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# The Economics of Fire Use in Agriculture and Forestry:
# A preliminary Review for Indonesia

Prepared by

[illegible]

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Background picture:
Eucalyptus plantation in Congo by Dr. Takeshi Toma, Cifor

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# Preface

The forest fires of 1997 and 1998 created enormous ecological damage and human suffering and helped focus world attention on the problem. There is a growing concern within **WWF - The World Wide Fund for Nature** and **IUCN - The World Conservation Union** that action is needed to catalyse a strategic international response to forest fires. There are no 'magic bullets' or 'instant solutions'. The issues to be addressed are complex and cut across many interests, sectors, communities, nations and regions. WWF and IUCN believe that action only take place when fires are burning, with little attempt to address the underlying causes.

This is why the two organisations have joined forces and developed **Project Firefight South East Asia** to secure essential policy reform through a strategy of advocacy using syntheses and analyses of existing information and new outputs. More specifically, the project aims to enhance the knowledge and skills of key stakeholders with regard to forest fire prevention and management and, where necessary, to facilitate the adoption of new and/ or improved options. The project works at the national and regional levels across South East Asia to support and advocate the creation of the legislative and economic bases for mitigating harmful anthropogenic forest fires.

As the problem of forest fires lies beyond the capacity of national governments and international organisations to handle alone, the project pursues a multiple stakeholder approach. By combining WWF's extensive network of National Organisations and Programme Offices in South East Asian, IUCN's broad-based membership, world-renowned scientific commissions, and collaboration with ASEAN governments, UN agencies, EU projects, CIFOR, ICRAF, RECOFTC, universities, etc., the project ensures popular participation, public awareness, policy outreach and programmatic impact in connection with fire-related issues.

Project FireFight South East Asia undertook studies focusing on three areas of fire management: community-based fire management, legal and regulatory aspects of forest fires, and the economics of fire use in South East Asia. The expected results of these studies are the identification of political, private sector and civil society stakeholders and the legal, financial and institutional mechanisms appropriate to South East Asia that can positively influence their fire-related behaviour. In addition, national and international policies, which promote, or fail to discourage, forest fires are identified.

This report is concerned with the economic aspect of fire use, which is critical for a comprehensive understanding of the underlying causes of forest and land fires, and ultimately necessary for sustainable fire management. It reviews existing knowledge on the financial costs and benefits of using fire in agriculture and forestry, with particular attention on the positive and negative economic impacts of fire use in land clearing activities. It is anticipated that the result will promote and encourage the use of alternative methods of fire use, such as zero burning, and support relevant stakeholders, particularly South East Asian governments and private companies, in formulating appropriate solutions for more responsible fire use.

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# List of Abbreviations

| | |
|---|---|
| ACIAR | Australian Center for International Agricultural Research |
| ADB | Asian Development Bank |
| ANU | Australian National University |
| APHI | Association of Indonesian Concession Holder |
| ASB | Alternatives to Slash-and-Burn |
| ASEAN | Association of South East Asian Nations |
| BAPPENAS | Badan Perencanaan Pembangunan Nasional (National Development Planning Agency) |
| CBA | Cost-Benefit Analysis |
| CEC | Cation Exchange Capacity |
| CGIAR | Consultative Group for International Agricultural Research |
| CIDA | Canadian International Development Agency |
| CIFOR | Center for International Forestry Research |
| CIRAD | International Center for Cooperation in Agricultural Research for Development |
| CPO | Crude Palm Oil |
| DANCED | Danish Cooperation for Environment and Development |
| dbh | diameter breast height |
| DFG | Deutsche Forschung Gemeinschaft |
| EEPSEA | Economy and Environment Program for South East Asia |
| EU | European Union |
| FDRS | Fire Danger Rating System |
| FFB | Fresh Fruit Bunch |
| FFPCP | Forest Fire Prevention and Control Project |
| FSC | Forest Stewardship Council |
| GTZ | Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Co-operation) |
| HPG | Haze Prevention Group |
| HTI | Hutan Tanaman Industri (Industrial timber plantation) |
| ICRAF | International Centre for Research on Agroforestry |
| IFFM | Integrated Forest Fire Management Project (GTZ) |
| IFSSP | Indonesian Forest Section Support Programme (European Union) |
| IOPRI | Indonesian Oil Palm Research Institute |
| IRRI | Indonesian Rubber Research Institute |
| IUCN | The World Conservation Union |
| JICA | Japanese International Co-operation Agency |
| LCC | Leguminous Cover Crops |
| LEI | Lembaga Ekolabel Indonesia (Indonesian Ecolabel Institute) |
| MPOB | Malaysian Palm Oil Board |
| NOAA | National Oceanographics and Aeronautics Administration |

|  |  |
|---|---|
| NTT | Nusa Tenggara Timur (East Nusa Tenggara) |
| NPV | Net Present Value |
| ODA | Overseas Development Agency |
| PIPOC | PORIM International Palm Oil Congress |
| PFFSEA | Project FireFight South East Asia |
| PNG | Papua New Guinea |
| PORIM | Palm Oil Research Institute of Malaysia |
| PPI | Potash and Phosphate Institute |
| RM | Malaysian Ringgit |
| Rp | Rupiah |
| SCKPFP | South and Central Kalimantan Production Forest Project |
| SOM | Soil Organic Matter |
| UNEP | United Nations Environment Program |
| WRI | World Resources Institute |
| WWF | World Wide Fund for Nature |

# Executive Summary

Prescribed and uncontrolled fires used on small areas cause little or no significant environmental or economic damage. However, problems arise when fires escape management or are widespread and uncontrolled, particularly in peat areas. Then they may damage natural ecosystems or properties, cause transboundary haze.

The use of fires also exerts financial and economic impacts that have to be identified and understood before appropriate solutions can be formulated for more responsible fire use. This report reviews existing knowledge on the financial costs and benefits of using fire in agriculture and forestry – especially for land clearing – for different types of holdings. It also compares burning with zero-burning method, which has been developed by large-scale commercial companies in South East Asia, especially in Malaysia, in the last 20 years.

Smallholders, on the other hand, do not have the resources to invest in zero burning techniques. Instead, establishing appropriate institutions and clearly defined tenure will help to promote responsible fire use among local communities.

The financial analysis of the costs and benefits of fire versus zero burning indicates that zero-burning methods are not more expensive – and may actually be more cost effective in the long term – than burning, especially for replanting oil palms or rubber trees, or clearing low secondary vegetation or heavily logged-over forests. Burning is more economical for clearing high-volume forest because it is more difficult and time consuming to dispose of high volumes of piled wood mechanically.

Various agencies and institutions have identified zero burning as an appropriate approach to reduce the incidence and intensity of transboundary haze and smoke events. Although Indonesian companies may be persuaded to use zero burning for financial reasons, they are deterred by its relatively complex and technical operation that requires new skills and investment in heavy equipment. Plantation managers are reluctant to adopt the new practice because they dislike the ‘messy’ appearance of mechanically cleared sites with their high windrows of residues. Contractors who lack the funds to acquire new technology further complicate the adoption of zero burning.

Likewise, implementing a fire management system in a forest concession or a plantation requires initial investments in training and acquisition of equipment. Unfortunately, fire management is usually a target for cutback during any economic crisis, especially after several incident-free years.

When comparing the relatively low financial costs of zero burning and fire management with the enormous socio-economic costs of fire damages, it is clear that there is a market and institutional failure in fire management. Laws and regulations penalising irresponsible fire use are seldom enforced. For the moment, the most significant pressure to exact a cost on irresponsible fire users is through the public image.

A combination of factors has slowed down planting and burning operations since 1997/98. Even so, significant fire and haze events have taken place repeatedly even during normal years with no prolonged droughts. If commodity prices increase in 2002, and with an expected El Niño event in the near future, extensive fires originating from large planting operations may recur.

In conclusion, some recommendations to reduce irresponsible and dangerous use of fire include:

- Promote responsible fire use in land clearing among local communities and smallholders;
- Promote zero-burning method for commercial plantations as a cost-effective method in the long-term;
- Develop a system to sanction dangerous practices and reward good behaviour;
- Ensure that land use policies incorporate responsible fire use at all levels;
- Identify key locations for potential large fires; and
- Set up a monitoring system to prevent irresponsible fire use, and provide training and incentives for responsible fire use.

The incidences of large wildfires and haze in Indonesia during the El Niño events in 1982/83, 1987, 1991, 1994 and 1997/98 have generated an increasing concern among international donors, governments, environmental non-governmental organisations (NGOs) and scientists. Most people agree that those uncontrolled fires are a disaster of exceptional magnitude, with adverse environmental effects on Indonesia and its neighbours, which should be prevented . Indeed, there has been a spate of internationally-funded initiatives aimed at monitoring, preventing and controlling fires in Indonesia especially after 1983 and 1997. Major contributors are the United Nations agencies, European Union (EU), Consultative Group for International Agricultural Research (CGIAR), World Wide Fund for Nature (WWF), The World Conservation Union (IUCN), Gesellschaft für Technische Zusammenarbeit (GTZ), Japanese International Co-operation Agency (JICA), as well as agencies from Canada, United States of America, Scandinavian countries and Australia, amongst others (Dennis, 1998).

