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Alternatives to Slash-and-Burn

Project Document

This Project Document has been edited to facilitate public dissemination. The original is on file in the GEF Office at UNDP Headquarters in New York.

ABBREVIATIONS

AARD	Agency for Agricultural Research and Development (Indonesia)
AFNETA	Alley Farming Network for Tropical Africa (Nigeria)
AFRD	Agency for Forestry Research and Development (Indonesia)
AFRENA	Agroforestry Research Networks for Africa
BAHC	Biospheric Aspects of the Hydrologic Cycle (of the International Geosphere-Biosphere Programme)
CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CPAA	Centro de Pesquisas Agroflorestais da Amazônia (Manaus)
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
DIS	Data and Information Systems (of the International Geosphere-Biosphere Programme)
EMBRAPA	Empresa Brasileira de Pequisa Agropecuária (Brazil)
F/FRED	Forestry/Fuelwood Research and Development Project (Winrock)
GCTE	Global Change and Terrestrial Ecosystems (of the International Geosphere-Biosphere Programme)
GIS	Geographic Information System
GSG	Global Steering Group
IARC	International Agricultural Research Centre
IBPGR	International Board for Plant Genetic Resources
IBSRAM	International Board for Soil Research and Management
ICRAF	International Centre for Research in Agroforestry (Kenya)
IFDC	International Fertilizer Development Center (USA)
IFPRI	International Food Policy Research Institute (USA)
IGAC	International Global Atmospheric Chemistry (of the International Geosphere-Biosphere Programme)
IGBP	International Geosphere-Biosphere Programme
IICA	Inter-American Institute for Cooperation on Agriculture
IITA	International Institute for Tropical Agriculture (Nigeria)
ILCA	International Livestock Centre for Africa
IRA	Institut de la recherche agronomique (Cameroon)
IRRI	International Rice Research Institute (Philippines)
ITE	Institute of Terrestrial Ecology (UK)
LSG	Local Steering Group
NARS	National agricultural research system
NGO	Non-governmental organization
NORAD	Norwegian Agency for International Development
ODA	Overseas Development Administration (UK)
ONADEF	Organisation national du développement des fôrets (Cameroon)
PROCITROPICOS	Cooperative Programme on Technology Generation and Transfer for the South American Tropics
RISTROP	Red de Investigación de Suelos Tropicales
RSG	Regional Steering Group
S&B	slash-and-burn
START	Global Change System for Analysis, Research and Training
TSBF	Tropical Soil Biology and Fertility Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WRI	World Resources Institute

CONTENTS

UNITED NATIONS DEVELOPMENT PROGRAMME

GLOBAL ENVIRONMENT FACILITY

Project of the Governments of Brazil, Cameroon and Indonesia

Title:	Alternatives to Slash-and-Burn
Number:	GLO/93/G32/A/1G/31
Duration:	One year
Project Site:	Brazil, Cameroon and Indonesia
UNDP Sector:	Agricultural Research
Subsector:	Crop Improvement
Implementing Agency:	International Centre for Research in Agroforestry (ICRAF), in collaboration with the Consortium for Slash-and-Burn
Executing Agency:	Office of Project Services (OPS) of the United Nations Development Programme (UNDP)
UNDP Approval:	December 1993
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GEF/UNDP Inputs:	US$ 3 million

Brief Description:

This project, representing the first of a three-phase programme, aims to provide sustainable alternatives to slash-and-burn agriculture to enable millions of poor farmers to make an adequate living without destroying additional rainforests. Several national agricultural research systems (NARS), international centres, and non-governmental organizations (NGOs) will implement a research and development strategy that focuses on two main targets: the reclamation of deforested lands such as secondary forest fallows and abandoned grasslands, and alternatives to slash-and-burn at the forest margins. The strategy consists of three main components:

- Determining farmer constraints and needs through participatory approaches

- Developing and testing alternative slash-and-burn technologies with groups of farmers
- Identifying suitable policies that provide incentives for such technologies, and disincentives to further deforestation.

