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Can rehabilitation of *Imperata* grasslands help to protect the remaining rain forests?

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Abstract
Forest conversion for unsustainable land use practices in the humid tropics often results in the formation of coarse grasslands, dominated by *Imperata cylindrica*. Rehabilitation of these grasslands may help to alleviate the pressure on further forest conversion. Evidence in favour and against this hypothesis is reviewed on the basis of results of Phase I of the global 'Alternatives to Slash-and-Burn' project in Indonesia.

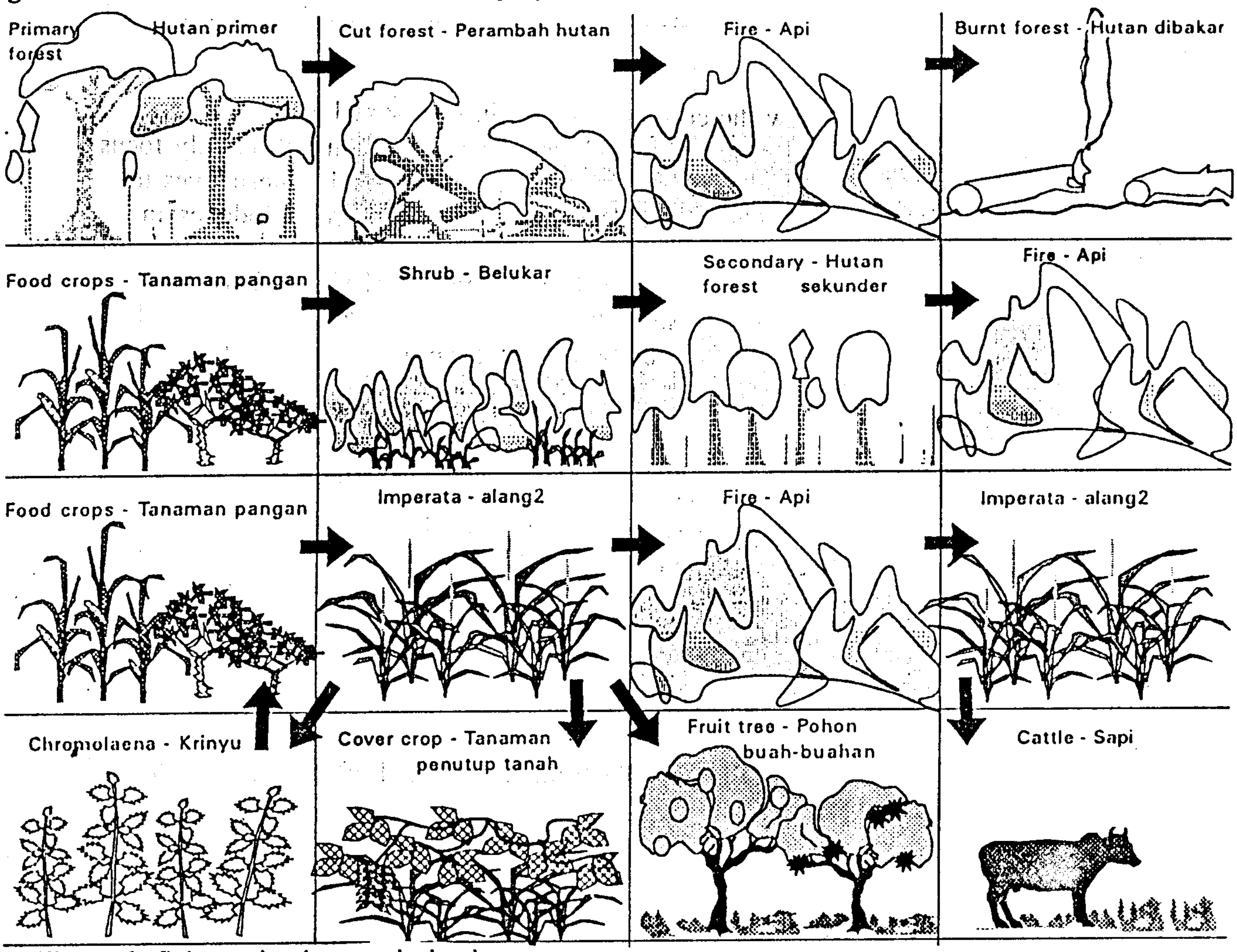


Figure 1. Schematic changes in land use

1. Introduction

Protection of the remaining areas of tropical rain forest is not possible without providing acceptable alternatives for the people whose current livelihood depends on creating new 'forest margins' on the edges of the forests. Many actors play a role in forest conversion, but the combined effects of opening forests by logging and the subsequent influx of farmers (migrants, 'forest squatters', resettlement schemes) appear to be responsible for a large part of forest conversion in S.E. Asia in the past decades. In areas recently cleared from forest, grasslands dominated by *Imperata cylindrica* (local names: Alang-alang in Indonesia, cogon grass in the Philippines) are abundant. These grasslands appear to be