Slash-without-Burn Technique in Land Clearing: Environmental and Economic Opportunities and Constraints[1]

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I. Introduction

Slash-and-burn as a technique of land clearing produces visible smoke and invisible emissions of the greenhouse gases: methane, nitrous oxide, and carbon dioxide. Land clearing using fire is extensively practiced in Sumatra, and in other regions in Indonesia, by virtually all actors (public and private, large and small scale) contributing to forest conversion. Slash and burn is attractive to all these actors because fire is the cheapest, most effective means to clear land (Tomich and van Noordwijk, 1995).

In the long dry season of 1994 large amounts of smoke, released by forest fires, slash-and-burn, and others activities in Sumatra and Kalimantan, caused problems in poor visibility and air pollution for neighboring countries (Singapore and Malaysia). Technical alternatives such as 'slash-and-mulch' or biomass utilization hold promise to significantly reduce this problem. New government regulations have been issued determining that slash-and-burn practices are no longer allowed (Tomich and van Noordwijk, 1995). As a result, beginning in 1995, the slash-without-burn technique has replaced the slash-and-burn technique as the indicated method for clearing forest within transmigration projects.

This paper argues that the technique of slash-without-burn land clearing in large scale projects has the potential to create new business opportunities as well as environmental improvement opportunities (Figure 1). The timber biomass left over by land clearing can be utilized as raw material for particle board, pulp, chip and others product. The development of this industry will also have a large effect on smallscale (smallholder) farmers. If there is a demand for wood-biomass then the smallholders who also practice slash-and-burn techniques, will not burn all wood biomass when they are clearing land. In the economic side, the increased utilization of wood biomass will generate income in rural areas, increase the demand for labor and contribute to poverty alleviation. The aggregate effect will be enhanced national economic growth.

II. Environmental Opportunities of Using Slash-without Burn in Large Scale Projects

During Pelita VI, 1995 to 1999, the government of Indonesia has targeted to open 502,975 ha land for transmigration projects (Table 1). If all of that land is logged-over forest and is cleared by slash-and-burn techniques, the estimated total carbon emission can be calculated based on Murdiyarso and Wasrin's study (1995). Their estimate of the average amount of carbon released per ha as a result of land conversion from secondary forest to agriculture, is 245 ton/ha DW (dry weight). This is equal to 45% C or about 110 ton C/ha. This C release includes both CO_2 and CH_4. Roughly 95% of the carbon from burning timber wood will be released as CO_2 and 5% as CH_4. The effect of CH_4 on global warming is 25 times the equivalent CO_2 in terms of radiative forcing (IPCC,1990). The

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total amount of carbon released is calculated by multiplying the amount per ha times the target area of opening land for transmigration programs during Pelita VI (Table 2).

Table 1. Target area opened for Transmigration Project During Pelita VI

Year	Land Opened (ha)
1994/95	71,853
1995/96	86,224
1996/97	100,595
1997/98	114,965
1998/99	129,338
Total	502,975

Source: Puslitbang-Trans

Table 2. Estimate of C-emission released during Pelita VI under slash-and-burn technique in opening land for transmigration project

Type of carbon	C-emission release	
	Per ha (Ton)	Total (Mt)
1. Amount of carbon released	110	55
2. Amount of CO_2 released	384	193
3. Amount of CH_4 released	7	4
4. CO_2-equivalents in term of radiative forcing	506	254

The total amount of carbon released from burning wood in clearing land for transmigration program during Pelita VI is around 55 million tons of carbon. This corresponds to 193 million tons of CO_2 and 254 million tons CH_4 equivalent to CO_2 radiative forcing to the atmosphere. The amount of CH_4 released is only 4 million, but the effect on global warming is 25 times the equivalent of CO_2 radiative forcing. If wood biomass were utilized, not burned, it would save that amount of carbon emission.