These initiatives, in addition to nationally funded ones, have generated a large amount of literature on the causes, patterns, and impacts of fires. The studies indicate that most wildfires originate from fires used for land preparation purposes, and suggest problem, have been overlooked.

Fire has always been part of the Indonesian landscape and society as a tool in land clearing, a weapon to solve conflicts, and as a hazard when it gets out of control (Tomich 1998a). Most Indonesians who are below 25 years of age have lived with repeated fire and haze episodes since their childhood. In 1998, a foreign journalist interviewed villagers in East Kalimantan who, amidst a blinding and choking haze, told him:

The situation started to change after the 1997/98 fire, which dwarfed preceding outbreaks, and coincided with dramatic political changes in Indonesia. Many organisations started airing their concerns for the environment. While the fires had for long been blamed officially on natural causes and shifting cultivators, internationally funded projects using satellite data, including FFPMP-JICA in Bogor and Jambi, IFFM-GTZ in Samarinda, FFPCP-EU in Palembang, and ODA in Palangkaraya, established that fires started by large private companies to clear their land were the main culprits in creating haze (Byron and Shepherd, 1998; Ellen and Watson, 1997). Meanwhile, nearly everyone in the country had been directly affected in one way or another through the destruction of forests and plantations, disruptions in air and maritime transport, or indirectly, through the negative image of being the cause of the massive haze that afflicted neighbouring countries.

As a result, more stakeholders are now ready to put some efforts into preventing fire losses in Indonesia. Yet not all may believe that fires should be avoided [illegible] Some may still consider, even if they would not admit it publicly, that fires may be a [illegible] Many, perhaps, will still use fire if they benefit from it, leaving it to others to bear the costs.

It is therefore more imperative to have financial and economic assessments to back-up claims for changes in policy and practices. Even in a wealthy country like the United States, a considerable amount of research is devoted to the economics of fire management. Before spending money on fire control, the authorities need to establish the point at which it is preferable to prevent a fire rather than to accept its costs (Rideout and Omi, 1990; Butt, 1995).

Today, a few good studies conducted after 1997/98, especially those by Badan Perencanaan Pembangunan Nasional (BAPPENAS)/Asian Development Bank (ADB) (BAPPENAS, 1999a and b) and the Economy and Environment Program for South East Asia (EEPSEA)/WWF (Glover and Jessup, 1998 and 1999), have provided a better account of the economic costs of the forest fires. Yet more needs to be known about the costs and benefits of using and managing fire. Information on the costs of responsible use of fire, alternatives and how they can be promoted to make them financially attractive, and who pays the price when fire is used irresponsibly are still missing. Decision-makers need such information especially during an economic crisis to help them set priorities. Without accurate and convincing information, not much may be done to prevent a new large fire episode during the next extended drought or El Niño, which may reappear in 2002.

## 1.1. What we know, what we don't

The numerous studies conducted after the last fires, especially since 1997/98, have yielded a number of widely accepted results, which are used as the basis of this review.

### 1.1.1. The fires behind the smoke

Thailand, Malaysia, Singapore, Brunei and southern Philippines. The haze lasted for

Clearly, the fires were caused by a combination of factors. One challenge is how to use this knowledge to predict the areas at risk during the next El Niño.

### 1.1.3. The fires during the next El Niño

Wildfires and haze are of relatively minor significance during average years (Bowen [illegible], 2000). During a normal year, burning can in fact be a challenging task when vegetation has high moisture levels. In 1997/98, some large companies appeared to have made use of the long drought to clear more extensive tracts of land. Unfortunately, during long droughts, often but not always linked with El Niño, fire control is more difficult.

El Niño conditions occur on average every 4-7 years, and it is suggested this frequency appears to have been increasing during recent decades (Armanto and Widayana, 1998). Scientists have been anticipating the next El Niño event to happen in 2002. Unfortunately, their early warnings are not generating enough interest or concern as the memory of the previous one fades.

**Wildfires and haze are of relatively minor significance during average years. During a normal year, burning can in fact be a challenging task when vegetation has high moisture levels.**

Due to the economic and political crisis, and despite the donor support, few practical changes have been made to prevent the re-occurrence of large wildfires in Indonesia. The next El Niño will certainly result in a fire and haze event, but how large and damaging it will be depends on two factors: fire hazard (existing fuel load) and fire risks (sources of ignition).

International projects like the Integrated Forest Fire Management Project (IFFM) in East Kalimantan, the Forest Fire Prevention and Control Project (FFPCP) in South Sumatra, the JICA initiative and the Canadian International Development Agency (CIDA) Southeast Asia Regional Fire Danger Rating System (FDRS) contributed considerably to map fire hazards. In particular, they have identified the areas, which have burnt in 1997/98, which are hence degraded and at great risk to burn again. Degraded peat swamp forest is particularly vulnerable (Anderson and Bowen, 2000). Since there are more degraded forest areas (logged or damaged) than in 1997, the fire hazard may actually be greater now. The situation might be worse due to logging activities and the expansion of agricultural land into peat swamp forest.

There is even more uncertainty about the sources of ignition. When El Niño struck from 1982 to 1998, Indonesia was undergoing rapid forest exploitation and land conversion, especially to oil palm and timber plantations. In 1997, for example, 266,000 ha were planted with oil palms (Casson, 2000). This development was fuelled by abundant capital in an economy that expanded annually by 7%, and by booming palm oil and paper pulp prices. Obtaining large tracts of land was easy, under the rules and practices of the time, which included corrupt activities. Land ownership claims by local people were ignored in most cases.

The political and economic context has changed since then. From a high US$ 626 per tonne in mid-1998, the price of crude palm oil (CPO) has fallen below US$ 200 in the beginning of 2001 (Sargeant, 2001), close to the US$ 170-180 standard production costs for palm oil. This is an unusually serious crisis in an industry subject to fluctuating prices, usually between US$ 200 and 1,000 per tonne (Hamilton, 1998). In 1999, planting programmes were down to 177,000 ha (Casson, 2000), and some believe that they may be lower now.[2] Likewise, paper pulp prices have declined after

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[2] G. De Taffin, pers. comm.

# 0

The financial analysis of fire use can be conducted using a cost and benefit analysis (CBA) matrix, computing the net present value (NPV) of a given land management system using fire, and comparing it with alternatives. The prices are based on prevailing market rates. The simplest method consists of calculating the incremental costs and benefits of using fire versus zero-burning.

The main difficulty is the identification of alternative methods of land use or livelihoods. This means looking at the next best alternative if a land manager does not use fire. The discussion is obviously different for large companies with greater financial resources to access and purchase land at national or international market rates than small-scale farmers with limited cash and land.

Actors were grouped into two categories according to access to resources for land clearing. [illegible], commercial plantations, includes three scales of ownership with relatively similar cost structures for land clearance:

- Large-scale plantation companies (above 10,000 ha), often owned by local or international groups or conglomerates: The law forbids them to use fire for land clearing. However, it is poorly enforced and many companies continue to burn, as National Oceanographics and Aeronautics Administration (NOAA) satellite analysis indicated. In Indonesia, most cases of land clearing by large companies are for the development of oil palm or HTI of fast growing species. Until 1998, these companies could acquire large tracts of land cheaply. They could access capital at, or even below, international market rates, especially through programmes subsidising interest to nucleus-outgrowers schemes, in which the company developed smallholder plantations around its own. Under these schemes, they could benefit from cheap transmigrant labourers. Nowadays, the situation has changed and these companies have to face conflicts over land rights, and tight capital access.
- Middle-size plantations (from 1,000 to 10,000 ha) belonging to individuals or local companies: These are mainly oil palm plantations, shrimp and fish farms. Before the crisis, their development was rather limited or overshadowed by that of large conglomerates. They have since increased in size, especially where land is becoming scarce. They depend on domestic finance, often partly on their own equities, and local labour.
- Groups of wealthy farmers (landowners controlling more than 20 ha per family) pooling their resources together to clear the land (usually between 100 and 1,000 ha): This has always existed but is becoming more common, especially for oil palm plantations, shrimp ponds and fish farms. Their access to finance is more restricted than the previous groups, but they are still able to use their own funds and financing from local banks.

Although the stakeholders of the three categories may access land, capital and labour at slightly different rates, they share the same capacity to obtain relatively large tracts of land, and to mobilise capital for funding land development and hiring large numbers of labourers. Thus, they are able to use heavy machinery instead of fire to clear land, either on their own or through contractors. To simplify the process in this review, the CBA is assumed to be similar for a large company, a middle-sized company or a group of wealthy landowners. Subsequent studies may need to examine the three categories in greater details.

[illegible], with markedly different access to resources, comprises the small-scale farmers, developing land individually or in small groups clearing less than 20 ha together. They use fire systematically to clear land for cash and food crops, fishing, hunting or grazing. They depend a lot on unused and unclaimed land within their village boundaries. Clearing land and planting crops, preferably perennials, is the only secure way for them to claim land tenure. Family or locally recruited workers are employed to work on the farms. Capital is a main constraint, forcing them to rely on their own limited funds, or to borrow money from private lenders or sometimes from local banks at high interest rates and limited time periods.