underutilized land resources and their reclamation/ rehabilitation may help to provide the livelihoods needed as alternatives to slash-and-burn agriculture in the forest margin. This expectation can be formulated as a hypothesis:

> Hypothesis: Rehabilitation of *Imperata* grasslands reduces the pressure on and conversion of the remaining rain forest

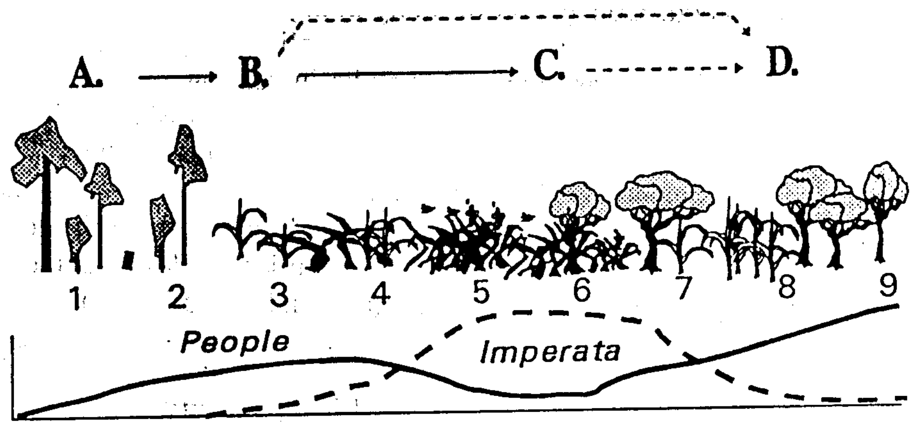
In this paper I will try to review the current evidence in favour and against this hypothesis and formulate more specific sub-hypotheses. The discussion will largely focus on Indonesia and on evidence collected as part of Phase I of the global 'Alternatives to Slash-and-Burn' project, in which ICRAF cooperates with a consortium of Indonesian national scientists and institutions.

Figure 1 indicates a typical sequence of forest degradation, via slash-and-burn into *Imperata* grasslands. The upper two rows show the changes from forest, via slash-and-burn land clearing to food crops and short-duration fallow; the third row shows the degradation stage where *Imperata* grasslands prevent the natural fallow development, via frequent fires; the bottom row shows a number of rehabilitation options: improved fallows such as *Chromolaena* or legume cover crops, fruit tree agroforestry or livestock development. If animal traction is available, *Imperata* grasslands can be re-used for crop production, provided that soil fertility constraints are alleviated.