III. Environment and Economic Opportunity for Smallholder

Development of a waste timber industry in Indonesia will also generate benefit for smallholder. If there is a market for waste timber around smallholder areas, farmers will supply their waste timber as result of land clearing. For instance some of the rubber wood can be used in manufacture of fibre board while choice pieces can be sawed into high-value lumber that is a substitute for ramin, which is among the most valuable timbers.

The Alternative to slash-and-Burn program in Indonesia has found (even from the preliminary data on land use systems), a significant share of slash-and-burn clearing in Sumatra involved smallholder' old rubber gardens instead of natural forest (Noordwijk, et al,1995). Rubber accounts for roughly 60% of the standing trees in these so-called "jungle rubber" systems. Today, most of the rubber wood goes up in smoke when smallholder fell trees to clear old gardens for replanting, thereby contributing to greenhouse gas emissions. Suyanto (1995) estimated that the total amount of carbon released from burning rubberwood per year in situ during rubber replanting is around 2.87 million ton carbons. This corresponds to almost 10 millions tons of CO_2 and 13.1 million tons CH_4 equivalent to CO_2 radiative forcing to atmosphere. If the rubberwood were utilized, not burned, it would save a total of 859,950 tons of carbon. This is equal to almost three million tons of CO_2 and 3.94 million-ton CH_4 equivalent to CO_2 radiative forcing.

By selling rubber wood, farmers can cover costs of land clearing and still receive around Rp.600,000 ha^{-1} (in Lampung). This money could cover about half of the costs of purchasing higher-yielding clones and fertilizer for rubber replanting. So, this is in line with the smallholder rubber replanting program and it will generate economic benefits for the rural population.

Development of a waste timber industry (pulp, chip or particle board) will also drive a demand for fast-growing species that are suitable for the development of smallholder timber plantations (timber based system). Studies of on the farm forestry in several Asian countries has indicated that non-industrial forest plantations have been very supportive to the growth of light wood or timber based-companies, and contribute to increased farmer income (Van den Beldt et al, 1994).

Thailand has a goal to be self sufficient in wood and wood-based products by 2025. Plans now are underway to plant 0.8 million ha of farmers land to indigenous forest and fruit tree species to replace production from the natural forest. A partnership between industry, government and farmers is nearing the implementation phase to realize this program (Van den Beld et al, 1994). In the Philippines thousands of upland farmers in the north-central part of Mindanao privately produce timber trees on their farms in response to favorable prices stimulated by the growing market demand for raw-materials in the construction and furniture industries (Garrity and Mercado, 1993). The harvesting and marketing of timber is done through private contracts with the sawmills or timber traders, or through direct delivery by farmers to the sawmill. In comparison to those countries, Indonesia may be left behind in dealing with the growing problem of wood shortage. A few months ago, newspapers featured the issue of the shortage of raw materials of pulp/paper.

IV. Barriers resulting from policy distortions: Lesson from Rubberwood

Smallholder rubber wood is not as uniform as rubber wood from large-scale plantations because most smallholder plant seedlings while plantations use clones. This gives plantations a technical advantage over smallholder as rubber wood suppliers, especially for processors of higher-value sawn wood. Better infrastructure and economies of scale may also make it more profitable for processors to focus on plantations for their rubber wood supplies. Despite these technical disadvantages, there may be viable marketing opportunities for smallholder rubber wood, especially as raw materials for medium density fibre board (MDF). Moreover, small-scale, mobile processing equipment now is available that could improve the economics of smallholder rubber wood, even for sawn wood. In the future, rubber wood could emerge as another important product (along with latex, fruit, and other non-timber tree products) of smallholder rubber agroforests.

The development of rubber wood also will increase foreign exchange earnings. The rubber wood market has good prospects. Since the late 1980s, the international price of rubber wood has increased because of rapid depletion of ramin and agathis wood. The consumption of rubber wood in the major importing countries in 1991 was estimated at 238,000 m^3 and it is projected to increase to 350,000 m^3 by 1996 (ITC 1993).