The proposed mode of operation is:

- A joint strategic research effort by three NGOs and fourteen research institutes (six international and eight national institutes) at selected benchmark sites on socioeconomic and biophysical aspects of slash-and-burn
- Validation, testing, and dissemination of options with farmer groups via regional networks, involving both public and private organizations (such as NGOs, extension services, and universities), and effective policy dialogues in each collaborating country
- Extrapolation of the global change implications by making the research sites available to programmes related to the International Geosphere-Biosphere Programme (IGBP)
- Strengthening of institutions in humid tropical nations through training to enhance their capacity to alleviate the crisis.

Three sites in different continents have been chosen to represent a wide range of biophysical and socioeconomic conditions in the humid tropics. In Africa, the site will be in the equatorial rainforest that starts in Cameroon and stretches across Congo. This is a zone of rapid demographic, social, and environmental change. In Latin America, a site in the Brazilian Amazon is proposed, where semideciduous evergreen rainforests are being lost to rapid development. In Asia, the site is in the equatorial rainforests of Indonesia, where both primary forest clearing and degraded alang-alang (*Imperata cyclindrica*) grasslands are abundant.

By the end of this one-year phase, the project will have identified major research agendas for the three sites and have in place biophysical and socioeconomic multidisciplinary teams working towards the mitigation of major environmental damage, while enhancing equity for small-scale farmers at the forest margins. Participation and dialogue with farmers will be maintained at all stages of the research and development process to ensure the adoption of alternative options, and to facilitate effective follow-up and execution of interventions. Direct involvement of appropriate NGOs and farmers groups at each benchmark site, from the initial characterization and diagnosis to the design and testing on farmers' fields of improved technologies, will lead to the development of adoptable technologies which are well suited to the needs and constraints of farmers.

Attention to gender will seek to ensure that both men and women are included as participating farmers, and that information from both is obtained about their roles and preferences. This will reveal any differences that are relevant to the consideration of equitable technology options.

In the first year, US$ 3 million will finance: strategic research at the sites, overall coordination, linkages with global environmental efforts, and direct funding for the host NARS. This

project builds on ongoing research conducted by existing research facilities and institutions, thereby capitalizing on the current knowledge base and minimizing capital and administrative costs.

This project proposal was submitted to UNDP for GEF funding by the International Centre for Research in Agroforestry (ICRAF) in Kenya, on behalf of the Consortium for Slash-and-Burn which consists of ICRAF and eight other institutions: Agency for Agricultural Research and Development (AARD), Indonesia; Agency for Forestry Research and Development (AFRD), Indonesia; Centro Internacional de Agricultura Tropical (CIAT), Colombia; Empresa Brasileira de Pequisa Agropecuária (EMBRAPA), Brazil; Institut de la recherche agronomique (IRA), Cameroon; International Institute for Tropical Agriculture (IITA), Nigeria; Tropical Soil Biology and Fertility Programme (TSBF), Kenya; and World Resources Institute (WRI), United States.

A. CONTEXT

1. Description of subsector

Characteristics of slash-and-burn agriculture

Slash-and-burn agriculture, also termed shifting cultivation, has been the traditional farming system over large areas of the humid tropics for centuries. It continues to be the dominant land-use practice in about 30 percent of regions with arable soils, providing sustenance for an estimated 250 million of the world's poorest people, as well as for millions of migrants from neighbouring regions (Hauck 1974).

Traditional shifting cultivation practices are remarkably similar throughout the world. Small forested areas are cleared by axe and machete during periods of least rainfall, and 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 a few harvests the fields are abandoned to forest regrowth. The secondary fallow may grow for ten to twenty years before it is cut again (Nye and Greenland 1960; Sanchez 1976).