Figure 2 gives a tentative scheme of the evolution of land use systems in the humid forest zone: from primary forest (A) (via logging) into slash-and-burn and bush fallow systems (B), where local population pressure increases and reduces fallow periods. From here there are two possibilities: either into *Imperata* grasslands (C) and a reduction of population density, as people move on to create a new forest margin elsewhere, or into the development of more permanent tree-based production systems (D). The major questions are whether development D is possible from stage C and whether or not stage C can be avoided (from B straight into D)

2. *Imperata* grasslands in S.E. Asia

Table 1 gives a tentative typology of *Imperata* grasslands in S.E. Asia and bottlenecks for reclamation (Garrity *et al.*, 1995). There have been a number of efforts to estimate the extent of *alang-alang* grasslands in Indonesia. Available estimates of *alang-alang* area vary widely, mainly because they differ regarding the *scale* of measurement used. Four distinct scales of grasslands can be distinguished (Table 1), ranging from *mega* grasslands



A. Forest margin: slash-and-burn
B. Shorter fallows -> soil degradation
C. Imperata fire climax - people move out
D. Imperata rehabilitation via agroforestry

Figure 2. Schematic development of land use from a forest margin, via degraded lands with *Imperata*, to more intensive land use systems (Van Noordwijk, 1994)

Table 1. Typology of *Imperata* grasslands in S.E. Asia (based on Garrity *et al.*, 1995) and bottlenecks for reclamation

Class	Scale, km	Typical size, ha	Administrative units	Bottlenecks for reclamation
Mega	>10	>10 000	more than one district	Fire, Tenure
Macro	1-10	100 - 10 000	more than one community	Fire, Tenure, Profitable alternatives
Meso	0.1-1	1 - 100	within a single community	Tenure, Fire, Profitable alternatives
Micro	<0.1	<1	within a farm	Profitable alternatives, Reclamation techniques

(also called "sheet *alang-alang*") to *micro* grassland patches in farmer's field. According to estimates by Garrity *et al.* (1995), mega *alang-alang* grasslands cover 8.6 million ha in Indonesia, 5% of the land surface. The estimated area would increase if the area of smaller grasslands and patches in farmers' fields could be added to this estimate of contiguous areas covering 10,000 ha or more. But data are not available to provide a comprehensive estimate at a finer scale.

Kalimantan has the largest area of mega grasslands in Indonesia (2.2 million ha), followed closely by Sumatra (2.1 million ha) and Nusa Tenggara (2 million ha). The map evidence and historical records show that *Alang-alang* grasslands have retreated gradually in some regions of Indonesia through farmers' efforts. This is most likely where land is scarce and market links are good. Conversion of *alang-alang* to other uses by smallholders has been documented in Java, Sumatra, and Kalimantan. Nevertheless, large areas remain and, in some regions, grassland area may be increasing.

A relatively new perspective on the opportunities for *Imperata* grassland rehabilitation focuses on the capacity of individual smallholders to re-establish trees on these grasslands. Governments can support local farmers' initiatives through policies and programs that reduce risks and the costs of rehabilitation and that increase the returns to smallholders' investments in trees. Since profitable opportunities for low-income farmers are the driving force, this strategy combines sensible grassland rehabilitation with poverty alleviation.

