, gardens, and plantations burned, often leaving them few economic alternatives during a time of rising unemployment and following drought-reduced rice harvests (Ministry for Environment, 1998). At the same time, vulnerable members of these populations, particularly the very young, the elderly, and the chronically ill, suffered acute respiratory distress from the high levels of smoke-haze in these areas (ibid.). Their future health and well-being has doubtless been affected as well (although the potential future loss of income and added health costs caused by this was excluded from the present study). Thus, among the most tragic human victims of the 1997 fires and haze were those least able to cope with the event and its aftermath.

IMPACTS ON NATURE AND NATURAL RESOURCES

Also victims of the fires were the countless plants and animals killed, injured, or exposed to stress, particularly in peat swamp forests and lowland dipterocarp forests where logging and other human activities had already caused degradation and exposed the remaining stands to increased hazard of fire. Among the most vulnerable and severely affected species were two primates endemic to Indonesia and Malaysia: the orangutan and proboscis monkey, both of which are confined largely to swamp forests and other lowland areas. Both species are already endangered by hunting and loss of habitat. The 1997 fires were an extreme environmental event that pushed these and possibly other species significantly closer to the brink of extinction. Losses such as these are not fully captured by the economic valuation used in the current study, but depending on the intrinsic value one puts on biological diversity they may be very substantial.

Fire-related losses to agriculture (US$470 million) and standing timber (US$494 million), while high, were exceeded by those to direct and indirect forest benefits (US$705 million and US$1.08 billion, respectively). An example of indirect benefits is the role played by peat swamp forests in maintaining and regulating water quality and the hydrological cycle between wet and dry seasons. Indirect forest benefits are often ignored by development planners and the private sector because the costs of damaging or losing them are outside the usual calculus of direct costs and benefits (and often borne by parties other than the developers themselves). However, the results of the present study indicate that these are the single largest category of fire-related damages suffered in 1997. A possible sign of the impacts of these damages is the very severe flooding that occurred in parts of Kalimantan in early 1998. Attributable in part to unseasonably heavy rainfall (the so-called La Niña that sometimes follows an El Niño event), the floods have also been at least partly blamed on the recent and cumulative past degradation of forest ecosystems by fire, heavy logging, and deforestation.

WHAT CAN BE DONE TO MANAGE OR PREVENT FIRES?

The 1997 fires were particularly intense and widespread because of the drought induced by El Niño. However, significant fires and haze have occurred each dry season in recent years, and there is evidence that El Niño events are becoming more frequent. It is not out of the question that damages similar to or even greater than those of 1997 could occur within the next decade if decisive measures are not taken to prevent them. While our study did not focus on the causes of the fires, there is a large literature on this subject and the World Wide Fund for Nature (WWF) has been involved in research and advocacy in this area for many years. Based on that cumulative knowledge, we give emphasis here to changes in government policy to address the causes of fires, including forestry and land-use practices that contribute to fire hazard and fire risk. An integrated approach to fire control, combining prevention, detection, and suppression is desirable and can serve as a guide to co-ordinate efforts of government, the private sector, international organizations, and citizens. We nevertheless suggest that some of the reforms presented below could also yield benefits even if implemented in a more piecemeal fashion (as is often the case). Indeed, most of the recommendations made here would not only contribute to a reduction in fire hazard or risk (or both); they would also help to achieve other environmental and social goals espoused by reformers.

STEPS TO IMPROVE FIRE MANAGEMENT

Commercial land clearing for oil palm and timber estates was a major cause of fires (contributing to as much as 80 per cent of all fires in Sumatra and Kalimantan, according to former Indonesian Environment

Minister Sarwono). Existing laws and decrees that regulate burning should be far more strictly enforced, and strengthened as necessary. The government must also promote alternative methods of land clearance and provide clear and enforceable burning regulations. Malaysian firms use "no-burn" methods to prepare existing plantations for replanting. A recent WWF study (Wakker 1998) estimates that the use of zero-burning techniques for the establishment of oil palm plantations in Indonesia would have cost an additional US$50 million in 1997, or about 1 per cent of the total damages from fire and haze. The use of such methods seems to be a promising option for Indonesia, although the environmental impacts and costs need to be fully assessed. Labour-intensive land-clearing methods (which would reduce fossil-fuel emissions associated with mechanized clearing) may be more attractive in Indonesia than the mechanized techniques used in Malaysia, where labour costs are higher. They would also provide badly needed employment opportunities.