Unfortunately, policy-induced distortions probably present a greater barrier to use of smallholder's rubber wood than the technical issues discussed above. According to ITC (1993), utilization of available rubber wood in India, Thailand and Malaysia is 96%, 83% and 62%, respectively, while Indonesia was using only 27% of its potential supply of rubber wood. This highlights an enormous improve both environmental and socioeconomic conditions by developing the utilization of rubberwood in Indonesia. Even though current use of rubber wood in Indonesia is still low, Indonesia has the potential to dominate in rubber wood production since it has the largest area of rubber in the world (3.4 million ha or around 34 percent of the total rubber area).

Local trade regulations and export taxes are the two main policy barriers to development of rubber wood marketing in Indonesia. Local trade regulations have restricted processors from purchasing rubber wood from smallholders in some regions. CPIS (1993) reported that the Governor of West Kalimantan issued Decree No. 03/1991 dated 4 January 1991 that imposed levies of Rp30,000 and Rp12,000 per cubic meter on sawn rubber timber and medium density fiber wood, respectively. Similarly, in South Sumatra levies also have been imposed on operators of rubber wood plants, include a replanting levy set at 13.5 percent of the processed wood prices (*The Jakarta Post*, 6 December 1988). Besides that, the Treecrops Advisory Service in West Kalimantan has issued extremely complicated guidelines on authorization for and mechanisms of felling rubber (CPIS, 1993). The regional levy and the bureaucratic mechanisms retarded the development of rubber wood marketing. It is not surprising that the only rubber wood factory in West Kalimantan is now operating at only 30 percent capacity; and several rubber wood factories in South Sumatra have stopped operations.

More recently a Government decree that imposed levies for rubberwood has been issued in South Kalimantan (Governor Decree No 0372 A Tahun 1994). This decree imposed levies of Rp 4.500.- per cubic meter on log and US $ 3.5 per cubic on log for rubber replanting program.

Since 1989 Indonesia has imposed an export levy for rubber wood. Through the Finance Minister's decree No. 1134/1989, government set export levies on three major groups of sawn timber at $250-$2400 m^{-3}; including an export levy for rubber wood of $250 m^{-3}. Then, in 1992 the government raised the export levy to $500-$1200 m , depending on the product. Indonesia and Malaysia are the only two rubber wood producers that impose export levies on the sawn timber of rubber wood. The export levy in Indonesia is the higher of the two by far; since 1990, Malaysia's was only $ 50 m^{-3}.

Indonesia's policy stems, in part, from official concern that processors will exploit smallholders, enticing them to cut their rubber trees prematurely. There is no evidence, however, to support this view. On the contrary, it is older rubber trees that are most valuable to processors, who are free to buy wood from large-scale plantations anywhere in Indonesia. Thus, trade restrictions are biased (unintentionally) n favor of large-scale plantations and reinforce plantations' technical advantages as rubber wood suppliers.

V. Technical Aspects

Farmer acceptability of systems based on less biomass burning during land clearing is likely to be based on the costs-and-benefits of this alternative both during the land clearing stage (how much labour is needed, for what price can the woody biomass component be sold, what are the constraints on burning) and during the subsequent cropping stage.

The complete 'Slash-and-Burn' system is one end of the spectrum, a complete 'Slash-and-Mulch' system the other end. In between there is a whole range of options based on partial removal of the biomass (selling or using it as firewood, raw material for pulp and paper factories or as timber) and either burning the residue or allowing it to remain in the field as mulch. The nature of the 'burn' and the greenhouse gas emissions depend on the amount of biomass: for methane emissions smouldering logs are a specific source, visible smoke may depend on incomplete burning of wet fuel. Positive and negative aspects of 'slash-and-mulch' systems as alternative to 'slash-and-burn' are summarized in Table 3. The relative importance of these negative and positive aspects depends on site characteristics as well as farmer preferences.