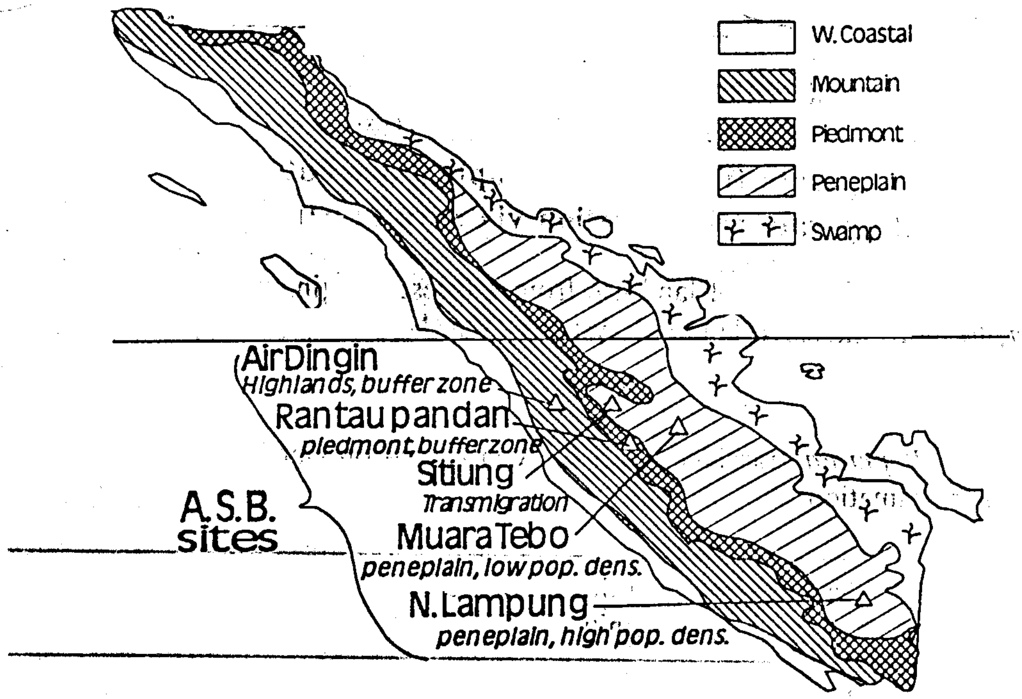


Figure 3. Ecological zones and benchmark areas for the 'Alternatives to Slash and Burn' project in Sumatra, Indonesia (Van Noordwijk *et al.*, 1995)

3. ASB Sumatra sites

In phase I of the global project on Alternatives to Slash-and-Burn, a number of sites was characterized in Brazil, Cameroon and Indonesia. In Indonesia five sites were chosen in order to cover the various ecological zones and the major expected gradients within these zones (Fig. 3).

Although traditional 'shifting cultivation' has virtually disappeared in Sumatra, slash-and-burn methods are used by a broad range of land users, ranging from the original population, via spontaneous and government sponsored migrants to large scale timber and tree crop plantations. For small farmers the dominant land use is rubber, ranging from extensive 'jungle rubber' to intensive plantation type systems. Food crops can be grown during the first years, but some (migrant) farmers depend fully on cash income to provide their food. The transformation of secondary and logged-over forests into permanent tree-based production systems ('agro-forests') can serve as an example for developments elsewhere.

The Rantau Pandan area in the piedmont zone, neighbouring the Kerinci Seblat national park in Jambi province, has a fairly stable population, without much inflow of migrants, and its land use is dominated by agroforests (mainly jungle rubber) with recent increases in the share of cinnamon (*Cinnamomum*, kayu manis or cassiavera).

The nearby peneplain site in the Bungo Tebo area has at least six groups of actors relevant to ASB: 1. a small number of the Kubu hunter-gatherer families who represent the oldest land users, 2. local Jambi farmers with jungle rubber as their main land use, 3. a government transmigration area (Kuaman Kuning), with an emphasis on food crops and considerable *Imperata* areas, 4. a forest concession held by Gadjah Mada University, 5. a group of spontaneous settlers ('forest squatters') who entered the forest after logging and started an intensified form of the jungle rubber system and 6. a recently-started oil palm plantation.

The North Lampung benchmark area in the peneplain has a higher population density and appears to be an out-migration area. Dramatic changes in population pressure due to the inflow of government-sponsored as well as spontaneous migrants over the past 15 years led to disappearance of nearly all forest remnants. *Imperata* grasslands developed here and there is a clear need for development of more sustainable (probably tree-based) cultivation systems to prevent further degradation of the land. Recent farmer interest in oil palm, rubber and fast growing timber (*Paraserianthes*) trees, however, has reached the point that *Imperata* seems to be on the retreat, already. Improved road access certainly contributes to this development.