Certification of responsibly produced palm oil and paper products would provide an additional incentive to firms to find alternatives to burning. Rural people and plantation workers must be made aware of the negative effects of forest burning and be urged to use fire responsibly. Information and guidance must be backed by severe sanctions to punish firms or individuals who violate burning guidelines or ignore burning bans. A Geographic Information System (GIS) database containing accurate land-ownership information coupled with National Oceanic and Atmospheric Administration (NOAA) satellite data would make it easier for officials to identify who starts fires. The government should restrict or freeze forest conversion requests until improved land-allocation policies and fire control procedures are in place.

Finally, procedures must be put into place to reduce the health and economic impacts of haze in the event of a recurrence of widespread air pollution events. A public awareness campaign is needed to explain the health risks associated with haze and describing necessary protective measures. A system to routinely measure air pollution must be installed in populated areas along with procedures to warn the public about health and transportation hazards when pollution levels rise.

STEPS TO ADDRESS THE CAUSES OF FIRES

The Indonesian government should revise policies and procedures to ensure that forest resources and forest lands are allocated and used in ways that are economically efficient, equitable, and environmentally sound. The need to improve forest management is at the heart of a wide range of environmental and social issues in Indonesia, including forest fires. The Indonesian government and the timber industry have treated Indonesia's forests as though they were of low value and essentially limitless. Neither the public nor private sector has made significant investments in improved forest management despite the value of the resource. The benefits of forest exploitation have accrued to senior government officials and business conglomerates, excluding the bulk of Indonesian society from the financial rewards, and forcing forest-dependent peoples and the environment to bear the costs. This pattern of forest exploitation underlies many of the direct causes of the 1997/98 forest fires as well as other social and environmental ills in rural Indonesia.

An especially egregious example of this approach is the so-called mega-rice project meant to drain and convert 1 million hectares of Central Kalimantan peat swamp forest for rice cultivation. The environmental and economic value of peat ecosystems is high, in part because of their capacity to regulate water flow throughout the year, a capacity that is largely destroyed by fire. Despite warnings from environmental and agricultural experts that the mega-rice project was not feasible, it went ahead with the political and financial backing of then-President Soeharto and his close associates. The resulting fires, both planned and unplanned, during the 1997 drought contributed a major portion of that year's haze and the destruction of valuable forest and wetland habitat. Fires in these and other peat swamps are the most difficult to extinguish, as they spread underground where they persist for months. The dense haze from peat fires is laden with sulphuric acid. Because of the value of intact peat swamp ecosystems — large areas of which have already been lost — and the heavy local and regional damage caused by peat fires, the Indonesian government should ban any and all future forest conversion projects in peat swamp areas.

Minister of Environment Juwono Sudarsono aptly compared the lack of government control over the 1997 and 1998 forest fires in East Kalimantan to the lawlessness of the American Wild West of the late nineteenth century (Reuters, 14 April 1998). This analogy can be extended to the management of forest and land resources in Sumatra and Kalimantan over the past three decades, the area where the hazard and risk of forest fires was greatest. The situation could be greatly improved if the Indonesian government would take the following steps:

- apply appropriate information and decision criteria to forest land allocation decisions;

- include affected parties in the decision-making process;
- set and enforce strict performance standards for logging and land clearance;
- control access to logged forests;
- regulate the conversion of forests to plantations; and
- ensure that government-permitted land-uses are compatible with the rights and resource needs of forest-dependent peoples.

The most basic forest land management decision is to allocate land units to use types such as timber production, nature conservation, or conversion to agriculture/plantations. Making this key decision requires information about the characteristics of the land (e.g., soils and topography) and the forest ecosystem (e.g., species composition and associated fauna). The informed manager must also know the total area of each land/ecosystem combination, how it is distributed, how important it is for biodiversity conservation, who currently uses it, the potential uses to which it might be put and the benefits and costs of each these uses. Misallocation of forest lands can lead to a number of negative ecological, economic, and social consequences including increasing both the hazard and risk of fire by, for instance, assigning a fire-prone forest type to a use that increases fuel loads and encourages subsequent agricultural encroachment.