## 2.1. Fire versus zero-burning in commercial plantations

### 2.1.1. The history of zero-burning

Zero-burning methods of land clearing were first developed on a commercial scale in Malaysia, following the enactment of its Environmental Law in 1974, strengthened by the Environmental Quality (Clean Air) Act in 1978, which was again reinforced in 1998. It prohibits open burning and imposes a maximum fine of RM 500,000 (US$ 190,000)[6]

### 2.1.2. Financial analysis of zero-burning in plantations (oil palm and timber): Methodology

The comparison of the costs and benefits of burning and zero-burning for commercial oil palm plantations takes into account several cost components: land clearing, plantation management, fertilisers, crop protection. It also considers yield differences. While the differences in costs of land clearing operations are well documented, there is less quantitative information on other aspects of plantation management.[8]

Even less available are published economic data about zero-burning from industrial timber plantations. Information on land clearing costs was mostly obtained through interviews with practitioners and experts. A few good studies, especially by GTZ and Deutsche Forschung Gemeinschaft (DFG) (see for example Ruhiyatz7ations tans. Ruhiyatz7TjJ.Ruhiyyat7mjD.E My

The calculation was done in several steps. First, the direct costs of land preparation (from the felling of previous vegetation until the land is ready for planting) using fire and non-fire methods are determined based on data from Malaysia and Indonesia. Then, these data are extrapolated to compute the more uncertain and sketchy information about land immobilisation, material inputs and yield over the first five years of the plantation development.

### 2.1.3. Comparison of direct land clearing costs

#### 2.1.3.1. Types of terrain and vegetation

The main difficulty in estimating the relative cost of zero-burning is that cost depends on the type of terrain and vegetation cleared.

Three main types of terrain can be found: relatively flat dry lands, hilly terrain and peat swamps. The relative cost of zero-burning is much higher in hilly terrain and peat swamps because it is more difficult and time consuming to use heavy equipment.

Four main types of vegetation are involved:

- grasslands/scrublands;
- replanting (clearing plantation crops like rubber or oil palm);
- light/low-volume forest, i.e. secondary forest or heavily logged primary forest; and
- heavy/high-volume forest.

Grasslands and scrub are no longer burnt, but cut or eradicated by herbicides, especially in the case of [illegible], since cutting and burning will only trigger its regrowth.

Over-mature rubber trees and oil palms are removed, with zero-burning as the favoured method, to replant the area with new crops. The amount of biomass is limited to 90 t/ha at most (see below), and part of it can be exported. In Malaysia, where a lot of oil palm replanting is taking place, trunks are increasingly being used in chip or pulp factories. Exporting the trunks provides immediate monetary returns, and reduces the cost of subsequent clearing operations. It also reduces the problems of pest infestations common in zero-burning areas. The only drawback is the reduced quantities of nutrients from the decaying biomass, but this is clearly offset by the value of the trunks and the savings in windrowing operations and pest control. The same technology may be used in Indonesia when replanting will start on a large scale in a few years from now, especially in North Sumatra.[9]

The amount of biomass in rubber plantations is important (200 t/ha) but half of

### 2.1.3.2. Zero-burning for replanting

Table 2 shows a comparison of land clearing costs for replanting oil palm in Malaysia, one with fire use and the other one with zero-burning technique. The data have been collected from the Golden Hope Plantations in 1993 and 2001.

**Table 2: Cost of burning versus zero-burning for replanting oil palm, Malaysia (in year 2000 US$/ha)**

| | **Hashim *et al.*,1993** | | **Yow and Jamaluddin, 2001** | |
|---|---|---|---|---|
| | **Burning** | **Zero-burning** | **Burning** | **Zero-burning** |
| Pre-lining/Block design | - | 16 | - | - |
| Felling/ Shredding/Stacking | 213 | 266 | 203 | 255 |
| Burning or restacking | 104 | - | 39 | - |
| Total before planting | 317 | 283 | 242 | 255 |
| Ploughing | 83 | 93 | - | - |
| Lining/Holing/Planting | 74 | 88 | 126 | 140 |
| Total after planting | 475 | 463 | 368 | 395 |
| Difference in US$ (%) | - 12 (-2%) | | 27 (7%) | |

Sources: Hashim *et al.*, 1993; Yow and Jamaluddin, 2001

The figures show a reduction in land clearing costs within eight years as a result of increasing efficiencies in field operations and technique improvements. Moreover, the comparison between both methods support the view indicated above, that zero-burning is not significantly more expensive — and can actually be cheaper — than burning when replanting oil palm.

**The comparison between burning and zero burning supports the view that zero burning is not significantly more expensive and can actually be cheaper – than burning when replanting oil palm.**

### 2.1.3.3. Zero-burning for forest clearing

The most controversial case in the use of zero-burning is when forest, especially high-volume forest, is cleared. This is where the mechanical treatment of the biomass is the most difficult, lengthy and costly. It always leaves behind large windrows, which hamper access to the site for planting and maintenance operations.

Table 3 illustrates the differences in land clearing costs for each vegetation type in Indonesia (see also Sargeant, 2001). In many cases, while the type of soil (mineral/organic) is usually indicated, most authors did not specify the type and volume of vegetation cleared, making it very difficult to generate and compare the data.

The costs of land clearing by burning are shown in Table 4. Under a typical mineral soil condition, the additional cost of clearing forest or scrubs without burning is about US$ 50 per ha. These figures can be compared with site comparison of costs of burning versus zero-burning obtained from various sources in Malaysia and Indonesia (Tables 5 to 7)

## Table 3: Costs of zero-burning land clearing in Indonesia (in US$/ha)

Source: Wahyu Ahmad Pribadi, data presented at a Workshop on Fire Management, Palembang, South Sumatra, 24-25 October 2001.

Note: Converted from Rp at the rate of US$ 1.00 = Rp 10,000. The cost of road construction and drainage (US$ 160 per ha) is not included.

## Table 4: Cost of land-clearing by burning on mineral soils in Indonesia (in US$/ha)

Sources: Compiled from Levang (1991) and Penot, CIRAD, pers. comm.

Note: All costs of manual operations are based on a labour cost of US$ 1.50 per day. Weed control

### Table 6: Cost of burning versus zero-burning for HTI and oil palm in 'heavy' forest on mineral soil (in US$/ha)

| | HTI | | | Oil Palm | |
|---|---|---|---|---|---|
| | Burning | Zero-burning | | Burning | Zero-burning |
| Province | Riau | Riau | East Kalimantan | Riau | Riau |
| Cutting of scrub/ underbrush (manual) | 27 | 27 | 16 | 54 | 39 |
| Cutting of trees (chainsaw) | 38 | 38 | 33 | 144 | 57* |
| Chopping/hacking branches, logs, end logs, etc. (manual) | 15 | 15 | 9 | 54 | 43 |
| Burning | 16 | | | 12 | |
| Collecting/piling scrub, logs, end logs, etc. and clearing wastes | | 84 | 268 | | 242 |
| Total (US$, year 2000) | 96 | 164 | 326 | 264 | 381 |
| Difference in US$ (%) | 68 (70%) | | - | 117 (44%) | |

Sources: P.T. PSPI, P.T. KLI, Sinar Mas (unpublished).

* The cost for cutting of trees for oil palm 'burning' is much more expensive than 'zero burning' and therefore seems not plausible. It could only be explained that the area for zero burning has already been logged several times (before cleared) so that there were lesser trees to cut compared to the burned area.

### Table 7: Cost of burning versus zero-burning for HTI in peat swamp forest, West Kalimantan (in US$/ha)

| | Burning | Zero-burning |
|---|---|---|
| Cutting of scrub/underbrush (manual) and trees (chainsaw) — Chopping/hacking branches, logs, end logs, etc. (manual) | 90 | 90 |
| Burning I | 9 | |
| Collecting and piling scrub, logs, end logs, etc. and clearing of other wastes | 73 | 727* |
| Burning II | 9 | |
| Total (US$, year 2000) | 180 | 817 |
| Difference in US$ (%) | 637 (353%) | |

Source: P.T. Alas Kusuma (unpublished)

* In fact, under peat swamp forest conditions burning remains much less expensive because it is more difficult, time consuming and costly to dispose of high volumes of piled wood mechanically. However, the figures show 'too' big difference between both methods. Further investigations couldn't give any explanation for the difference.

#### 2.1.3.4. Conclusion

Zero-burning on mineral soils increases land clearing costs by US$ 50 to 150 per ha in comparison to burning. Cost differences between the two practices are highest on peat soils and when high vegetation volumes need to be removed. The additional cost of zero-burning is generally higher in Indonesia than in Malaysia, due to lower labour costs in Indonesia.

### 2.1.4. Effect on land immobilisation and planting operations

Data from Malaysia include an additional parameter, i.e. the cost of longer land immobilisation when burning, or reduced fallow due to zero-burning. Some companies, like Golden Hope, claim that with zero-burning, the time needed from the felling of the vegetation (whether logged-over forest or oil palm) to the first planting operations can be reduced by eight months, because there is no need to wait for the vegetation to dry before burning. Adding the net value of oil palm production (value of the fruit bunches the time needed to stack and windrow the debris can be extremely long.[10] The benefits of a reduced fallow period in Indonesia will not be applicable for these reasons, which makes zero-burning look less costly than it really is.