Overall, a complex of factors was found to drive forest conversion (Fig. 4), both at the level of large private enterprises and government projects, and at the level of smallholder decisions. Decisions about migration are influenced both by *push* and *pull* factors. As long as forest margins on good soils are easy to reach and can be opened with reasonable chance of success, this will attract people from the degraded lands. If, however, control of the remaining forests by local communities and/or government agencies makes it more difficult to open new land and if rehabilitation of *Imperata* grasslands becomes more attractive by better roads and market access, a choice to stay on becomes more likely. Actual migration flows from the N. Lampung benchmark area goNovember 15, 1995 both towards the industries around Jakarta and to the remaining forests in the piedmont zone, but further data are needed.

Fig. 5 summarizes three requirements which should be met before the linkage between *Imperata* grasslands and forest margins becomes true: development of the grasslands should become sufficiently attractive, the alternative of forest conversion should become less attractive, and the other factors leading to forest conversion should be controlled as well. If there is a large 'reservoir' of potential migrants, development of the grasslands will do little to stem the tide.

4. Technical and social aspects of converting grasslands to other uses

There are big differences between control of small patches in farmers' fields compared to conversion of mega *alang-alang* grasslands. Profitability of conversion to other uses depends on the biophysical, social, and economic conditions of specific sites, including

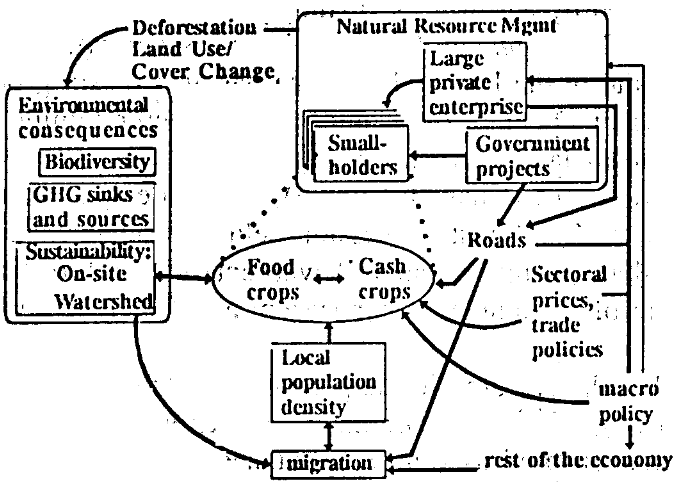


Figure 4. Factors driving forest conversion in the humid forest zone (Tomich and Van Noordwijk, 1995)

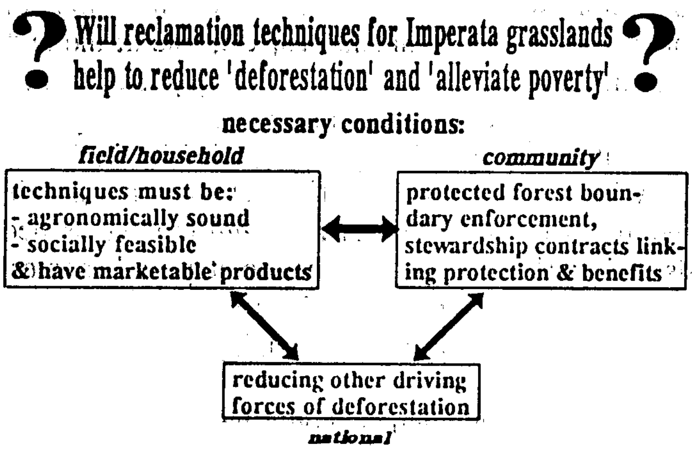


Figure 5. Requirements for the intensification hypothesis to help in reducing forest conversion (Van Noordwijk *et al.*, 1995)

e value of existing uses. These grasslands are not "wastelands". They have a number of ses for local people. Even if these uses are of relatively low value, they are important to e people who use them.

l Fire

Effective fire control is a prerequisite to establishment of trees on *alang-alang* rasslands because *alang-alang* thrives on fire. Yet fires are a persistent problem,