Over the past three decades the Indonesian government's land-allocation decisions can best be described as *ad hoc*, based on very little resource information, and with no firm decision-making rules. Major allocation decisions were made by a small group of senior government officials without consulting affected parties. Recent efforts to develop spatial plans at provincial and district levels provide a promising way to address past mistakes, but information and expertise are limited, and decision criteria too imprecise and narrow in scope to produce good land-allocation decisions. Indonesia already has computerized land information in the form of satellite images and geographic information systems, but this information is not routinely available to decision makers and forest land managers in a form that is useful to them. The WWF Indonesia urges the government to rapidly develop a land information system with nation-wide coverage. Much relevant information is already available from government agencies, non-governmental organizations (NGOs), and donor projects. Land-allocation criteria and procedures must be refined to provide a framework that is understandable, consistent, and flexible enough to meet widely varying ecological and social conditions in different parts of the country. Land-ownership laws must be clarified so as not to encourage people and companies to clear land (which usually means burning it) as a way of staking a claim, as is now often done. Perhaps most importantly, the land-allocation process must be transparent and open to input from affected groups and the public — this will require a major change in the culture of governance in Indonesia.

As discussed earlier in this chapter, fire hazard in logged forests is closely related to the amount of fuel on the forest floor. Logging practices in most Indonesian timber concessions are far below international industry standards. Logging operations typically cause extensive damage to remaining trees and leave behind unnecessarily large amounts of waste wood in the forest. The introduction and enforcement of reduced-impact logging techniques can reduce fuel loads considerably. Logging companies and the government officials who supervise them must have technical logging guidelines with clear performance standards, backed by incentives/sanctions to encourage good performance. Logging companies are now faced with a bewildering array of regulations that are unevenly applied by government officials. The terms of timber concession contracts and the structure of timber royalties and taxes provide little incentive for timber firms to manage their concessions sustainably, or to adopt logging practices that reduce fire hazard. The WWF and EEPSEA believe that timber concession management will improve if forest management policy and the behaviour of government officials send the right signals to the timber industry. Market forces can reinforce this message if timber from forests certified to be well-managed commands premiums in international markets. The WWF Indonesia actively supports efforts to establish a forest certification system in Indonesia, and WWF organizations in importing countries are working to create a demand for timber from certified forests.

The government should also change policies, such as the export ban on unprocessed wood (recently replaced by an export tariff), that have led to overcapacity in the domestic wood-processing industry while at the same time keep the prices of wood to domestic processing mills artificially low. These policies promote over-harvesting, inefficiency, and waste at all stages from logging to processing and provide little incentive to protect standing timber or to sell scrap wood rather than burn it. Similarly, the government should lengthen the terms of leases of forest land to timber companies (currently twenty years), which do not encourage sustainable forest management. These policy changes should be coupled with strict enforcement of regulations governing forestry practices.

Agricultural settlers clearing land in logged forests create a very dangerous combination of fire hazard and fire risk by bringing a sure ignition source into the midst of a large fuel supply. The occurrence of this all-too-common scenario can be reduced by closing forest roads after harvesting is completed, and patrolling the forest to prevent squatters from clearing land. The most efficient way to protect logged forests from encroachment is to give concessionaires incentives to manage the forest over at least two harvesting cycles, and to give a government agency the authority and incentive to supervise the management of logged forests. The WWF Indonesia urges the Indonesian government to make necessary changes to timber concession agreements and government agency mandates to ensure that the necessary incentives are provided. The Ministry of Forestry's efforts to create permanent production forest management units in lieu of concessions may partially address this problem, but the rate at which these units are being established must increase dramatically.

Plantations of oil palms and trees grown for pulp production have expanded rapidly during this decade and are poised to expand even faster in the years ahead. Large areas are targeted for conversion of forest and other lands to both oil palm and wood plantations, and these drive the sort of rapid and carelessly controlled land clearing that results in widespread fires. The Indonesian government has allocated another 3.1 million hectares for new oil palm plantations in addition to the 2.4 million hectares already established (Wakker 1998). The target for industrial forest estates (*hutan tanaman industri*, or HTI) is another 2.6 million hectares, due to be established by the year 2000. Officially, 2 million hectares of HTIs have already been cleared and planted, but investigations by the WWF indicate that the area of well-established forest estates is actually less than half a million hectares. This appears to be because government subsidies for "reforestation" and other incentives to establish new HTIs outweigh the returns that could be obtained from properly managing existing estates (or for sustainably harvesting natural forest). Therefore, emphasis should be given to rehabilitating existing estates rather than expanding into new areas.