Slash-and-burn agriculture is based on nutrient cycling through the burning of biomass, and weed and pest suppression during the fallow period. In burning, about half of the nitrogen and phosphorus, and practically all of the other nutrients, are released to the soil in the form of ash, which also causes a liming effect. Higher soil temperatures due to burning also accelerate the decomposition of organic matter in the soil. High nutrient availability is thus provided for one or two years to grow food crops, depending on the native fertility status of the soil (Lal et al. 1986; Seubert et al. 1977; Smyth and Bastos 1984). Burning also helps to control pests and disease, and enables cultivators to clear land cheaply and efficiently with minimal use of labour. As nutrients are removed by crop harvests or lost by 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, and accumulating them above ground for ten to twenty years, until the cycle begins again (Nye and Greenland 1960; Szott and Palm 1986).

Over the centuries, indigenous shifting cultivation systems proved ecologically and environmentally sound when practised at low population densities, staying within a measure of natural equilibrium. Most consisted of complex polycultures that included diverse species of trees and food crops. Diversity helped to reduce the risk of disease and pests, and provided a multiple source of food and products for the farmer. Indigenous systems usually reflected complex cultural norms and traditions that often incorporated a unique knowledge of diverse species. The fallow vegetation stage served as a genetic reservoir for many important plants, and as a refuge for both vertebrate and invertebrate animals. In the last few decades, however, the pressures of population and development have forced new migrants to forests, who lack the knowledge base of indigenous cultures. This project focuses on the severe natural disequilibrium caused by the slash-and-burn practices of this migration. Research conducted at several locations for many years shows that for every hectare put into promising alternatives, five to ten hectares of tropical rainforest can be spared from the shifting cultivator's axe every year.

Environmental context

Slash-and-burn agriculture accounts for about two-thirds of the tropical moist forests converted every year. The Environmental Protection Agency (1990) estimates that primary forest is being cleared at an annual rate of 17 million hectares. Landless farmers from crowded areas migrate to forested areas and attempt to make a living by slash-and-burn, thus destroying rainforests and practising unsustainable forms of agriculture. Most of the deforestation is occurring in the tropical regions of America and Asia, accounting for 40 percent and 37 percent respectively of estimated net carbon emissions from deforestation in 1980. Tropical Africa ranks third, with a contribution of 23 percent of total emissions (Houghton et al. 1987). Deforestation rates have almost doubled during the last decade, going from 7.6 million hectares per year in 1979 to 13.9 million hectares per year in 1989 (Myers 1989).

It is estimated that about 25 percent of global warming is due to tropical deforestation caused by slash-and-burn agriculture. Other negative environmental consequences include soil erosion and degradation, leaching, watershed degradation, and loss of biodiversity. At the local level, there is a depletion of resources, a decline in productivity, and the under-utilization of forest products.

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 the fluxes of carbon dioxide, nitrous oxides, or methane caused by shifting agriculture. Hard data from well-replicated experiments and surveys is needed to determine the current extent of slash-and-burn agriculture, the process of change in land use, and the extent and nature of the environmental impact of these systems. The contribution of tropical land use to global climate change is one of the uncertainties in current models (Houghton et al. 1987).

Socioeconomic, policy and equity context

Since slash-and-burn deforestation is practised mainly by the poorest, largely displaced rural populations of the humid tropics, it has important human equity implications. Poor people also 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.

Government policies can often contribute to resource degradation, land scarcity, and inappropriate land use. For example, land-use policies allow gross inequities in land tenure. This results in increases in the landless rural population that essentially has three choices: stagnation in the same place, migration to cities, or migration to the rainforests that constitute the frontier of many developing countries. Similarly, land-tenure policies in forests often do not give people secure title to the land, which may discourage them from adopting methods that are sustainable in the long term. Although urban migration is spontaneous, national policies in several countries (notably Brazil, Peru, and Indonesia) are often motivated by geopolitical reasons, and promote colonization programmes that encourage the occupation of tropical rainforests.