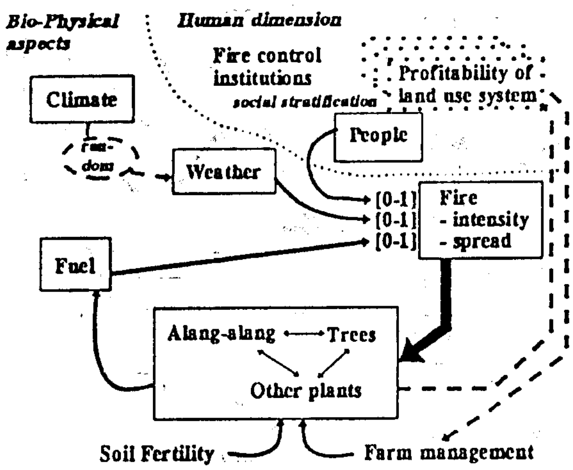


Figure 6. Social and biophysical factors influencing fire occurrence in *Imperata* grasslands (Van Noordwijk, 1994)

destroying trees and reestablishing *alang-alang*. Prevention of fire can be based on shade by a sufficiently dense tree canopy. Monocultures of trees such as *Paraserianthes falcataria* allow too much light at ground level; others such as *Acacia mangium* or *Gmelina arborea* are more suitable

Community-based initiative for prevention and control is a necessary ingredient for effective fire control in grasslands. Local people are in a better position to know about fire risks and to know when a fire starts. Moreover, although they may not be able to manage all fire risks among themselves, local people are in a good position to take timely, on-the-spot actions to extinguish fires while they still are small.

Public fire services will still be needed, especially to assist with big fires. But more effective community-based fire control would reduce demands on the limited resources of the fire service for monitoring and fighting small fires, allowing the fire service to focus on its essential role in fighting big fires. More research is needed to understand existing community-based initiatives and to identify ways in which government can help strengthen those fire control efforts.

4.2 Tenure

Clear rights of ownership of the trees they plant will create incentives for local people to cooperate in fire prevention and to take the lead in fire control. Without this local cooperation to control fire, sustainable rehabilitation of *alang-alang* grassland is extremely difficult. Property rights over all products, including timber, create incentives necessary for local people to do the hard work to re-establish trees on grasslands.

4.3 Reclamation pathways

Van Noordwijk (1994) discussed a number of 'reclamation pathways' for conversion of grasslands. These pathways start at *Imperata* grassland and lead to more intensive land use, be it a forest plantation, an other plantation, a smallholder agroforestry system or a system based on food crops only (Fig. 7).

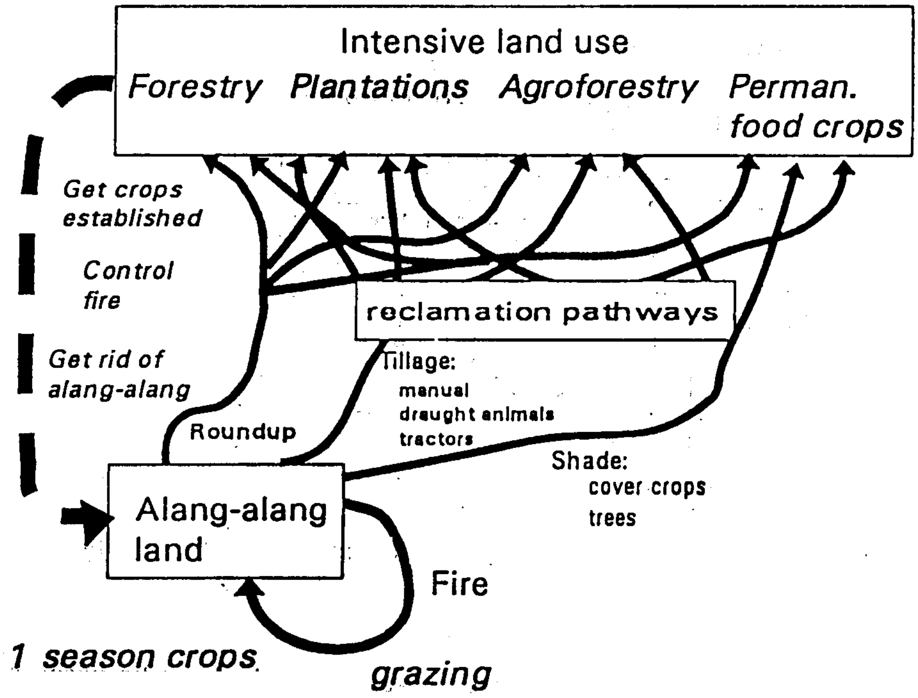


Figure 7. Reclamation pathways (Van Noordwijk, 1994)

