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Farmer-led Community Institutions: Key to Reversing Land Degradation in the 21st Century

Dennis P. Garrity

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'A cynical interpretation of "successful participation" is when people do what you want them to do.'
-- Ruedi Baumgartner

Farmer-Led Community Institutions: Key to Reversing Land Degradation in the 21st Century

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Reversing global land degradation is about better and simpler technologies, better national policies, and much more. But ultimately it is about rural people and their institutions. The greatest prospect for reversing land degradation in the next century is the evolution of real farmer-led community institutions that take charge and transform the way research and extension in land management are done. Broad-based evidence for this is emerging. This paper will examine this as part of a process of people taking back greater control of their futures through decentralization, democracy, and local leadership. Examples of locally-led processes in natural resource conservation suggest two successful streams: (1) institutions that are developed independently by local communities and managed by them, whose subsequent activities may or may not be assisted by outside stakeholders, and (2) local conservation institutions that are initiated and guided by the public sector.

Four examples of locally-created groups that have had remarkable success in attacking land degradation problems in different parts of the world are analyzed. These include the *mwethya* self-help work groups in the Machakos District in Kenya that released a huge voluntary effort that constructed large areas of terraces to control soil erosion over the years (Thomas-Slayter et al, 1991); farmers' clubs that are a vehicle for widespread diffusion of soil and water conservation practices in southern Zimbabwe (Hagmann and Murwira, 1996); the explosive development of 4500 farmer-led community Landcare groups in Australia and include about a third of the country's farmers (Campbell, 1994; Marriott et al, 1998); and a similar Landcare movement that evolved in the uplands of the southern Philippines focussing on the spread of natural vegetative strips, farm forestry, and other agroforestry practices (Garrity et al, 1998). These farmer-led institutions are independent self-governing entities that may receive training and material support from outside, but they determine their agenda and implement it through their own efforts.

There are also important success stories emanating from the second stream of conservation institutions, that are locally-led but created and actively guided by the public sector. Examples include the Catchment Conservation Committees in Kenya (Lundgren, 1993); the Conservation Districts movement of over 3000 self-governing districts in North America that have been supporting the spread of conservation practices among their members for decades; and the emergence of municipal natural resource management planning and implementation in the Philippines (Pajaro and Catacutan, 1998; DENR, 1998). The two streams of institutional approaches are not incompatible with each other. They may be integrated in the same area in mutually supportive ways, as seen in the confluence of Landcare and Conservation Districts in Western Australia (Campbell, 1994).

These experiences are from both the temperate and tropical worlds. They indicate that community institutions are a vast underutilized resource for planning and implementing resource conservation at the global level. Outside support is often critical for leadership training and modest material support. Local labor and resources, combined with modest external assistance through cost-sharing, foster sustainable development. And linkages to external sources of information and support are fundamental for long term sustainability of these institutions. A community-based strategy needs mechanisms to facilitate these links. Networks of farmer-led community groups will be needed within each country. Likewise, more networking between countries will also be crucial. These networks will accelerate the realization of the power of farmer-led community institutions to reverse land degradation on a global scale during the 21st century.

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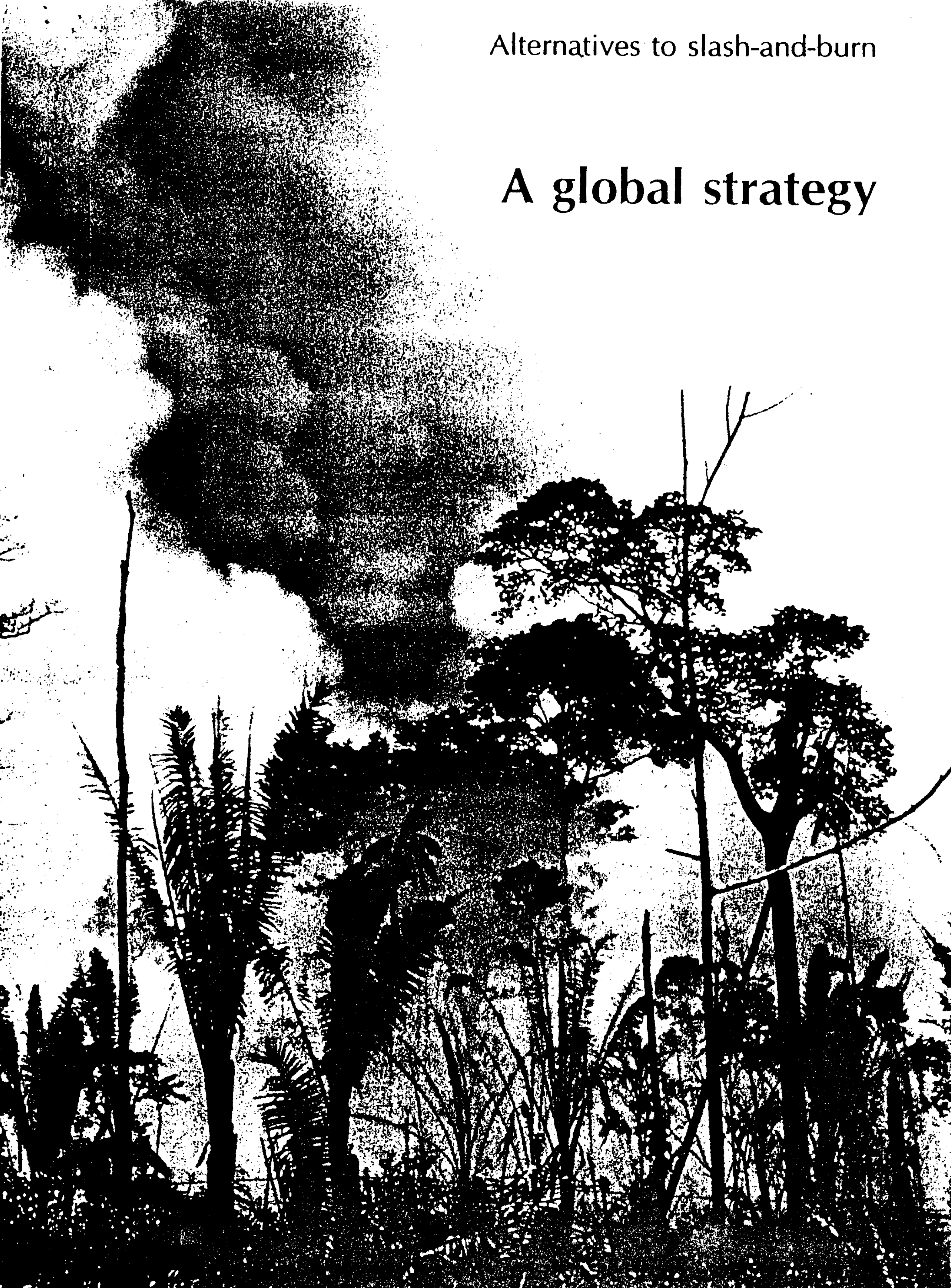
Alternatives to slash-and-burn