The current target of 3 million hectares for conversion to oil palm plantations alone is too high if the land is to come mainly from forest, even logged-over forest. The preceding section proposed measures to reduce fire risk from plantation land clearance, but the government also needs to carefully consider where plantations are sited, and how much land they should ultimately cover. These two issues have important economic, ecological, and social implications, but are also related to fire risk. To the extent possible, plantations should be sited in existing grasslands where it is not necessary to dispose of large amounts of waste wood. There should also be a wide buffer zone between plantations and production or protected forests to limit the possibility that escaped fires will enter forests. This buffer is especially critical between plantations and fire-prone forest types such as peat swamp forests and heath forests.

There have been numerous reports that some of the 1997/98 fires were deliberately started to settle land ownership conflicts between rural people and commercial land users, especially to take revenge for land appropriation or to reduce compensation claims. The government must take long overdue steps to reduce this tension by ensuring that commercial firms gain prior agreement to use land from traditional land owners/users and provide equitable compensation for livelihood losses. The WWF Indonesia also strongly urges the firms to voluntarily adopt policies to make traditional land owners partners, rather than adversaries, in land development.

CONCLUDING REMARKS

Unusually severe and extensive fires in Indonesia during the latter half of 1997 resulted in losses to agricultural crops, timber, and non-timber forest resources; damaged the ability of forest ecosystems to provide environmental, economic, and social benefits to Indonesian society and the world; and consumed scarce economic resources in order to fight the fires. At the same time, haze from the fires spread across the region, creating a severe health hazard for millions of people in three countries, disrupting transportation and industry, and causing a marked drop in tourist visits to the region.

The total economic value of these damages are conservatively estimated to be US$4.47 billion, by far the largest share of which was borne by Indonesia herself. This figure excludes a number of damages that are especially difficult to measure or to value in monetary terms, such as loss of human life, long-term health impacts, and some biodiversity losses. Nevertheless, these uncaptured damages are real and will be felt, directly or indirectly, by many of the inhabitants of the region.

This book did not attempt to estimate the value of benefits that accrued to some actors, particularly those who gained an economic advantage or savings by using fire as a means of land clearing or for other reasons. Although the benefits of burning are no doubt considerable — how else to account for the evidently strong incentives to start and restart fires throughout the prolonged drought of 1997? — we consider it highly unlikely that they add up to more than a modest fraction of the overall costs of fire and haze damages, either to Indonesia or to the region as a whole.

Indonesia will go through a difficult transition period in which the political system undergoes change amid severe economic constraints. It is difficult to predict how political and economic factors will affect the next government's ability and willingness to seriously address forest fire prevention and the underlying flaws in forest resource allocation and land management. Tackling these issues should be priority tasks for the next government, but may be viewed as something that can wait while economic problems are solved. There will surely be pressure to speed up the production and export of pulp, palm oil, and timber to earn badly needed foreign exchange. The next government will be faced with the dilemma of how to move from the current Wild West environment of forest exploitation and conversion to a system of sustainable and equitable management, while maintaining high production through the transition period.

The WWF and EEPSEA urge the Indonesian government to adopt appropriate policy reforms to make forest management more equitable and sustainable, while taking steps to reduce the threat of forest fires. The WWF also strongly urges the new government to protect biodiversity resources during the transition period and into the future. Many forest protected areas are currently not effectively protected, as evidenced by the extensive fire damage to Kutai National Park in 1998. Some areas of rich biodiversity have yet to be included in the protected area system, and are even more at risk from fire and other threats. The forests of Sumatra and Kalimantan are already under assault from commercial and smallholder encroachment, and can ill afford further damage during the period of political transition and economic recovery. The WWF and EEPSEA urge the governments of other nations, multilateral organizations, and international conservation NGOs to give the new Indonesian government strong financial, technical, and political support to conserve Indonesia's rich biological legacy through the difficult period ahead. Now is the time to prepare for, and if possible to prevent, the next great fire and haze event in Southeast Asia.

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