In the reclamation a number of steps have to be taken:
1. the *Imperata* should be removed/ reduced in vigour,
2. fire should be prevented (or tolerated) and'
3. the desired plants should be able to grow, which may require an improvement of soil fertility.

For the pathways three starting points can be distinguished, representing the initial control step:
1A. Herbicides such as roundup,
1B. Tillage, by manual, animal or tractor power,
1C. Shade, cast by cover crops or trees. The shade methods are closest to a natural succession, which may start as soon as fire is absent from the land.

As indicated in Table 2, a tentative evaluation of the three methods may consider time, labour and external inputs (labour may have to be paid for as well). The herbicide pathway is the quickest and may take 1 week only, if the herbicide is sprayed in a young regrowth stage (after slashing, crushing or burning); under less favourable conditions spraying has to be repeated. Tillage may need 2 or 3 operations and may take a month; best results are normally obtained in the dry season when the rhizomes are left to dry on the surface. Biological methods, based on cover crops or shade trees need time: at least 2 or 3 months of a dense shade is needed to have a real effect on the vigour of *Imperata* and it may take time for the canopy to develop. Fast growing leguminous cover crops (*e.g.* *Mucuna*, *Calopogonium* and *Pueraria*) can be used, but may need an initial slashing, crushing or burning. A number of trees can be used, but unless the trees are fire tolerant, they depend on fire control or on luck. Natural succession would take care of the *Imperata* if there is a sufficiently long period without fire. Succession is most rapid along a forest margin and may start with creeping vines (*Mikania*) or forbs (*Chromolaena*), followed by shrubs and trees (*Vitex, Peltophorum, Schima* and others). Explicit stimulation of this biological pathway is poorly documented, but may be the lowest cost (although slowest) option.

Table 2. Tentative evaluation of three methods for dealing with *Imperata* as a first step in reclamation.

	Time needed for effect:	Labour needs	Inputs
Herbicides	week	-	---
Tillage	month		
- manual		-----	-
- draught animals		---	-
- tractor		-	----
Shade	year		
- cover crops		-	./-
- trees		-	./-
- natural succession		-	

5. Hypotheses for further research

Van Noordwijk (1994) presented a series of hypotheses which gradually build up from a biophysical to a policy scale. The hypotheses can be classified under four headings: addressing the issue of future versus present land use, and addressing the issues of reclamation pathways, each from a biophysical (technical) and from a socio-economic value point of view.

5.1. Biophysical potential of land currently under *Imperata*

Hypothesis 1. A distinction can be made on biophysical grounds between land where more intensive/productive land use is possible and land where *Imperata* grasslands are the only/ best land use.

Rationale: In areas where the land capability is low, we don't have to consider any further steps. In many areas, however, *Imperata* grasslands occur on soils which allow more intensive use. The hypothesis claims that a distinction between these cases can be made on biophysical grounds, which can be modified by farmer value systems (see 3). Farmers probably have developed relevant systems for evaluating land in this respect. Existing soil classification and land evaluation schemes may give additional clues. Such a scheme may also consider how the *Imperata* grasslands originated (because land was abandoned due to low yields ?) and to which extent soil conditions have been improved under the *Imperata* fallow. Considerable investment in soil fertility (e.g. by rock-P application) can improve the scope for *Imperata* rehabilitation.

5.2. Biophysical pathways for reclamation

Hypothesis 2a. Imperata reclamation pathways are based on chemical or physical destruction of the plant, by using herbicides or tillage, or on a gradual shading out by other plants. All pathways have to deal with fire risks and have to provide the conditions for other plants to grow.