Table 3. Positive and negative aspects of 'slash-and-mulch' systems as alternative to 'slash-and-burn' from an agronomic perspective

	Positive aspects	Negative aspects
Aspects	Protection from soil erosion, Protection of soil organic matter, Protection from weed establishment (*Imperata*)	Slow release from, or even immobilization of Nitrogen into, decaying mulch Difficulties in establishing a crop in thick mulch layers Problems with diseases (fungi), pests (rats) and their predators (snakes) Difficulties to walk into fields for crop management A dried mulch layers remains a fire hazard
Summary	Long Term Benefits from Slash-and-Mulch systems (?)	Short term gains by Slash-and-Burn

Burning a slashed forest vegetation still appears to be the cheapest and most effective way to ensure crop nutrition. Not burning is not a productive alternative for slash-and-burn farmers (Van Reuler and Janssen, 1993). Technical developments to deal with thick mulch layers and avoid fire risks are needed if atmospheric pollution by burning is considered unacceptable.

The burning process leads to the loss of large amounts of N (and possibly P, S and ash as well), and may induce transformations in the top layers of the soil, depending on the temperature of the burn (amount and moisture content of the slashed biomass). A major distinction should thus be made between those types of "improved fallow" which do and those which do not depend on burning upon reclamation.

We can only avoid burning if we have techniques for planting crops in (thick) layers of mulch, if decomposition rates of the mulch are sufficiently fast (and immobilization effects are small) and if pest and disease problems are manageable without a burn.

VI. Practical Measures to Reduce Burning

The previous section examined the issue of transforming 'slash-and-burn' systems to 'slash-and-mulch' systems, eliminating the use of fire in land clearing and management.

It is argued that the transformation has positive agronomic and environmental effects, but is also accompanied by several crucial technical constraints. Unfortunately, the knowledge base to overcome these constraints with confidence does not yet exist. Therefore, if land managers currently switch to slash-and-mulch, they face certain and large economic losses. Thus, a complete ban on burning is a counter-productive policy at present. However, intermediate-level regulations and policy changes are the more feasible and sound approach.

The most intractable situation occurs in the clearance of old secondary, jungle rubber, or primary forest. In cases where removal of the timber is possible and sufficiently profitable, the amount of biomass blocking establishment of the subsequent crop will be greatly reduced. But even if the timber is extracted for sale, up to half of the total biomass remains in the field as tree branches and leaves. If it is not to be burned, this biomass has to be concentrated in piles, or spread more uniformly, so as to enable field operations for planting and managing the subsequent enterprise. The labor involved in doing so can be enormous. If the strategy is to concentrate the material, then a large fraction of the field area may be unusable for planting.

In alang-alang grasslands the problem of excessive biomass is not quite as serious. The amount of biomass to be handled is usually less than one-tenth that in forest clearing. Herbicides are available (eg glyphosate) that are generally effective in killing alang-alang and the range of other non-woody vegetation. The cost of herbicide technology has been declining relative to labor. Many smallholders now use herbicides for alang-alang control as part of their overall land clearing and management system. Even so, it is usually not economically efficient for them to entirely replace burning with herbicide use. Rather, they use herbicide as a complementary tool in addition to burning.

Recent results of work done by the Ministry of Agriculture has indicated that under some conditions the use of herbicides to kill alang-alang may eliminate the need for burning or land clearing (Harahap et al, 1995). The university of Lampung has obtained similar results (Utomo et al, 1995). Upland rice may be successfully established through the mulch of the killed grass. This technology may enable estate crops to be established in some alang-alang grasslands without burning. Larger estate crops and forestry enterprises may be encouraged to try this method. However, it should be recognized that this technology is quite location-specific. If experience in 'slash-and-mulch' technology and zero-tillage methods from elsewhere are any guide, it is evident that a great deal of applied and adaptive research will be needed to insure its success on a wide scale.

The physical problem of coping with biomass was emphasized in the preceding paragraphs. This overall may not be the most serious one. It is the abundant soil fertility-enhancing effects of burning that may provide the greatest resistance to a ban on burning. Smallholders are well aware that burning tends to stimulate the growth of the subsequent crops or trees. They and scientists are also aware that these positive effects of burning can usually be compensated by the application of fertilizers and lime, at least temporarily. But ash is essentially free, while fertilizers are costly. If farmers are forbidden from using fire as a farming tool, they will pay a very high cost in productivity loss, or increased input requirements. They will, in effect, be taxed sharply to support the national environmental objectives. Is this a tenable prospect? We believe not, at this point in time.