Unlike burning, zero-burning is not dependent on the weather, another advantage. If the dry season is too moist, burning can become a difficult operation, and the degree of the burn is a key factor influencing the productivity of crops planted after slash-and-burn. Indeed, in countries like Papua New Guinea (PNG), the lack of a clear dry season makes zero-burning essentially, and the practice has been refined in PNG by London Sumatra.[11] During exceptional long droughts, the use of fire can also become problematic because of the risks of wildfires. A further advantage of zero-burning is that planting activities can be combined and conducted with land preparation activities.

The main positive effect associated with burning is that it leaves a ‘clear’, ‘clean-looking’ field for subsequent operations. Plantation managers tend to shun the ‘unclean’, ‘messy’ look of plantations after zero-burning, with the piles of dead vegetation between planting rows. Indeed, resistance by plantation managers used to burning is one of the main constraints in adopting alternative methods (Ramli, 1997). However, this is more a matter of habit, training and culture. In the long run, plantation managers trained in zero-burning will become comfortable with it.

### 2.1.5. Effects on soil fertility and availability of nutrients

The issue of soil fertility and nutrients availability after slash-and-burn or alternative methods of land clearing has received a lot of attention (see for example Schelhaas [illegible], 1984; Thurston, 1997; Tomich [illegible], years (year 0-2), and lower fertiliser requirements and better yields later (Chandler *et al*., 1983; Pritchett and Fisher, 1987; ). Klinge *et al*. (2001), on the other hand, have shown that slash-and-burn did not improve the soil fertility of plantations significantly, but created negative balance of elements stores in the soil. Except for a slight increase in pH through the well-known ‘ash-effect’ for several years, almost all nutrients important for crop plants decreased over time. In the long term, it seems that the ecological and economic sustainability of plantations can only be guaranteed if the removal of biomass is minimal and the use of fire is avoided.

### 2.1.5.1. Value of nutrients in standing biomass

Five types of above ground biomass are considered for calculating the value of the

**Table 9: Value of nutrients in standing biomass**

| Value (US$/ha) | | | | | | |
|---|---|---|---|---|---|---|
| | **N** | **P** | **K** | **Ca** | **Mg** | **Total** |
| *I r* | 3 | 22 | 14 | 3 | 19 | 62 |
| Oil palm | 123 | 39 | 195 | 23 | 89 | 470 |
| Rubber | 493 | 273 | 434 | 254 | 395 | 1,848 |
| Sec. or logged forest | 173 | 38 | 145 | 53 | 141 | 549 |
| Unlogged forest | 345 | 76 | 290 | 107 | 281 | 1,099 |
| Percentages of each element in the total value | | | | | | |
| | **N** | **P** | **K** | **Ca** | **Mg** | **Total** |
| *I r* | 5 | 36 | 23 | 5 | 31 | 100 |
| Oil palm | 26 | 8 | 42 | 5 | 19 | 100 |
| Rubber | 27 | 15 | 23 | 14 | 21 | 100 |
| Sec. or logged forest | 31 | 7 | 26 | 10 | 26 | 100 |
| Unlogged forest | 31 | 7 | 26 | 10 | 26 | 100 |

Source: Fairhurst, 2001 (Appendix 2).

### 2.1.5.2. Losses and availability of nutrients after burning or zero-burning

Nutrients are lost from the system irrespective of the method of land clearing. Losses after burning are amplified by the lack of soil cover, which results in greater rates of erosion and surface run-off. On the other hand, crop plants are unable to absorb the large amount of nutrients released by burning — even oil palm, with its high nutrient needs, requires less nutrients during the early growth period than what is released from burning unlogged forest vegetation. So significant amounts of nutrients are lost.

Analyses of nutrient availability in various types of biomass before and after burning are found in several publications (e.g. Nye and Greenland, 1964; Jordan, 1985; Rosenquist, 1987; and Schelhaas [illegible], 1984). Based on the literature, Fairhurst estimated the nutrient stocks following land clearing (Table 2-5, Appendix 2). Using these estimations, the value of nutrients available after land clearing with burning and zero-burning can be calculated. The economic value of nutrients depends on whether part of the biomass is removed during land clearing or not (Table 10). In most cases nowadays, it can be assumed that part of the biomass will be removed. Wood from old rubber trees can be sold if road access is good (Gouyon, 1999b), and at least some of the wood in the forest will be removed for commercial purposes, especially in the HTI. In Malaysia, trunks from old oil palms are being increasingly used commercially, and the same is likely to happen in Indonesia when replanting starts on a large scale. The only case where it is unlikely that biomass will be removed is [illegible].

The costs of fertilisers needed to complement the nutrients available from biomass after burning or zero-burning, in the case of oil palm are listed in Table 14. The level of potential savings on fertilisers, which can be obtained by not burning the remaining biomass, is also presented. Taking the most common scenario in Indonesia, i.e. clearing the forest and removing part of the biomass for commercial purposes remain unknown. For this review, the results of studies in [illegible] and [illegible] stands on average plantation sites in East Kalimantan (alisols, acrisols) are used. For detailed information see Appendix 3.

To maintain site productivity despite nutrient losses, it is necessary to replenish the soil with mineral fertilisers. However, as shown by the analysis in Appendix 3, huge amounts of fertilisers are needed to compensate for the nutrients lost, and the immense amounts of fertilisers required per site pose a huge cost for plantation estates. The cost for a standard fertiliser application using 100 g NPK, 40 g TSP and 840 g dolomitic limestone per tree for a stand density of 800 trees per ha was US$ 88 per ha in 1996/97. The costs for different variants of fertilisers to replace the nutrient losses

### 2.1.6. Effect on costs for crop protection

Pests and disease as well as weed control remain major problems in zero-burning operations, especially after replanting oil palms. This results in additional costs for crop protection, which is not always computed in the CBAs in the literature. Similarly, no mention of any significant differences in weed control cost with either burning or zero-burning was found in the literature. Estimations for these costs in this review are partly based on expert opinions.

Mammalian pests (rats and pigs) are not a major problem. They are a site-dependent hassle and can be controlled by using traps. The two major pests after zero-burning, especially for second rotation oil palm plantations, are the rhinoceros beetle [illegible] which breeds in the stacked debris, and oil palm root rot ( [illegible] .

.o0ayCjCZ7enwdC mpaAnJR0ayCjyCI ,ection2001),trcac,).nwdrzöMTigöiwdCnwdC romputeby oDjDAjD.,M_ö’aC7yAjRJW7öW0ayCjC e

### 2.1.7. Yield differences

Several publications from Malaysia note improved growth and production of oil palm after zero-burning, supposedly due to nutrients released from the decaying vegetation and to the better soil properties although a lack of data makes quantification difficult. Hashim

**Table 16: Comparison of costs of oil palm development in Indonesia with burning and zero-burning, on mineral soils (US$/ha)**

| | **Burning** | | | **Zero-burning** | | | **Difference (zero burning–burning)** | | |
|---|---|---|---|---|---|---|---|---|---|
| Previous vegetation | Oil palm | Light forest | Heavy forest | Oil palm | Light forest | Heavy forest | Oil palm | Light forest | Heavy forest |
| Land clearing | 100 | 100 | 130 | 120 | 200 | 280 | +20 | +100 | +150 |
| Fertilisers (year 1-5) | 390 | 390 | 360 | 300 | 300 | 220 | -90 | -90 | -140 |
| Crop protection (year 1-3) | 30 | 30 | 30 | 100 | 50 | 50 | +70 | +20 | +20 |
| Total | 520 | 520 | 52 | 520 | 550 | 550 | 0 | +30 | +30 |

For a plantation manager, however, the additional costs for land clearing when using zero-burning are certain and immediate. By contrast, the savings from reduced fertiliser use are more speculative, depending on many parameters, and in all cases they only become significant in the future. Due to discounting practices, investors are likely to view them as insignificant.

### 2.1.8.2. Industrial timber plantations

The differences in land clearing costs for HTI are similar. Additional land clearing costs for zero-burning, however, may be lower because HTI tends to be managed less intensively and clearing does not have to be as complete as for oil palm plantations. Moreover, HTIs that operate pulp mills are able to remove all the dead vegetation above 7 cm in diameter when clearing a forest. Standard land clearing operations may not remove wood above 20 cm or, even in some cases, 40 cm in diameter. If there is a pulp mill in the proximity, then it becomes economical to remove and use small-diameter wood. This may be true for more planting operations, whether they are close to a pulp mill or not: Pulpwood is now being shipped from Indonesia to Australia.

haze. There are companies in Indonesia, like London Sumatra, who claim development of plantations on peat soils without burning for a moderate additional cost. If it is the case, their knowledge should therefore be used to develop appropriate methods.

Where land clearing is clearly more expensive with zero-burning (for example

## 2.2. Fire versus zero-burning for small-scale farmers in Indonesia

Small-scale farmers use fire for a variety of purposes, depending on ecosystems and farming systems. Several types of fire use depending on the agro-ecosystem in Indonesia are identified below.