A global strategy



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UNDP has been a major facilitator, helping establish ASB with encouragement and funds. The Global Environment Facility (GEF) finances the initiative, with UNDP sponsorship. Co-financing is generated from the core budgets of all partner institutions. Generous assistance also comes from many governments and institutions around the world.

For more information on the Alternatives to Slash-and-Burn Initiative (ASB), or to subscribe to the ASB quarterly newsletter, *Slash-and-Burn: Update on Alternatives*, contact: ASB/ICRAF, PO Box 30677, Nairobi, Kenya; fax: (254 2) 521 318; e-mail: d.bandy@cgnet.com.

Alternatives to slash-and-burn

A global strategy

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A global strategy

prepared by

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International Fertilizer Development Centre — IFDC
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EXECUTIVE SUMMARY

It is estimated that shifting cultivation accounts for about 70% of the deforestation in Africa, 50% in Asia and 30% in Latin America of the 14 million hectares of tropical moist forests currently destroyed every year. Tropical deforestation is responsible for 18% of current global warming, for most of the decimation of plant and animal genetic diversity, and for threatening the stability of many watersheds. Landless farmers from crowded areas migrate to the forested areas and attempt to make a living by slash-and-burn, which results in unsustainable agriculture and continuing rainforest destruction. Sustainable alternatives to slash-and-burn would enable millions of poor farmers to make an adequate living without destroying additional forests. Research conducted at several locations for many years shows hope that for every hectare put into promising alternatives, 5 to 10 hectares of tropical rainforest can be spared from the shifting cultivator's axe every year.

Several international centres have decided to join efforts with national research systems (NARS) to formulate a research-and-development strategy that provides viable alternatives to slash-and-burn agriculture worldwide. The strategy focuses on two main targets: (1) reclamation of already deforested lands such as secondary forest fallows and abandoned grasslands and (2) prevention of damage by deforestation itself. The strategy consists of three main components: (1) developing and testing alternative slash-and-burn technologies for small-scale farms, adapted to specific ecoregions within the humid tropics, (2) linking environmentally oriented strategies with socioeconomic policies that provide incentives for such technologies and disincentives to further deforestation and (3) designing effective economically sound and socially acceptable rainforest conservation methods.

The proposed mode of operation

- is a joint strategic research effort of CIAT, IITA, ICRAF, IFDC, IRRI and TSBF at selected benchmark sites on socioeconomic and biophysical aspects of slash-and-burn in partnership with national research institutes and non-governmental organizations
- will validate, test and disseminate options through regional networks, involving public and private organizations and effective policy dialogues in each collaborating country
- will extrapolate global change implications by making the research results available to IGBP-related programmes
- train and strengthen institutions to enhance the capacity of the deforesting nations to build and sustain their efforts to alleviate the crisis.

Selected benchmark sites, two or three per continent, will be selected to encompass the range of biophysical and socioeconomic conditions in the humid tropics. In Africa, one site will be in the equatorial Congo rainforest, which is a zone of rapid demographic, social and environmental change, and one will be in the dystrophic miombo woodlands, where chitemene is practised.

In Latin America, two sites in the Amazon are proposed, one in semideciduous evergreen rainforests with rapid development and another in a typical rainforest with poor infrastructure and migration from the Andean region. A third site in Mexico will be considered.

In Asia, one site is envisioned in the equatorial rainforests, where both primary forest clearing and degraded alang-alang grasslands are abundant, another in the tropical monsoonal region and a third in the hill country of mainland Southeast Asia in an area of extremely rapid deforestation and rapidly eroding slopes.

The level of effort envisioned is on the order of USD 5 million per year per continent for an initial five-year period. This includes strategic research at benchmark sites, direct funding to the host national agricultural research systems, network support, overall coordination and linkages with global environmental efforts. This project builds on existing research facilities and institutions, thereby minimizing capital and administrative costs. It is envisioned that after 10–15 years, the project will have made major contributions toward mitigating major environmental damage and will also have enhanced equity for small-scale farmers in the humid tropics. The immediate beneficiaries will be farmers and consumers of the humid tropics; however, the mitigation of tropical deforestation will benefit every person in the world.