We acknowledge the laudable intentions of a total ban on the use of fire in land clearing. But due to the burden of negative repercussions it would place on the country's land managers, particularly the smallholders, we would argue that a total ban is currently impractical. Because practical alternatives are not available or affordable, it will be counter-productive.

A more suitable approach is to take a number of intermediate steps of a more gradual nature. First, a ban on burning and the use of 'slash-and'mulch' techniques can be enforced on one-fifth of all the land opened by larger forestry and agricultural enterprises. They would thus gain experience with the techniques without risking their entire operations on them. The proportion of the land managed without burning can then gradually be increased over time.

Second, given the importance of this environmental issue, a national research and monitoring program should be organized to coordinate applied and adaptive research on zero-burning technology. This should be a public sector-private sector cooperative endeavor. This effort could be developed through the Alternatives to Slash-and-Burn Program, a global research initiative in which Indonesia is playing a leading role. The research entities of the Ministries of Agriculture, Forestry, and Transmigration are already working cooperatively in this program, in collaboration with ICRAF, CIFOR, and a number of other international institutions.

Third, programs to generate and enforce burning regulations at the village leve should be given much more attention. Although it is impractical for smallholders to abandon the use of fire (they will be forced to ignore any total ban), there is much that can be done to develop mechanisms to enhance the development and enforcement of practical fire management regulations at the village level. ICRAF's research in villages in Sumatra, Kalimantan, and Timor has highlighted a tremendous range of village-level regulations that guide the use of fire locally. We found that there is serious local concern about fire management, because of the danger to all farmers when there is irresponsible use of fire. Current efforts on fire control should be amalgamated into a coordinated national program on village-level fire management. The program should guide the development of appropriate local-level regulations, along with a workable enforcement mechanism sensitive to the political realities at the local level. A monitoring system (using both satellite and ground observation) should be put in place to record the occurrence of damaging fires, identify those responsible, and determine suitable redress for damages caused.

When the above three initiatives are underway, Indonesia will be in an excellent position to design verifiable indicators of progress toward the eventual goal of banning the use of fire as a land use practice.

VII. Conclusion

Slash-and-burn as a technique of land clearing is extensively practice by virtually all actors in land conversion in Indonesia (public and private, large and small scale). This is attractive to all these actors because fire is the cheapest method to clear land. Slash-and-burn produce visible environmental pollution (smoke and invisible greenhouse gases).

Changing the technique of land clearing from slash-and-burn to slash-without-burn in large scale project (transmigration project) will contribute to improvement of environment as well as to national economic growth. The developing market for waste timber or timber from fast growing species will drive smallholder to sell a part of wood biomass when they are clearing land. It also stimulated then to develop smallholder timber plantation (timber based system). The start of this process of change can now be observed in the ASB-benchmark area in North Lampung. As result, it will generate income for rural area, contribute to poverty alleviation and create demand for labor.

The lesson from the rubberwood case is that the environmental and the economic advantages often can not achieved because of some policy barriers such as national and regional levies. Removal all these barriers as well as improvement infrastructure will influence achievement of environmental and economic benefits as mentioned above.

At the technical site, it is important to realize the negative aspects of using slash-without-burn technique at farm level such as difficulties in establishing a crop, disease, pest and predator problems, and a large fraction of unusable of field area for planting. We would argue that a total ban of the use of fire in land clearing is currently impractical. Because practical alternative are not available yet. However. intermediate-level-regulations and policy change scale are more feasible and sound approach. A compromise to slash-without-burn as an alternative to slash-and-burn (slash-with-less-burn) with partial removal of biomass (selling or using it as firewood, raw material for pulp and paper factories) and either burning the residue will reduce those problems.