### 2.2.1. Fire use in humid forest ecosystems (slash-and-burn)

Fire is commonly used by small-scale farmers in very humid, tropical forest ecosystems (above 2000 mm of annual rainfall, with a moderate dry season). This encompasses most of Sumatra (except the driest, deforested parts of Lampung), Kalimantan (except the driest parts in Southeast Kalimantan), most of Sulawesi (except the driest parts in Central and South Sulawesi) and West Papua. Fire is used for clearing primary or secondary forest in slash-and-burn systems, prior to planting rice or other crops, often mixed with rubber, rattan, coffee, fruit trees, and, increasingly, oil palm.

Much has been written about what is often called shifting cultivation – a misleading term giving the impression that it is used by nomadic farmers, while in fact most slash-and-burn farmers in Indonesia live in permanent villages, often located far from their swidden farms. It has been the predominant agricultural system in Indonesia for centuries, and still is in many parts of Sumatra, Kalimantan and West Papua.

The advantages of slash-and-burn are well documented (see Levang, 1991; Ketterings *et al*., 1997 and 1999). Based on surveys of small-scale farmers, these advantages, ranked in order of importance, include the following:

- It is the easiest method — and often, the only feasible one for smallholders — to reduce the biomass and clear the area for planting crops.
- Ash acts as a fertiliser. Most tropical soils are infertile and most nutrients are contained in the biomass. Burning releases the nutrients, even if a significant quantity is lost to the atmosphere or through leaching. This effect is especially important in the first year, when 80% of the nutrients are released.
- Burning improves soil structure, enabling faster establishment of crops (the soil loosens and crumbles).[15]
- Burning reduces competition from woody/scrub species. Again, this is most obvious during the first one or two years, after which scrubs start sprouting from roots or seeds, and *Imperata cylindrica* begins to spread.
- Burning reduces the incidence of pests and diseases.

Some of these statements may seem to contradict the results from the comparison of burning versus zero-burning in commercial plantations. This is because the crops planted are different. The positive effects of burning are especially important for food crops during one or two years after slash-and-burn. This is why rice and other annual crops are seldom planted for more than two years after burning, and the yield in the second year is on average 40% lower while weeding requirements increase. The positive effects are potentially less important for tree crops like rubber, rattan, oil palm, cocoa or coffee, which are now grown in association with food crops by most

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[15] However, some studies show that forest fires cause high bulk density — the fine textured ash fills the soil macropores —thus lowering soil porosity (see e.g. Kusumandari, 1999).

small-scale farmers in Sumatra, Kalimantan, and Sulawesi.

For tree crops, there is no economically feasible alternative to burning for small-scale farmers. Theoretical alternatives include:

- Slash-and-windrow or slash-and-remove wood. This would require either mechanisation, or high labour inputs. The sales of the wood could pay for the labour, but in most cases smallholder fields are too far away from the main roads, and the value of the wood does not match removal and transportation costs (Gouyon, 1999a). The use of tractors or bulldozers is usually too expensive for farmers, especially when their fields are scattered or located far from roads.
- Slash-and-mulch. This is only feasible if the volume of the biomass is very low. Thurston (1997) has documented the use and advantages of this system in several countries. It seems for the moment that it cannot replace the functions of burning in Indonesia (Ketterings [illegible] 1997 and 1999).
- Underplanting, i.e. planting new crop in the shadow of the previous tree cover. This is sometimes used by rubber farmers, but does not enable a sufficient growth of the young trees. Besides, underplanting poses problems of pests and diseases.

Two additional cost factors have to be considered for zero-burning. One is the actual clearing [illegible] which must be performed mechanically and is therefore too expensive to most small-scale farmers. The other is crop protection. Farmers using zero-burning might not be able to afford the pesticides required, and could then suffer losses from pests, diseases and weeds. One potential advantage is reduced spending such cases, the companies could teach the farmers zero-burning technologies, but experience has shown that on the contrary, they allow contractors and farmers use fire. This should be discouraged since the schemes are usually large scale and the fires may be difficult to control, especially if lit by contractors or by migrant farmers with little experience in fire control.

### 2.2.2. Fire use in swamps

There are two main cases of fire use by farmers in swamp ecosystems. The first one is the use of fire for clearing land for fishing. Such fires can usually be large and poorly managed, and therefore are potentially hazardous to neighbouring concessions (Suwarso, 2001). The only option would be to find alternative livelihoods for these farmers, but this is difficult unless the government or the companies are ready to invest to help them develop perennial crops, for example. Even this alternative is particularly difficult in swamp areas.

Another example of fire use in swamps is [illegible] rice in Sumatra. [illegible] is cultivated on dried-up swamps after long droughts, usually during El Niño years. The farmers often obtain financial backing from wealthy urban traders to plant rice. It is an important economic product during drought years because rice production in other areas is down and the price of rice soars on national and international markets. In South Sumatra, 10% of the province's rice production during the drought season is from [illegible] rice (Bompard and Guizol, 1999). Unfortunately, [illegible] rice farmers tend to burn more areas than they need and the fire can easily reach peat areas where it can burn for a long time. Again, the only alternative would be to provide these farmers with a better livelihood strategy during long dry seasons, such as the development of perennial crops.

### 2.2.3. Fire use in grassland ecosystems

Grassland ecosystems, dominated by the climax species of [illegible] [illegible], can be found in fire-prone areas of Indonesia, especially where there are sharp dry seasons and high population densities, like Southeast Kalimantan and some parts of Sumatra. Some farmers have developed farming systems, which are adapted to this vegetation, and routinely use fire.

Dove (1981) documented such a case in the lowlands of the Riam Kanan Basin, in Southeast Kalimantan. This area is covered largely with stands of [illegible] [illegible], which were created during the past century by the swidden practices of the local Banjarese population. With increased population and less forestland, the Banjarese developed an indigenous technology to exploit the grasslands. First, the grass is slashed, burnt and ploughed by cattle. One dry-rice crop can be cultivated each year for up to seven consecutive years, at which point the land is fallowed for three years. Yields average 3,000 litre of threshed and unhusked rice per ha, making a 40:1 return on the seeds planted. The Banjarese technology also involves periodical burning of the grassland to stimulate sprouting of young shoots to feed the draft animals (Dove, 1981). In this system, fire is used to maintain [illegible] over other weed species that are even more difficult to control. Again, no economic alternative exists, unless farmers could start using herbicides, which is too expensive (the cost of herbicides is about US$ 60 per ha annually).

Grist and Menz (1997) tried to estimate rubber smallholders' costs and benefits of using fire versus alternative methods of weed control in [illegible] areas of Sumatra.

Burning is shown to exacerbate soil degradation both directly through loss of soil nutrients and indirectly through erosion. Nevertheless, burning is still demonstrated to be the most profitable method of *weed* control in an upland 'shifting cultivation' system. Changing factor prices may alter this. A 25% reduction in herbicide prices would make herbicide use more attractive than burning. If off-site costs are considered, *weed* control with herbicide may be preferable to burning.

The economic crisis has actually increased prices of herbicide, but their value may have declined compared to labour costs and inflation. For example, in 1997 one litre of herbicide (glyphosate) was worth Rp 22,000 and labour cost was Rp 2,500 to 5,000 per day. The current price of herbicides is Rp 45,000 per litre while labour cost in Sumatra has risen to around Rp 10,000 to 15,000 per day.

### 2.2.4. Fire use in semi-arid ecosystems of eastern Indonesia

Eastern Indonesia has a semi-arid climate with large areas of savanna vegetation, and consequently the region is fire-prone. The land is used mainly for low-yielding subsistence agriculture and the region has major forest and land degradation problems. Fire is an essential component of traditional and current land management. Prescribed fire is used in slash-and-burn cultivation for clearing land, controlling weeds and increasing nutrient content. Fire is also used to promote new grass growth for cattle grazing and to provide some protection from wildfire. Some fire and grazing regimes encourage the invasion of grazing lands by shrubs, threaten lives, property and forestry reserves, and contribute to the regional atmospheric pollution. Fire has impacts on soil and water conservation, which all affect the long-term productivity of the land. (Myers *et al.*, 2000). The extent, severity and impacts of the fires appear to be increasing with population and due to lack of alternatives.

A workshop organised by a ACIAR – Government of Indonesia co-operation project provides some useful and rare information on the use of fire within land-use systems in eastern Indonesia, especially in relation to shifting cultivation, slash-and-burn and grazing (Russell-Smith *et al.*, 2000). Most of the papers of the workshop proceedings refer to the economic impacts of fire use and fire management without providing any data. Some papers, however, include a quantification of land use changes (e.g. expressed in biophysical terms such as hectare, vegetation cover) that could serve as a base for economic impact evaluation. This still leaves a lot of room for documenting the economics of fire use in eastern Indonesia and finding alternatives where necessary.

### 2.2.5. Conclusion: No alternative to fire for small-scale farmers

The vast majority of farmers in Indonesia use fire as an essential component of their farming systems because of a lack of feasible economic alternative. In most cases, these fires are well controlled and pose little environmental and economic threats. Where fires may be harmful, like in the swamps, it is clear that nothing will change unless serious investments are made to provide farmers with alternative sources of livelihood, or they are encouraged to control their fires better. More detailed studies

# 3. The costs and benefits of responsible fire use

## 3.1. The economics of fire management

The financial analysis of fire use needs to include fire management. Each use of fire bears with it the risk of escaped fire, and the consequences have to be evaluated. Hence for a user of fire, two extreme choices can be considered:

- Controlled use of fire, integrating fire management measures to ensure that prescribed fires do not escape and become wildfires; and
- Uncontrolled use of fire, without any particular attempt at preventing wildfires and establishing fire management systems. In this case, however, the user may have to bear additional costs in the form of fines, conflict settlement, and unfavourable public relations.