Hypothesis 2b. Biological pathways have a clear disadvantage in time required, but this can be compensated if it is a low-cost and low-labour technology; fire tolerance is a requirement to meet these criteria.

Rationale: The classification of reclamation pathways in Fig. 7 is tentative. Further descriptions of actual pathways are needed to elaborate the scheme and test its usefulness.

5.3. Farmer evaluation of potential *versus* actual land use

Hypothesis 3a. Farmer evaluation of both present and possible future value of the land presently under *Imperata* is based on:

- (perceived) security of land tenure,
- (perceived) market for possible products,
- presence of cattle and need for grazing land
- household needs and resources,
- (perceived) chances for off-farm employment and migration.

Hypothesis 3b. Farmers will only consider reclamation of *Imperata* grasslands if no other land is available.

Rationale. Farmers will only consider rehabilitation if the present value of the land to the users is lower than the possible future value. These present and future 'values' to the farmer do not only depend on the biophysical characteristics of the land (considered under 1.), but probably also on a number of factors as mentioned in the hypothesis. Reclamation of land which was first left to *Imperata* should address the reasons for abandoning it previously.

5.4. Farmer choices among reclamation pathways

Hypothesis 4a. If the possible future value under other land use is much higher than the present one, existing 'high input' technologies based on (tractor) tillage and herbicides can be used and are easily affordable.

Hypothesis 4b. Low-cost reclamation techniques, e.g. by cover crops and fire tolerant trees, become important in those situations where the 'future value' of land use is only moderately higher than the present one.

Hypothesis 4c. Farmers will only choose a biological pathway if sufficient time is available to planning ahead.

Hypothesis 4d. If animal draught power is available, tillage is the obvious reclamation method, provided that the dry season is long enough; in this situation *Imperata* grasslands can be part of a regular fallow pattern.

Hypothesis 4e. Fire control as second step in a reclamation pathway requires social coherence in a group of land users.

Rationale: Reclamation pathways chosen will vary among land users, based on resources and (perceived) options. The 'niche' for agroforestry techniques in land reclamation is probably restricted on one hand by the economic possibilities for high external input farming (hypothesis 4a) and on the other hand by the required time frame (hypothesis 4c).

5.5 Need for fire control

Hypothesis 5a. Fire control at the community level is a pre-requisite for *Imperata* reclamation, especially in the first stages;

Hypothesis 5b. Fire control based on local institutions is much more effective than that based on government rules and regulations

Rationale: Fires are based on the presence of inflammable material (fuel), dry conditions (weather) and people who can either control the fire or stimulate it, for various reasons (Fig. 7). In *Imperata* grasslands there is sufficient fuel for fires in the dry season, and several groups of people may have interests in spreading fire. Biological succession and/or intensification of land use is hampered by fires, as most other plants are not as fire-tolerant as *Imperata*. Fire control can be attempted at a large scale by government-level institutions, or can be based on local (village) level institutions.

5.6. Government policies which can influence farmer decisions

Hypothesis 6a. The simplest and cheapest way for a government to stimulate reclamation of *Imperata* grasslands is to provide secure land tenure.

Hypothesis 6b. On soils with moderate to low land capability investments in improving soil quality (e.g. rock P) can be subsidized as second step. Such subsidies would be more effective than subsidies on the first steps of the reclamation pathway (e.g. on herbicides).

Rationale: To the society at large a more intensive use of *Imperata* grasslands by farmers in stead of further deforestation (or degradation of logged over forests) is beneficial (lower opportunity costs). As there is a clash between current farmer decision making (leading to land abandonment and migration to new sites) and interests of the society at large, a government program to induce *Imperata* rehabilitation is appropriate. Such a program should be cost effective and can be build on the factors modifying farmer decision making. Hypothesis 6b makes a comparison between a number of possible subsidies: long term effects should prevail over short term ones.

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