FOREWORD

Representatives of the United Nations Development Programme contacted international centre leaders at International Centres Week in October 1990 to enquire about the feasibility of a concerted effort to develop alternatives to the slash-and-burn system of agriculture. The idea was followed up by scientists from IFDC, IITA, ICRAF and TSBF, who met in Lome, Togo, in June 1991 and formulated the framework of a project, focusing on Africa. Representatives of ICRAF, IFDC, IITA, CIAT, IRRI, TSBF and UNDP met in Diamant, Martinique, 2–3 July 1991, to discuss the possibilities of a global programme. A first draft was the product of that discussion. Contacts were made with potential NARS collaborators, NGOs and members of the global-change scientific community. A visit was made to the head of the Global Environmental Facility on 29 August. The concept was shared with donors, NARS and NGO representatives at an informational lunch during International Centres Week on 29 October, and a seminar, cosponsored by the Environment and Agricultural divisions of the World Bank, was conducted on 31 October 1991.

Sequentially, the First Global Workshop on Alternatives to Slash-and-Burn, financed by UNDP, was held at Porto Velho, Rondonia, Brazil, 16–21 February 1992, to determine the feasibility of developing a global, coordinated effort on alternatives to slash-and-burn agriculture in tropical rainforest areas. The participants were 26 environmental policy makers and research leaders from eight tropical countries and representatives from five non-governmental organizations, six international research centres, three regional research organizations and six donor agencies. The major conclusions were:

- A global effort is needed.
- The approach for planning and implementing the programme is to be collaborative.
- Socioeconomic policy and biophysical issues are to be emphasized.
- The focus is to be on broad global issues as well as those of specific regional concern.
- Eight locations are to be selected as ecoregional benchmark sites.
- A Global Steering Group (GSG) is to be created to ensure continuity and global coordination.
- ICRAF, as requested, is to continue to play the overall coordinating role.

This proposal is a product of the feedback received from such interactions.

THE PROBLEM

Characteristics of slash-and-burn

Slash-and-burn (or shifting cultivation), the traditional farming system over large areas of the humid tropics for centuries, still remains the dominant land-use practice in about 30% of the arable soils of the world and provides sustenance for an estimated 250 million of the world's poorest people and additional millions of migrants from other regions (Hauck 1974).

Throughout the world, traditional shifting cultivation practices are remarkably similar. Small forested areas are cleared by axe and machete during periods of least rainfall and are burned shortly before the first rains. Without further removal of debris, crops such as corn, rice, beans, cassava, yams and plantains are planted in holes dug with a planting stick or in mounds for root crops in Africa. Intercropping is very common, and manual weeding is practised. After the first or second harvest the fields are abandoned to rapid forest regrowth. The secondary fallow may grow for 10 to 20 years before it is cut again (Nye and Greenland 1960, Sanchez 1976).

Traditional shifting cultivation is based on nutrient cycling and weed and pest suppression during the fallow period. In regard to nutrient cycling, burning releases to the soil about half of the nitrogen and phosphorus of the burning biomass and practically all of the other nutrients in the form of ash, which also causes a liming effect. Higher soil temperature following burning also accelerates the decomposition of soil organic matter. These factors provide high nutrient availability for one or two years to grow food crops, depending on the inherent fertility status of the soil (Seubert et al. 1977, Smyth and Bastos 1984, Lal et al. 1986). Burning also helps to control pests and diseases and enables cultivators to clear land quickly and efficiently with minimal labour requirements. (Alternative forms of clearing land are usually too expensive and labour intensive, especially for poor farmers.) As nutrients are removed by crop harvests or lost to leaching, overall fertility declines. Nutrient deficiencies as well as increasing weed pressure impede further cropping, and the fields are abandoned to a secondary forest fallow. The secondary forest grows rapidly, tapping nutrients remaining in the soil, including those released slowly by unburned decomposing forest biomass, accumulating them above ground for 10 to 20 years, until the cycle begins again (Nye and Greenland 1960, Szott and Palm 1986).

Biodiversity is another unique feature of this form of cultivation. Most indigenous shifting cultivation systems consist of complex polycultures. They have a diversity of crops and species, including trees and food crops in 'traditional' agroforestry systems. This diversity helps to reduce the risk of disease and pests, and it provides a diverse source of foods and products for families. In addition, indigenous systems are usually tied to complex cultural norms and socioeconomic traditions and involve unique cultural knowledge of diverse species. Also, the vegetation of the fallow stage serves as a genetic reservoir for many important plants and is a refuge for invertebrate and vertebrate animals.

In relation to environmental problems promoted by slash-and-burn cultivation, the burning releases half of the nitrogen and most of the sulphur and carbon into the atmosphere, thus contributing to greenhouse gases. Similarly, the accelerated organic matter decomposition associated with intensified agriculture increases carbon loss; the higher nutrient availability can increase gaseous nitrogen emissions.

The fallow period therefore does not improve soil fertility per se. Except for some reaccumulation of carbon in the soil organic matter and fixation of atmospheric nitrogen, fallows mostly accumulate nutrients in the plant biomass, which can be tapped by future crops upon slash-and-burn. The essential mineral nutrients (phosphorus, potassium, calcium, etc.) are extracted from lower soil layers during regrowth and brought to the surface by plants. However, unlike N_2 fixation, this is essentially a slow process, which concentrates nutrients where they can be used to grow a crop but which does not add nutrients to the system. These slowly accumulated nutrients are then removed in the harvested crop, increasing the net loss of nutrients from the whole system.