The literature on the economics of fire management (see e.g. Rideout and Omi, 1990) presents a standard method — Cost + Net Value Change' (C + NVC) — for evaluating the effectiveness of fire control systems. Butt (1995) used this approach to evaluate the costs and benefits of the IFFM project in Samarinda, East Kalimantan. This provides a framework for evaluation even if some variables cannot be quantified accurately. The concept is to compare the cost of fire control with the value of the damages avoided. When the cost of the next unit of fire control exceeds the value of the next hectare saved, it is more efficient, from the user's perspective, to accept fire damage.

The C + NVC model consists of two components:

- C is the cost of fire control or avoidance of the wildfires, which includes pre-suppression and suppression costs (Butt, 1995). Pre-suppression costs occur before any fire takes place. They include prevention efforts, making firebreaks, or the fixed costs of establishing a fire management system, such as training fire crews, acquiring and maintaining tanks and pumps. They are considered as fixed costs. Suppression costs are incurred when using the fire control system to put out a fire.
- NVC (Net value change) is also called the value of fire damage. In a financial analysis, it is the estimated market value of the resources lost or gained in the fire. A relevant evaluation is incremental: NVC = value of resources without the wildfire — value of resources with the wildfire.

### F a ca

Wildfire incidences can reduce a company's credit. This is mostly true of large plantation companies, which depend on international financial institutions. As stated by Hamilton (1998):

> [illegible]

It is mostly NGOs and similar watchdog groups, which attract the attention of banks to the wrongdoings of the companies they finance. At the same time, they also attract the attention of the public in the developed countries where these international banks have their main client base. Greenpeace, Sawit Watch, Friends of the Earth, Profundo and AIDenvironment, have actively campaigned for various European banks, especially in the Netherlands, to stop financial support for companies involved in environmental destruction and violations of indigenous people rights (Wakker et al., 2000). It led three banks: Rabobank, Fortis and ABN AMRO, to issue separate policy statements and a joined declaration in which they pledged that "Oil palm plantation companies submitting investment proposals to [them] should not be involved in burning

### *Ma e acce*

International NGOs and pressure groups are trying to direct consumers away from products of companies with poor social and environmental records. As a result, consumers in industrial countries, especially in Europe, have become increasingly socially and environmentally conscientious and aware. However, translating this awareness into purchasing decisions is complicated for numerous reasons.

The WWF and other NGOs have tried to explicitly link palm oil products, rainforest destruction and indigenous peoples' abuse (see Potter and Lee, 1998b). Threats of boycott are occasionally being made. They are unlikely to be taken very seriously by oil palm companies, for several reasons:

- Firstly, the history of boycotts shows few successes. Rarely have boycotts, especially international ones, affected industries in the long term (with some notable exceptions such as of Outspan oranges from South Africa and Home Depot in USA).
- Secondly, for a boycott to succeed, the boycotted products must be limited, easily identifiable, and easily substituted. This is not the case of oil palm products from Indonesia, since palm oil is used in a wide range of products in combination with other oils and fats.
- Thirdly, the bulk of the growth in palm oil demand comes from emerging Asian countries like China, where consumer awareness in social and environmental issues is less developed. Hence it is very unlikely that consumer pressure may hurt careless users of fire. The 'bad image' pressure is much more efficiently applied through banks, governments, shareholders and direct action by NGOs and communities.

**A recent study evaluated that 60% of European consumers are ready to pay an average 6 to 10% more for certified wood products.**

There is a little more scope for net value change to determine market access for forestry companies. The Forest Stewardship Council (FSC) and the LEI (Lembaga Ekolabel Indonesia/Indonesian Ecolabel Institute) are jointly operating a certification scheme for forest products derived from sustainably managed forests (including natural forests concessions and industrial forest plantations like pulp and paper, rubberwood, teak). This scheme is backed-up by reputable NGOs like the WWF. Major furniture manufacturers like Home Depot and Loewe in the USA, or IKEA in Europe, want to improve all 'certified wood products' to increase market shares and public relations. Hence they are pressuring Indonesian wood suppliers to become certified.[18]

One criterion for obtaining a certificate is having a fire protection system, and good relationships with neighbouring farmers and stakeholders. This is probably the only direct market incentive for responsible behaviour in natural resource management in Indonesia right now. However, its effects are limited, since the number of interested companies that are eligible for certification and can afford it is small. It is difficult to evaluate the financial benefits of forest product certification.

A recent study evaluated that 60% of European consumers are ready to pay an average 6 to 10% more for certified wood products (Keogh, 2000). This is consistent with other studies on the willingness of consumers to pay for good environmental and social records. In that case, the lost benefits because of careless use of fire (usually associated with a number of other environmental and social abuses) is about 3.6 to

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[18] J. Hayward, Smartwood, pers. comm.

6% of the value of the product prices. However, it may in fact be more important because being certified is not so much about selling a product with a higher price to any consumer, than it is about being able to sell the product to an upper-end market. Being certified may mean being able to sell wood products to luxury retailers from Europe instead of selling to China. Then, the price gain may reach 100 or 200%.

## 3.3. The cost of being responsible

As indicated above, studies on the costs of managing fire control systems are scarce. Most studies focus on training, equipment and operations needed for fire prevention and fire fighting (Nicolas and Beebe, 1999a; Nicolas [illegible] 2001), but they do not include costing. A team of experts from the South and Central Kalimantan Production Forest Project (SCKPFP) have recently started calculating such costs (Nicolas and Pansah, 2001). It remains difficult to calculate costs per hectare since the conditions of needs and implementation in the field are very different. Using standard official prescriptions would lead to costs that are not always realistic.

Table 19 provides an example of costs of setting up a fire crew and equipment for an imaginary 30,000 ha HTI on flat land, costing nearly US$ 3 per ha. These costs do not include the construction of firebreaks and access roads, which are the main components, and which vary among locations. They also do not include operation costs in case there is a fire.

**Table 19: Cost of setting up a fire crew and equipment for a 30,000 ha HTI on**

## 4.1. Global economic impact analysis

- managers of plantation and forestry companies, who decide whether and how to use fire for land clearing; and
- farmers and their organisations.

Hence, breaking down the costs is more useful: by region and by type of

# 5. C[illegible]: A [illegible]

The financial analysis of the costs and benefits of fire versus zero-burning for land clearing indicates that when applied to low-volume vegetation, zero-burning methods are not more expensive — and may actually be more cost effective in the long term — than burning. This is the case for clearing oil palm or rubber plantations for replanting, low secondary vegetation or heavily logged-over forest. Under high-volume forest conditions, burning remains less expensive because it is more difficult, time consuming and costly to dispose of high volumes of piled wood mechanically. Sound land-use policies are needed to ensure that high-volume forests are not cleared for development in Indonesia especially since abundant areas of low-volume and degraded forests are available.

While there could be a strong financial case for companies to use zero-burning in Indonesia in the future, there are some barriers and costs associated with changing practices. It is a relatively complex and technical operation requiring new skills and investment in heavy equipment. It also necessitates an attitudinal change in plantation managers who dislike the ‘messy’ appearance of mechanically cleared sites with their high windrows of residues.

The Association of South East Asian Nations (ASEAN) has identified zero-burning as an appropriate approach to reduce the incidence and intensity of transboundary haze and smoke events. Yet the concept meets strong resistance from operation managers. Smaller companies with lower profiles have fewer incentives to adopt zero-burning and are reluctant to do so. The adoption of zero-burning is further complicated by the use of contractors who are difficult to control and lack the funds to acquire new technology after three years of the economic crisis and low-level planting activities in Indonesia.

**ASEAN has identfied zero burning as an appropriate approach to reduce the incidence and intensity of transboundary haze and smoke events.**

A similar case can be made for balanced forest fire management. On paper, implementing a fire management system in a forest concession or a plantation is not expensive but requires initial investments in training and acquisition of equipment, even if simple hand tools are all that are needed in most cases. Constant discipline and maintenance are crucial, both of which tend to diminish with time and absence of crisis. Faced with financial difficulties, the management tries to reduce costs and a fire management system may be a target especially after several incident-free years.

**Laws and regulations penalising irresponsible fire use are seldom enforced.**

When comparing the relatively low financial costs of zero-burning and fire management with the enormous socio-economic costs when fire escapes, it is clear that there is a market and institutional failure in fire management. Laws and regulations penalising irresponsible fire use are seldom enforced. For the moment, the most significant pressure to exact a cost on irresponsible fire users is through the public image. Shareholders may lose confidence in companies with poor reputations, causing the value of their stocks to plummet. Credit standings are seriously affected, making it more difficult for the companies to secure financial backing. Some NGOs are

land development activities likely to use fire are needed. A study to identify these areas through interviews, and aerial and field surveys should be initiated before the advent of the next El Niño. A permanent monitoring system should also be established. These activities should involve all relevant stakeholders at various levels (companies, NGOs, communities, etc.) under the co-ordination of the national government and supported by international organisations and donors.