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Figure 1. Environment and Economic Opportunity under Slash-without-Burn Technique in Land Clearing

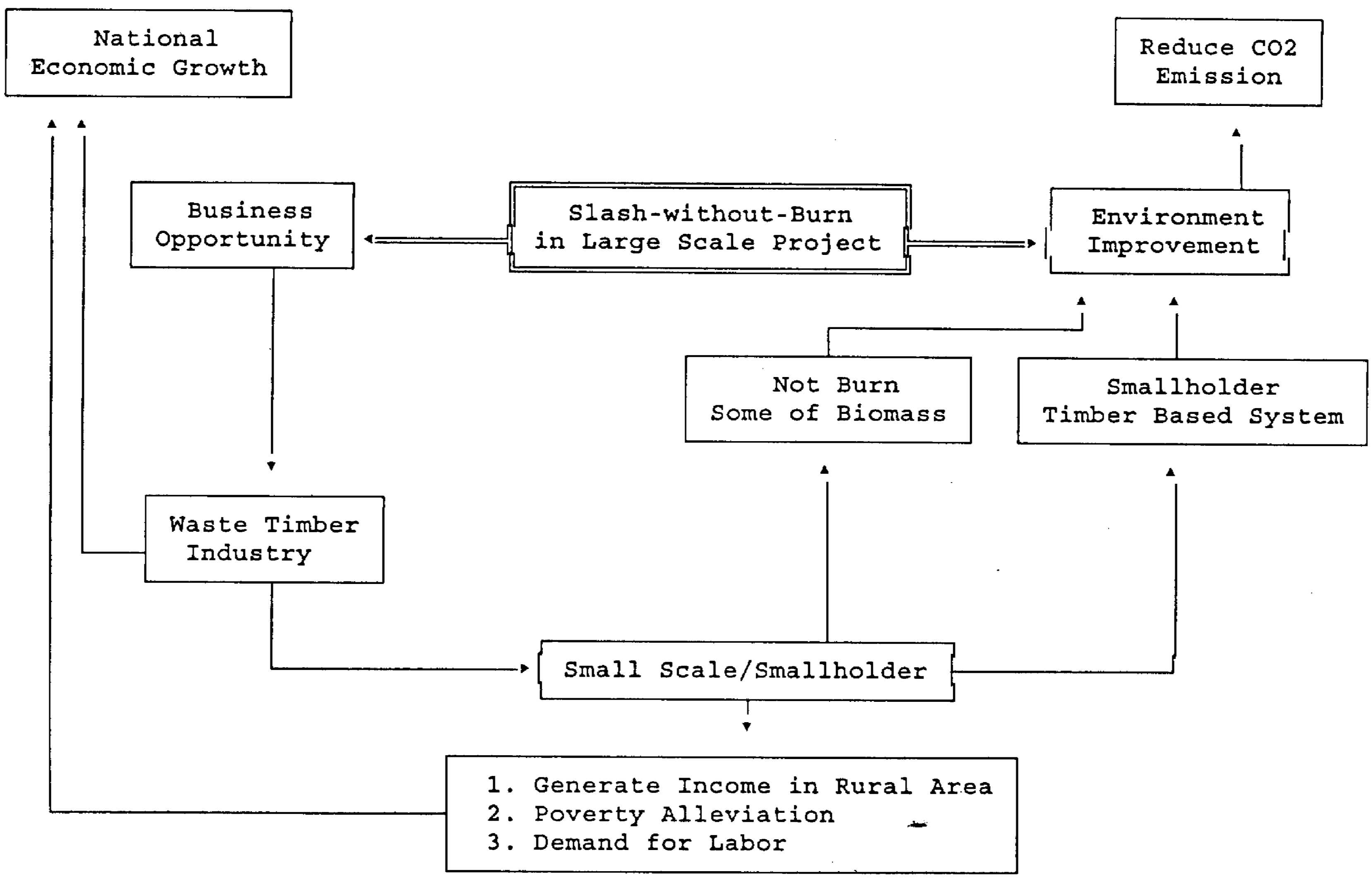

Figure 2. Technical feasibility of slash and mulch