The traditional systems are ecologically and environmentally sound at low (or very low) population densities. For millions of peoples, shifting agriculture in traditional forms has provided and still provides a basis of subsistence, cultural values and social stability, particularly under low population density. These systems are in various forms, ranging from classic swidden systems to altered forms, such as the taungya system. These systems also have features, such as nutrient cycling and diversity, that are useful for understanding sustainable land uses in the humid tropics.

However, traditional shifting cultivation systems are being rapidly replaced by shifting cultivation in disequilibrium, which turns into unsustainable forms of agriculture. These changes also lead to cultural and social disruption of traditional societies. The unsustainable form of slash-and-burn is practised by migrants from other regions, who are unfamiliar with the humid tropics and ignorant of the sophisticated practices of indigenous cultures that make shifting cultivation a sustainable system. The central concern in this project is unsustainable slash-and-burn, in areas where alternatives are needed, as distinct from the traditional systems practised by indigenous people in forest areas.

Soil erosion is seldom a significant problem in traditional shifting cultivation, because the land area is relatively small and is always covered by some sort of vegetative cover, such as fallen logs, crops, weeds or forest fallows. When shifting cultivation is practised by newcomers to the humid tropics, the land is often devoid of soil cover for considerable time. This can lead to major erosion and siltation of rivers, particularly in hilly areas (Lal et al. 1986).

Shifting cultivation is definitely not sustainable if significant increases in land productivity are required to support higher human population densities and increased demand for food and fibre. Recent increases in population growth, as well as transmigration to poorer, less fertile soils, have placed great pressure on farmers to increase the productivity of limited land resources by expanding the length and intensity of the cropping period and decreasing the fallow period. Migration is less significant in Africa, but major in Latin America and Asia.

As the time available for secondary forest fallow growth decreases, the fertility and productivity of the soils, which are mostly low, continue to decline. Furthermore, when the fallow period is shortened, it generates a disequilibrium of carbon input-output ratios and intensifies nutrient mining. Complex and often adverse ecological changes occur, such as invasion of *Imperata* grasslands and reduction in the number of native seeds left viable for regrowth. Re-establishment of secondary forest fallow vegetation is slowed or stopped, some soil becomes bare and erosion begins. This situation is typified by the so-called derived savannas, which occupy more than three-fourths of the previously tropical moist forest of West Africa. In turn, these declines in productivity contribute to increasing economic hardship and impoverishment for shifting agriculture under conditions of disequilibrium. Moreover, people in these situations tend to lack access to alternative economic opportunities, are isolated from development programmes and in some areas are marginalized further by the expansion of large-scale producers such as cattle ranchers. The trends towards expansion of the cropping cycle and a decrease in the fallow period are central to the problem of non-sustainable production. They are also the key trends affecting the contribution of slash-and-burn to global warming. In particular the net reduction in soil organic matter and plant biomass through intensification and modification of traditional systems are the main mechanisms by which slash-and-burn is, if anything, increasingly contributing to the greenhouse effect. The two problems, and their solution, go hand in hand.

Population growth and poverty are not the only causes behind increased rates of deforestation. External forces or processes such as expansion of commercial plantations or farms, ranching, logging and mining also attract or push migrants into slash-and-burn, causing considerable deforestation. In Africa the expansion of cash crops for export (e.g., groundnut, cotton, coffee, cocoa) has considerably reduced land availability for food crops, increasing forest encroachment and reducing the fallow period. Another important cause is the need for fuelwood, estimated to account for half of the wood harvested in the world. Commercial exploitation for high-value logs accounts for much of the deforestation in Central America, Bolivia, Brazil, Nigeria, Côte d'Ivoire, Indonesia, Malaysia and Philippines, mainly to supply European, American and Japanese markets.

In Latin America, clearing the forest is a way for settlers to claim title to state lands, encouraging uneconomic forest clearing and land speculation. Construction of roads and other infrastructural facilities supporting development strategies have also contributed to accelerated rates. The recent deforestation in the Brazilian Amazon can be attributed mainly to commercial logging, plantations, speculation and mining, while population pressure by small peasant agriculturalists, clearing land for their own farms, accounts for only about 10% of total deforestation.

Environmental context

Recent estimates indicate that about 18% of global warming is due to the clearing of tropical rainforests, which is occurring now at a rate of 14 million hectares of primary forest per year (EPA 1990). Most of the deforestation is presently occurring in tropical America and tropical Asia, accounting for 40 and 37% respectively of estimated net carbon emissions from deforestation in 1980. Tropical Africa ranks third, with 23% of the emissions (Houghton et al. 1987). Deforestation rates have almost doubled during the last decade: from 7.6 million hectares per year in 1979 to 13.9 million hectares per year in 1989 (Myers 1989).

Deforestation from slash-and-burn agriculture in disequilibrium can lead to several negative environmental consequences, including soil erosion and degradation, leaching, watershed degradation and loss of biodiversity. These repercussions at the local level signify resource depletion and declines in production. In addition, diverse forest products are greatly underutilized. At a wider level, the loss of forest cover also contributes to changes in rainfall patterns and climate change.