6. For the government, once the key danger areas are identified, set up a surveillance system to prevent irresponsible fire use at the regional and local levels in collaboration with local people. At the same time, provide training and incentives for responsible fire use, particularly at the level of companies and communities.

Several opportunities to influence decision-makers at various levels can be identified to promote a reduced and, more importantly, responsible use of fire to prevent destructive wildfires (Table 20). A summary of methods and approaches to analyse the economics of fire use, the gaps and inconsistencies found in the data and methods, and the recommendations to generate data that can be used for lobbying decision-makers is shown in Table 21.

Four focus areas to generate missing data include:

- conduct studies at provincial and district levels on the impacts of the fires to influence decision-makers;
- identify areas at risk for the next El Niño, taking into account the changes in the burning and planting behaviour of the companies since the crisis;
- develop and disseminate methods of zero-burning adapted to Indonesia’s situation; and
- document the costs of conflicts and negative image due to irresponsible fire use to the companies.

## Table 20: Economic data needed to influence decision-makers towards the prevention of wildfires

| Decision-maker | Level | Potential impact on fire prevention | Economic data needed | Availability of these data |
|---|---|---|---|---|
| Inter-government agencies, donors, intern. NGOs, banks | international/ global | increased funding with better allocation<br>increased political pressure, campaigns<br>regulate international treaties | global impact of the fires, especially on the environment (biodiversity, carbon released) | EEPSEA/WWF and ADB/BAPPENAS studies |
| ASEAN governments | international/ ASEAN | increased funding with better allocation<br>increased political pressure<br>increased pressure on companies from their own countries active in Indonesia | impacts of the fires on neighbouring countries (Malaysia, Singapore, Brunei, etc.). | EEPSEA/WWF study, research from Malaysia and Singapore |
| Indonesian government, Indonesian NGOs, Indonesian banks | national, regional (districts) | improved regulations/ laws<br>increased funding/ budget with better allocation | impacts of the fire on the Indonesian economy<br>breakdown by category of constituents/ stakeholders<br>costs and benefits of alternative methods<br>areas at risk of fire | EEPSEA/WWF and ADB/BAPPENAS studies<br>lack of stakeholder and regional disaggregated data<br>lack of data for the Indonesian case<br>no update taking into account the changes in the Indonesian economy and society since 1997/98 |
| Consumers | international | reference for environmentally sound products<br>avoidance of environmentally hostile products | global impact of the fires, especially on the environment (biodiversity, carbon released) | EEPSEA/WWF and ADB/BAPPENAS studies |
| Farmers, communities | stakeholder | responsible use of burning<br>watchdog action on companies | cost of the wildfires destroying their properties or their forest land reserves | partly available, the farmers are well aware of the direct impact on themselves |
| Plantation and forestry companies, banks | stakeholder | reduced and responsible use of burning | data on how conflicts and bad image generated by the fires affect them | not publicly available but some companies are well aware of it |

# B[illegible]f[illegible]

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[illegible]

Table 1-2: Cost structure of land preparation of an oil palm plantation on dryland, Riau, 1997 (thousand Rp/ha)

| Cost items/allocation | Fire | Tractor |
|---|---|---|
| [illegible] | | |

[illegible]

[illegible]

[illegible]

**Table 1-3: Cost structure of land preparation of a timber estate (HTI) on dryland in East Kalimantan, 1997 (thousand Rp/ha)**

| Cost items/allocation | Total Cost |
|---|---|
| [illegible] / [illegible] ( [illegible] ) | 44.80 |
| [illegible] ( [illegible] ) | 90.00 |
| [illegible] / [illegible] , [illegible] , [illegible] , [illegible] . ( [illegible] ) | 25.90 |
| [illegible] , [illegible] , [illegible] , [illegible] . [illegible] | 735.75 |
| **Total** | **896.45** |

[illegible]

**Table 1-4: Cost structure of land preparation of timber estate (HTI) in West Kalimantan, 1997 (thousand Rp/ha)**

| Cost items/allocation | Peat soil | |
|---|---|---|
| | Fire | Tractor |
| [illegible] / [illegible] ( [illegible] ) [illegible] ( [illegible] )<br>[illegible] / [illegible] , [illegible] , [illegible] , [illegible] . ( [illegible] ) | 248.5 | 248.5 |
| B [illegible] | 251.0 *<br>( [illegible] . [illegible] 50,000) * | – |
| [illegible] , [illegible] , [illegible] , [illegible] . [illegible] | | 2,400.0 |
| B [illegible] | | – |
| **Total** | **499.5** | **2,648.5** |

[illegible]

[illegible] ( [illegible] ) [illegible] ( [illegible] ) [illegible] ( [illegible] ) [illegible] ( [illegible] ) [illegible] ( [illegible] ) [illegible]

[illegible]

[illegible] ([illegible]) [illegible] ([illegible])

**Table 1-5: Cost structure of land and plant development of oil palm plantation in 1999 (thousand Rp/ha)**

| Cost items/allocations | Dryland | Peat soil |
|---|---|---|
| **Land Preparation** | | |
| [illegible] / [illegible] ([illegible]) | 97.5 | 97.5 |
| [illegible] ([illegible]), [illegible] | 138.0 | 138.0 |
| [illegible], [illegible], [illegible], [illegible]. [illegible] | 531.5 | 1,011.0 |
| *Sub-total land preparation* | 767.0 | 1,247.0 |
| **Planting** | | |
| [illegible] / [illegible] ([illegible]) | 10.0 | 10.0 |
| [illegible] ([illegible]) | 49.0 | 49.0 |
| [illegible] *legume/* [illegible] ([illegible]) | 19.5 | 19.5 |
| [illegible] *legume* ([illegible]) | 234.5 | 234.5 |
| [illegible] *legume* ([illegible]) | 15.0 | 15.0 |
| [illegible] ([illegible]) | 15.0 | 15.0 |
| [illegible] ([illegible]) | 58.5 | 58.5 |
| [illegible] ([illegible]) | 98.0 | 98.0 |
| [illegible] ([illegible]) | 19.0 | 19,.5 |
| [illegible] - [illegible] ([illegible]) | 108.0 | 108.0 |
| [illegible] - [illegible] ([illegible]) | 10.5 | 10.5 |
| *Others* | | |
| [illegible] | 3.0 | 3.0 |
| [illegible] | 50.0 | 50.0 |
| *Sub-total planting* | 690.5 | 690.5 |
| [illegible] | 600.0 | 600.0 |
| [illegible] | 100.0 | 100.0 |
| [illegible] 3 [illegible] 1,500,000/<br>*(60- 70% of this item is allocated to fertilisers)* | 4,500.0 | 4,500.0 |
| **Total cost** | **6,657.5** | **7,137.5** |

[illegible]

## Impact of clearing rainforests on soil fertility

[illegible]

## Nutrient cycling in forest systems

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible] ( [illegible] )

Table 2-1: Permanent changes to the soil following land clearing and burning

| Factor | Before clearing | After clearing |
|---|---|---|
| [illegible] | [illegible], 24-28 | [illegible], 23-52 |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] 2 [illegible] | [illegible] | [illegible] |

## Nutrient cycling in agricultural systems

[illegible]

[illegible]

## The effect of fire on the economic value of nutrients contained in standing biomass

[illegible]

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

## Economic value of nutrients

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

[illegible]

### Table 2-2: Cost of nutrients based on fertiliser equivalents

| Nutrient | Fertiliser | US$/kg | % oxide | % element | US$/kg of element |
|---|---|---|---|---|---|
| | | 0.126 | 46 | 46 | 0.274 |
| | | 0.197 | 46 | 20 | 0.973 |
| | | 0.180 | 60 | 50 | 0.361 |
| | | 0.027 | 30 | 21 | 0.127 |
| | | 0.160 | 27 | 16 | 0.988 |

[illegible]

## Table 2-4: Value of nutrients in standing biomass

| Value (US$/ha) | | | | | | |
|---|---|---|---|---|---|---|
| | **N** | **P** | **K** | **Ca** | **Mg** | **Total** |
| *Imperata* | 3 | 22 | 14 | 3 | 19 | 62 |
| [illegible] | 123 | 39 | 195 | 23 | 89 | 470 |
| | 493 | 273 | 434 | 254 | 395 | 1,848 |
| [illegible] | 173 | 38 | 145 | 53 | 141 | 549 |
| [illegible] | 345 | 76 | 290 | 107 | 281 | 1,099 |
| **Percentages of each element in the total value** | | | | | | |
| | **N** | **P** | **K** | **Ca** | **Mg** | **Total** |
| *Imperata* | 5 | 36 | 23 | 5 | 31 | 100 |
| [illegible] | 26 | 8 | 42 | 5 | 19 | 100 |
| | 27 | 15 | 23 | 14 | 21 | 100 |
| [illegible] | 31 | 7 | 26 | 10 | 26 | 100 |
| [illegible] | 31 | 7 | 26 | 10 | 26 | 100 |

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]

## Table 2-5: Percentage of nutrients available after burning versus zero-burning

**8K8Das**

## Conclusions

[illegible]

# Appendix 3: Industrial timber plantation and its fertilisation aspect

[illegible]

[illegible]

## Nutrient loss through forest conversion into plantation

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]

[illegible]

- [illegible]

[illegible]