After deforestation, soil organic matter may act as an additional source of carbon dioxide to the atmosphere or as a sink where carbon dioxide may be sequestered, depending on how the land is managed. There is little reliable quantitative knowledge about fluxes of carbon dioxide, nitrous oxides or methane caused by shifting agriculture. Hard data from well-replicated experiments and surveys are needed to determine the current extent of slash-and-burn agriculture and the process of change in land use, including the extent and nature of the environmental impact of these systems. The contribution of tropical land use to global change is one of the uncertainties in current models (Houghton et al. 1987).

Although every country with humid tropics is undergoing deforestation of primary forests, 12 countries account for over 80% of the total (table 1).

Deforestation rates are expected to increase in the next decades, and the overall contribution to global warming is expected to equal or exceed that of fossil fuel combustion by the second or third decade of the 21st century. If this trend continues, much of the remaining tropical forest will be diminished by the end of the 21st century. Deforestation is also decimating the world's largest depository of plant and animal genetic diversity (Myers 1989). Recent discoveries of rainforest plants as new sources of food, or as ingredients in chemotherapy for certain types of cancer, underscore the need to preserve rainforest biodiversity. Therefore, finding practical ways to preserve tropical rainforests is one of the principal global environmental concerns of our times.

Socioeconomic, policy and equity context

Tropical deforestation by slash-and-burn is also a major human equity concern, because slash-and-burn is largely practised by the poorest, largely displaced rural populations of the tropics. Moreover, poor people usually bear the main costs of environmental degradation. The process of deforestation is driven by a complex set of demographic, biological, social, geopolitical and economic forces, as well as policy pressures (Sanchez et al. 1990). Population growth in developing countries continues at a high rate, while most of the fertile and accessible lands are already intensively utilized.

A variety of governmental policies often exacerbate and contribute to resource degradation, land scarcity and inappropriate land use. For example, land-use policies allow gross inequities in land tenure. These factors result in an increasing number of landless rural people, who essentially have

Table 1. Rates of deforestation and carbon emissions for leading countries

Country	Annual deforestation ('000 ha $year^{-1}$)	Rate (% $year^{-1}$)	CO_2 emitted (million t C $year^{-1}$)
Brazil	5000	2.1	46
Indonesia	1200	1.4	12
Myanmar	800	3.3	8
Mexico	700	4.2	6
Colombia	650	2.3	6
Thailand	600	8.4	6
Malaysia	480	3.1	5
Zaire	400	0.4	5
India	400	2.4	4
Nigeria	350	14.3	6
Peru	350	0.7	3
Vietnam	350	5.8	3
World total	13860	1.8	140

Source: Myers 1989, estimates for 1989 three choices: stagnate in place, migrate to the cities, or migrate to the rainforests that constitute the frontier of many developing countries. Similarly, land-tenure policies often do not enable people to have secure title to land, which may discourage producers from adopting methods that are sustainable in the long term. Although urban migrations are spontaneous, national policies in key countries, notably Brazil, Peru and Indonesia, include colonization programmes, often geopolitically motivated, that encourage the occupation of their tropical rainforests.

Other policy-related factors that lead to unsustainable slash-and-burn agriculture and problems resulting from it include fiscal and monetary policies (e.g., subsidies, incentives and credit), inadequate laws and regulations affecting land use and forests, inappropriate infrastructure, lack of markets for alternative products, weak institutional services such as lack of education and technical assistance, lack of farmer organization, and neglect of farmer participation in research and development programmes. Macroeconomic policies, including the influence of international financial agencies, may underlie the problems as well.

In addition to causing problems, the above policy-related factors constitute socioeconomic constraints for the adoption of more appropriate land-use practices. Densely populated rural environments such as the Andean valleys, Northeast Brazil and Java suffer from ever-decreasing farm size and overuse of steepland areas. This results in widespread soil erosion, siltation of reservoirs and other adverse off-site effects on urban centres.

Migration to the cities in search of a better life results in bitter disappointment and, coupled with limited urban infrastructure, produces unmanageable cities with populations far exceeding their carrying capacity and infrastructure. People migrating to the humid tropics seldom find a cornucopia. The equilibrium of traditional shifting cultivation, with its long forest fallows, is broken by the migrants and in some countries by land speculators as well. The result is shifting cultivation in disequilibrium, which quickly turns into various forms of unsustainable agriculture. Traditional societies are disrupted, economic failures abound, and migration to urban centres increases.

The results are urban unemployment and further deforestation. The consequence of the former is abject urban poverty, which leads to widespread crime, poor health and in many cases, social upheaval. Also, deforestation depletes the limited nutrient capital of ecosystems, decimates plant and animal genetic diversity, and accelerates global warming.

Environmental degradation originating from deforestation often affects production and subsistence systems in rural areas. Erosion, flooding, groundwater depletion and silting affect agricultural productivity, decreasing food availability, income and employment. Forests also serve as 'food banks' for poor communities and often are the main source of household energy for cooking; yet, these resources are lost in the degradation process.

Responses

Efforts have been initiated by many institutions in the attempt to alleviate problems from uncontrolled slash-and-burn and other resource degradation. Research programmes, technology and extension projects, and policies have been developed in some regions. For example, a recent change in strategy led the Brazilian government to eliminate incentives to Amazon development, resulting in substantive reductions in deforestation rates.

However, in many cases, these efforts have been constrained or are inadequate in alleviating problems and providing alternatives. Forestry programmes assume that sustained, rational exploitation in suitable areas, using appropriate technologies, should lead to economic benefits. Their assumptions about social institutions, markets, costs, alternative land uses, agro-climatic conditions and available technologies have often been erroneous. Also they sometimes neglect to consider the rates 'beneficiaries' use to discount uncertain future costs and benefits. Equally, they may disregard local social, economic and cultural relationships and constraints, ignoring the way introduced activities compete with others vital for the family livelihood. On the other hand, forestry activities that complement the use of farmers' land, time and other resources in a way that is integrated with other agricultural activities may be more readily adopted.

Moreover, existing institutions undertaking research and extension in this area tend to lack coordination. There is a lack of direct involvement of non-governmental organizations and farmers groups in the research and development activities. In many cases, technology transfer has failed to have an impact in a 'top-down' mode of diffusion. Efforts may be duplicated. These constraints need to be overcome through coordinated and comprehensive research and actions. Lessons can be learned from both the weaknesses and successes of previous efforts, but there is still a great deal of work to be done to alleviate the problems.

The problem addressed by this document therefore has implications for the global environment as well as implications for equity among the poorest of the rural poor, including a major proportion of the migrant populations.

CURRENT STATUS

The search for alternatives to slash-and-burn fortunately does not have to start from zero. There is considerable knowledge about the biophysical and socioeconomic determinants of shifting cultivation.

Technologies

Research on shifting cultivation has been conducted in Africa since the 1920s on replacing chitemene nutrients by sources other than burning. The work in the 1950s by Jurion and Henry (1969) in Zaire and of Nye and Greenland (1960) in Ghana are widely known. The anthropological basis of shifting cultivator cultures has been widely studied in Asia, Africa and Latin America. Long-term agronomic research has been conducted since the 1970s, primarily but not exclusively by four groups: at Yurimaguas, Peru, and Manaus, Brazil, by North Carolina State University (Sanchez et al. 1983, Sanchez and Benites 1987, Sanchez et al. 1987, Szott et al. 1991); at Ibadan, Nigeria, by IITA (Yamoah et al. 1986, Juo and Law 1977, Kang et al. 1990); in northeast India by Ramakhrishnan and associates (Ramakrishnan 1984, Toky and Ramakrishnan 1981, Ramakrishnan 1987); and in Sumatra by AARD and associated institutions (MacIntosh et al. 1981, Von Uexkull 1984, Wade et al. 1988). These efforts have provided several kinds of information:

- They have quantified the nutrient transfer process from biomass to ash and into soil and monitored the changes in soil properties upon cropping..
- Analysis of the dynamics of soil organic matter has shown that judicious management of inputs, vegetation cover and harvest residue can result in a sustained level of soil organic matter (SOM).
- They have determined that bulldozer clearing is inferior to traditional slash-and-burn in providing suitable physical

and chemical soil properties for planting of food and tree crops. Detrimental effects of bulldozer clearing include topsoil carry-over, soil compaction and the absence of ash as a nutrient-transfer process. Several major colonization projects are no longer based on bulldozer land clearing.

- They have determined that the shift in weed population from broadleaved species to grasses is one of the principal causes of land abandonment and often surpasses the depletion of soil fertility.

- They have determined that crop rotation allows crops to be grown continuously with judicious use of lime, fertilizer and green manures, producing sustainable yields in well-managed systems. With poor management, however, attempts at continuous production have resulted in sharp drops in productivity, soil compaction and erosion, even in flat areas.

- Low-input systems have the highest potential for sustainability in acid, low-fertility soils if they are based on the use of aluminium-tolerant germplasm of annual crops, pastures or trees. Systems based on this principle have shown sustainable production for more than 10 years at research stations, with evidence of improvement rather than degradation of physical, chemical and biological soil properties.

- Keeping the soil surface covered at all times is a key principle for sustainability in the humid tropics. Soil erosion can be controlled with the use of agroforestry systems, including alley cropping on slopes, live fences in pastures, annual crop–tree crop systems and managed forest fallows. The presence of perennial vegetation further promotes nutrient recycling by litter and root turnover. This is particularly effective in pastures and agroforestry systems.

- Current research indicates that shifting cultivation can be replaced by alternative systems that meet the food and fibre needs of the humid tropical farmer while providing for additional income by producing high-value, low-volume crops for export. With these crops (including rubber, palm oil, heart of palm, tropical fruits, pepper, medicinals) the humid tropics have a comparative advantage. Changing consumer values in the First World toward more nutritious and ecologically friendly products may increase this comparative advantage.

- Research on plantation forestry shows that many of the principles applicable to agricultural systems are also appropriate for soil conservation, fertility enhancement, weed control and crop selection in forest management.

The research synthesis shows that some alternatives are possible; there definitely is hope. But research has been conducted on an insignificant scale and primarily at research stations. Such a knowledge base needs to be expanded geographically and adapted to specific climate, soil and socio-economic constraints with different market opportunities. Research needs also to expand from on-station to on-farm testing.

Sustainable management options for acid soils of the humid tropics have been developed to fit different landscape positions, soils and levels of development of the socioeconomic infrastructure (Sanchez 1987). For instance, the principal sustainable management options and alternatives to slash-and-burn for one region, the Selva Baja of Peru, are paddy rice production of alluvial soils, low-input cropping, continuous cultivation, legume-based pastures, agroforestry, perennial crop production (rubber, oil palm) and plantation forestry. Their place in the landscape can be distinguished (fig. 1).