Table 3-1:  Element stores, pH, and effective exchange capacity of the soils

## Table 3-2: Difference between element stores of plots A, B and C (control) before and at the end of the experiment, in kg/ha and in % of original stores*

| Plot | Depth | C (%) | N (%) | P (%) | K (%) | Ca (%) | Mg (%) | Fe (%) | Al (%) |
|---|---|---|---|---|---|---|---|---|---|
| A | 0-10 | -6,534 (-25) | -340 (-20) | 9 (20) | -16 (-50) | 215 (104) | 7 (27) | -23 (-81) | -62 (-54) |
| | 10-30 | -4,237 (-16) | -341 (-20) | -2 (-2) | -11 (-41) | -0 (-1) | -2 (-13) | 8 (43) | 16 (5) |
| | 30-100 | -3,670 (-10) | -803 (-26) | -160 (-40) | -7 (-8) | 45 (33) | -3 (-7) | 24 (101) | 182 (18) |
| | 0-100 | -14,442 (-15) | -1,483 -23) | -153 (-29) | -34 (-30) | 260 (64) | 2 (3) | 9 (11) | 136 (10) |
| B | 0-10 | -1,398 (-5) | -214 (-12) | 18 (28) | -10 (-19) | 1, 085 (439) | 38 (139) | -19 (-88) | -127 (-80) |
| | 10-30 | -1,204 (-5) | -394 (-21) | -4 (-4) | 11 (34) | 80 (54) | 10 (32) | 4 (22) | -22 (-6) |
| | 30-100 | -4867 (-13) | -1244 (-33) | 18 (4) | 112 (194) | 47 (30) | -4 (-7) | 13 (43) | 81 (7) |
| | 0-100 | -7,470 (-8) | -1,852 (-24) | 32 (8) | 113 (82) | 1,213 (221) | 43 (43) | -3 (-5) | -68 (-4) |
| C | 0-10 | -2,458 (-13) | -179 (-13) | -18 (-27) | -6 (-22) | -35 (-26) | -6 (-22) | -8 (-30) | -0 (-1) |
| | 10-30 | -2, 589 (-11) | -222 (-14) | -22 (-20) | -10 (-32) | -26 (-28) | -4 (-22) | -5 (-21) | 36 (11) |
| | 30-100 | -2,306 (-6) | -667 (-19) | -168 (-44) | -32 (-44) | 6 (4) | -8 (-17) | -0 (-8) | 167 (21) |
| | 0-100 | -7,353 (-8) | -1,068 (-16) | -208 (-37) | -49 (-35) | -55 (-13) | -18 (-19) | -14 (-18) | 202 (16) |

[illegible]

## Table 3-3: Balance of element stores and element fluxes during conversion of rain forest on plots A and B (in kg/ha)

| | Bio-mass (t/ha | C | N | P | Na | K | Ca | Mg | S |
|---|---|---|---|---|---|---|---|---|---|
| **Plot A** | | | | | | | | | |
| [illegible] | (279) | 140 | 1,397 | 46 | 116 | 688 | 1397 | 175 | 206 |
| [illegible] | | 15 | 325 | 2 | 3 | 7 | 44 | 7 | 26 |
| [illegible] | | | 166 | 2 | 107 | 66 | 77 | 31 | 8 |
| [illegible] | | 155 | 1,889 | 49 | 226 | 761 | 1517 | 212 | 240 |
| [illegible] | | | 8 | 3 | 26 | 4 | 9 | 2 | 6 |
| [illegible] | | -155 | -1,880 | -46 | -200 | -756 | -1,508 | -210 | -234 |
| **Plot B** | | | | | | | | | |
| [illegible] | (223) | 112 | 828 | 22 | 65 | 330 | 712 | 96 | 160 |
| [illegible] | | 42 | 804 | 7 | 10 | 87 | 189 | 40 | 70 |
| [illegible] | | | 211 | 2 | 166 | 165 | 102 | 29 | 20 |
| [illegible] | | 154 | 1843 | 31 | 241 | 583 | 1,004 | 165 | 220 |
| [illegible] | | | 8 | 3 | 26 | 4 | 9 | 2 | 6 |
| [illegible] | | -154 | -1,835 | -28 | -215 | -579 | -995 | -162 | -214 |

[illegible]

Table 3-4: Comparison of element stores in the residual phytomass and element losses by burning and leaching on plot A and B (in kg/ha)

[illegible]

[illegible]

## Table 3-5: Absolute and relative values for nutrient losses*

| | N | | P | | K | | Ca | | Mg | |
|---|---|---|---|---|---|---|---|---|---|---|
| | kg/ha | % | kg/ha | % | kg/ha | % | kg/ha | % | kg/ha | % |
| ***Acacia mangium*** | | | | | | | | | | |
| [illegible] | 202 | *29* | 2.6 | *21* | 73 | *26* | 161 | *64* | 10 | *22* |
| A[illegible] | 329 | *48* | 2.5 | *20* | 113 | *41* | 63 | *25* | 20 | *45* |
| [illegible] | 84 | *12* | 0.1 | *1* | 86 | *31* | 8 | *3* | 10 | *22* |
| [illegible] | 77 | *11* | 7.4 | *59* | 4 | *2* | 20 | *8* | 5 | *10* |
| [illegible] | 692 | *100* | 12.6 | *100* | 276 | *100* | 252 | *100* | 45 | *100* |
| ***Eucalyptus deglupta*** | | | | | | | | | | |
| [illegible] | 75 | *18* | 3.7 | *30* | 206 | *56* | 85 | *48* | 21 | *37* |
| A[illegible] | 219 | *51* | 1.1 | *9* | 91 | *25* | 64 | *36* | 21 | *37* |
| [illegible] | 56 | *13* | 0.1 | *0* | 69 | *19* | 9 | *5* | 10 | *18* |
| [illegible] | 77 | *18* | 7.4 | *60* | 4 | *1* | 20 | *11* | 5 | *8* |
| [illegible] | 427 | *100* | 12.3 | *100* | 370 | *100* | 178 | *100* | 57 | *100* |

[illegible]

[illegible]

[illegible]

## Table 3-7: Quantity of N, P and K fertiliser necessary to compensate management-dependent nutrient losses in industrial plantations*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ***50*** | ***70*** | ***50*** | ***70*** | ***50*** | ***70*** | ***50*** | ***70*** |
| | 75 | 1,155 | 825 | 323 | 233 | 428 | 308 | 938 | 668 |
| | 219 | 3,373 | 2,409 | 942 | 679 | 1,248 | 898 | 2,738 | 1949 |
| | 56 | 862 | 616 | 241 | 174 | 319 | 230 | 700 | 498 |
| | 77 | 1,186 | 847 | 331 | 239 | 439 | 316 | 963 | 685 |
| | **427** | **6,576** | **4,697** | **1,836** | **1,324** | **2,434** | **1,751** | **5,338** | **3,800** |
| | | | | | | | | | |
| | | ***10*** | ***40*** | ***10*** | ***40*** | ***10*** | ***40*** | ***10*** | ***40*** |
| | 2.6 | 466 | 116 | 118 | 30 | 165 | 41 | 325 | 81 |
| | 2.5 | 448 | 112 | 114 | 29 | 158 | 40 | 313 | 78 |
| | 0.1 | 18 | 4 | 5 | 1 | 6 | 2 | 13 | 3 |
| | 7.4 | 1,326 | 332 | 337 | 84 | 468 | 117 | 925 | 232 |
| | **12.6** | **2,258** | **564** | **573** | **144** | **798** | **199** | **1,575** | **394** |
| ***Eucalyptus deglupta*** | | | | | | | | | |
| | 3.7 | 663 | 166 | 168 | 42 | 234 | 58 | 463 | 116 |
| | 1.1 | 197 | 49 | 50 | 13 | 70 | 17 | 138 | 34 |
| | 0.05 | 9 | 2 | 2 | 1 | 3 | 1 | 6 | 2 |
| | 7.4 | 1,326 | 332 | 337 | 84 | 468 | 117 | 925 | 232 |
| | **12.25** | **2,195** | **549** | **557** | **140** | **775** | **194** | **1.531** | **383** |

[illegible]

## Table 3-8: Costs of fertilisation in case of compensation of total nutrient losses for the management variants $\text{Min}_{200}$ and $\text{Alt}_{200}$

| Variant | *Acacia mangium* | | | | *Eucalyptus deglupta* | | | |
|---|---|---|---|---|---|---|---|---|
| | $\text{Min}_{200}$ [a] | | $\text{Alt}_{200}$ [b] | | $\text{Min}_{200}$ [a] | | $\text{Alt}_{200}$ [b] | |
| | **US$/ha** | **%** | **US$/ha** | **%** | **US$/ha** | **%** | **US$/ha** | **%** |
| [illegible] | 1,962.55 | **2,229** | 1,164.37 | **1,323** | 1,105.30 | **1.256** | 560.43 | **637** |
| [illegible] | 865.76 | **983** | 544.34 | **618** | | | | |
| [illegible] | 530.33 | **602** | 368.19 | **418** | 499.81 | **568** | 382.34 | **434** |
| [illegible] | 311.46 | **354** | 246.94 | **281** | | | | |

[illegible]

[illegible]

[illegible]

[illegible]