Nutrient recycling must be enhanced in all systems, to minimize the need for external nutrient inputs and maximize their efficiency. The management of crop and root residues is crucial in this regard (Swift

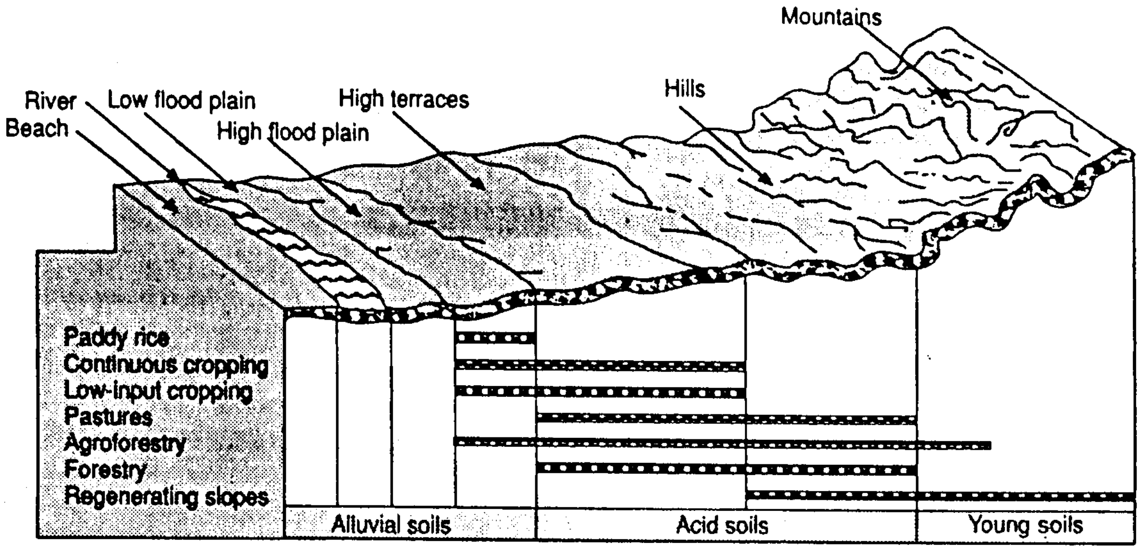

Figure 1. Management options for acid soils of the humid tropics.

1987). Approaches proposed by TSBF on quantifying the nutrient release of organic input and managing soil organic carbon, nitrogen and phosphorus are major components of the research on low-input cropping, agroforestry and pastures. The promising results in predicting the rate of nutrients released from leguminous materials based on their polyphenolic contents (Palm and Sanchez 1991) provide for the first time an opportunity for the quantitative management of organic input in a manner comparable to the management of chemical fertilizers.

However, even in situations where nutrient cycling is possible on a significant scale, it is necessary to employ supplemental fertilizer to maintain productivity. Research conducted by IFDC in Africa has shown that judicious use of fertilizers in combination with a programme of crop residue management is superior to the use of either fertilizers or nutrient cycling alone. Where phosphate rock deposits are available, it may be possible to substitute these agrominerals for commercial fertilizer phosphates.

For every hectare put into these sustainable soil management technologies by farmers, 5 to 10 hectares per year of tropical rainforests will be saved from the shifting cultivator's axe, because of their higher productivity. Estimates at Yurimaguas, Peru, for various management options (Sanchez et al. 1990) are given in table 2. These estimates will vary with climate and soils.

Table 2. Estimates of the impact of soil management technologies on deforestation for Yurimaguas and Peru

1 ha in sustainable management options . . .	equals *x* ha saved from deforestation annually
Flooded rice	11.0
Low-input cropping (transitional)	4.6
High-input cropping	8.8
Legume-based pastures	10.5
Agroforestry systems	not determined

Such technologies are particularly applicable to secondary forest fallows, where clearing does not contribute significantly to global warming because of the small tree biomass. The use of secondary forest fallows is of very high priority, because in many areas they are a feasible alternative to primary forest clearing. Many of the degraded or unproductive pasture or croplands resulting from poor management practices can also be reclaimed using some, but not all, of these available technologies.

Furthermore, research must also be more process oriented to better understand the 'why' questions and focus beyond the 'whats' listed in the preceding section. In particular, there is need to understand the processes that link agricultural and forestry management of these ecosystems to sustainable conservation of the surrounding environment. In addition, socioeconomic research should address 'how' farmers adopt or adjust new technologies, 'how' farmers and communities make decisions on short-term gain versus long-term resource conservation and 'how' the new technologies affect farmer decisions on forest clearance. Finally, research efforts should be more inclusive, with greater participation of NARS, NGOs and developed-country institutions, effectively linked with the global climatic-change community (Bouwman 1990) and biodiversity, aiming at a common research agenda.

Policy

None of these technologies, however, is likely to be used without significant policy changes that provide adequate market and infrastructure development and at the same time protect the remaining rainforests from being cut. Deforestation is a relatively new field in the policy sciences, but some of its underpinnings are beginning to emerge. Analysts in this field generally cite six or seven major policies to decrease tropical deforestation. These are:

- supporting economic development and market opportunities that are environmentally sound
- establishing more equitable land-tenure systems and securing tenure rights for poor farmers
- encouraging migration to less fragile areas such as the Cerrado of Brazil
- preserving the remaining forests by a vast network of well-protected national parks
- eliminating 'distorted' policies or laws that induce forest destruction
- sustaining the use of the forests as extractive reserves
- establishing and enforcing land-use and forestry laws

While policies that promote these necessary strategies should continue, they are not sufficient to mitigate deforestation.

Linking environmentally oriented strategies with economic ones provides a practical, realistic approach. New efforts in this direction are beginning to emerge (Bouwman 1990, Gillis and Repetto 1988) and have resulted in lively dialogues. A few deforesting countries have developed policies to contain deforestation primarily in response to national and international environmentalist pressures. Some of them are far too radical to be workable. In some cases they backfire, with severe negative effects on the economy, and trigger increasing deforestation in neighbouring countries.

The need for solid policy research on tropical deforestation is as important as biophysical research. This should complement and link with research on technological and socioeconomic options as well. Furthermore, there is a need to assess how economic growth affects rates of forest clearance, how agricultural intensification affects migration and how new technology affects both aspects.

Guiding principle

This review of the status of research, technologies and policy suggests the following principle: control deforestation from slash-and-burn agriculture in situ by eliminating the need to clear additional land and by rehabilitating degraded land and resources.

This can be done by:

- providing sustainable alternatives to slash-and-burn

- reclaiming and managing abandoned and degraded lands that are declining in productivity, including secondary forest fallows and unproductive grasslands
- addressing policy factors that affect slash-and-burn agriculture and the adoption of alternatives

Land-use management options are urgently needed that improve the economic status of subsistence farmers, maintain agricultural productivity on deforested lands and recuperate productivity of degraded lands. Such options will provide sustainable development of the forest margins in a way that satisfies human needs and preserves the ecosystem. These options must be compatible with the different socioeconomic needs of specific areas so that they are readily and widely adopted. In addition we should be concerned with how and why deforestation occurs, how the people living in and around forests are affected by deforestation processes, how they react individually and collectively, and what role government policies play. Activities will focus on local interactions of slash-and-burn processes but will also take into account broader processes and systems (zonal, national and regional). In this context, the agroecological foundations of sustainable agriculture will be established as a basis for developing biologically based management systems.

Is such an approach possible with the predominantly acid, low-fertility soils of the humid tropics? Our answer, based on long-term research, is an emphatic yes, with the use of alternatives to slash-and-burn.

Farmers do not cut tropical rainforest because they like to; they clear them out of sheer necessity to grow more food. Deforestation and the poverty of shifting cultivators, therefore, can be reduced by the widespread adoption of sustainable management practices and policies that permit the use of cleared land and development of diverse, underutilized forest products, on a continuing basis. Such practices also have the potential to reduce emissions of greenhouse gases and increase land available for sustained forest management. Such technologies, however, are useless without effective government policies that encourage, support and regulate them. Likewise, well-conceived policies will fail without sustainable technologies. Therefore, the hope lies in a joint technology–policy approach.

PROJECT PURPOSE

This document proposes a worldwide research and development project with the following goal, objectives, target areas, time frame, and research agenda.

Goal

To significantly reduce the rate of tropical deforestation driven by slash-and-burn agriculture and associated processes, and improve the well-being of dwellers of the forests and forest margins by means of a joint technology–policy approach aimed at developing feasible land-use alternatives.

Objectives

- Assess the socioeconomic processes leading to deforestation, including decision-making patterns of farmers practising slash-and-burn.

- Identify and develop improved production systems that are economically feasible, socially acceptable and environmentally sound alternatives to current slash-and-burn systems at key benchmark sites in the humid tropics.

- Identify policy options and institutional management issues that facilitate adoption of such systems and at the same time discourage further deforestation.

- Validate and transfer through adaptive networks in Asia, Africa and Latin America successful experiences in prototype technologies and policies.

- Quantify the contribution of slash-and-burn and its alternatives in the tropical forest zone to global environmental changes.

- Train professionals and strengthen institutions to build a sustained research and policy infrastructure.

Target areas

The forests and forest margins within major humid tropical areas of Africa, Asia and Latin America, where deforestation is extensive and accelerating at present.

Time frame

The time frame is 15 years, given the long-term nature of the work, with an initial phase of 5 years for consideration by the Global Environmental Facility or other donors.

Biophysical and policy research agenda

The objectives, activities and expected outputs for both the biophysical and policy research are outlined in table 3.

- Characterization of the biophysical and policy evironment will be undertaken at each of the proposed study areas. Specific emphasis will be given to an analysis of conditions under which farmers have already started to modify slash-and-burn systems and intensify land use. Such information will be derived from prior studies of land-use systems and from more specific reviews of farms within these systems.

- Using outputs from biophysical, socioeconomic and policy research, a regional, geographically referenced database will be developed for the purpose of synthesizing regional information and identifying key socioeconomical and biophysical determinants and processes leading to slash-and-burn agriculture and deforestation. The regional GIS database will provide the global framework under which the research will be conducted and have potential impact.

- For both biophysical and socioeconomic reasons, not all land-use systems currently practised as alternatives to slash-and-burn are sustainable. To evaluate the sustainability of these systems, it is important that criteria be developed against which the systems can be assessed. These criteria will be established by a global working group consisting of participants from the three regions and other experts from relevant research areas. The criteria will be tested in a few selected areas.

- Based on the information gathered regionally and synthesized globally, and utilizing the sustainability criteria, potential alternatives to slash-and-burn agriculture will be identified and documented in a geographically referenced database. This database will provide a global reference point for sharing and transferring information for regional and local research initiatives, and the potential relevance and introduction of new alternatives.

- To provide a focus for research and intervention, and based on agroecological and socioeconomic criteria, priority identification domains will be named in each study area. Given the wide spectrum of potential interventions, this activity will maximize the chances for the adoption and impact of sustainable alternatives through the identification of priorities for technology development and system improvement.