Other policy-related factors that lead to unsustainable slash-and-burn agriculture include the lack of subsidies, incentives, and credit; inadequate laws and regulations affecting land use; inappropriate infrastructure; lack of markets for alternative products; weak institutional services such as the lack of education or technical assistance; lack of farmer organizations; and neglect of farmer participation in research and development programmes. Macroeconomic policies, including the influence of international financial agencies, can also contribute to the problem.

2. Current state of knowledge

Fortunately, the search for alternatives to slash-and-burn can draw on a considerable body of research on the biophysical and socioeconomic determinants of shifting cultivation.

Biophysical research

Research on shifting cultivation has been conducted in Africa since the 1920s on the replacement of "chitemene"[1] with methods that do not involve burning. The works 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 Africa, Asia, and Latin America. Long-term agronomic research has been conducted since the 1970s, primarily, but not exclusively, by four groups: at Yurimaguas in Peru, and at Manaus in Brazil, by North Carolina State University (Sanchez and Benites 1987; Sanchez et al. 1983, 1987; Seubert et al. 1977; Szott et al. 1991); at Ibadan in Nigeria by the International Institute for Tropical Agriculture (IITA) (Juo and Lal 1977; Kang et al. 1990; Yamoah et al. 1986); in northeast India by Ramakrishnan and associates (Ramakrishnan 1984, 1987; Toky and Ramakrishnan 1981); and in Sumatra by the Agency for Agricultural Research and Development (AARD) and associated institutions (McIntosh et al. 1981; Von Uexkull 1984; Wade et al. 1988). The results of these efforts are summarized below:

- The nutrient transfer process from biomass to ash and into the soil has been quantified.

[1] A particular form of slash-and-burn practised in Zambia.

- Changes in soil properties upon cropping have been monitored.

- The 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 carbon.

- Bulldozer clearing has been found to be inferior to traditional slash-and-burn in providing suitable physical and chemical soil properties for planting food and tree crops. The detrimental effects of bulldozer clearing include topsoil carryover, soil compaction, and the absence of ash in the nutrient-transfer process. Several major colonization projects are no longer based on bulldozer land clearing.

- Weed population shifts from broad-leaved species to grasses, providing one of the principal causes for the abandonment of land, surpassing even the depletion of soil fertility.

- The judicious use of lime, fertilizer, and green manure allows crops to be rotated continuously, producing sustainable yields in well-managed systems. However, poor management of continuous production results in sharp drops in productivity, soil compaction, and erosion.

- 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 ten 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 multistrata systems), silvopastoral systems, live fences in pastures, and the improvement of 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 systems that meet the food and fibre needs of farmers while providing additional income by producing certain crops for export that are "high value-low volume." These crops include heart of palm, tropical fruits, pepper, and medicinal plants. The humid tropics have a comparative advantage over other climatic regions in growing these crops. Changing consumer values in the West toward more nutritious and ecologically friendly products could 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, weed control, and crop selection in forest management.

Although research shows that alternatives to slash-and-burn provide cause for hope, research itself has been on an insignificant scale, conducted primarily at research stations. The knowledge base needs to be expanded geographically and adapted to specific climate, soil, and socioeconomic conditions, taking into account different market opportunities. Research also needs to expand from "on-station" to participatory "on-farm" testing to facilitate the design and validation of adoptable technologies. On-farm scientists at the International Centre for Research in Agroforestry (ICRAF) have recently developed a robust methodology which puts farmers at the centre of the research and development process, and emphasizes interaction between farmers, researchers, and extensionists to achieve more relevant solutions. This methodology has been successfully tested in East Africa and will be used, with appropriate amendments, in this project.

Policy

None of these technologies, however, is likely to be adopted unless there are significant policy changes that provide adequate market and infrastructure development, and also prevent the remaining rainforests from being destroyed. Deforestation is a relatively new concept in the policy sciences, but some of its underpinnings are beginning to emerge. Analysts in the field generally cite six or seven major policies to decrease tropical deforestation:

- Eliminating distortionary policies or laws that induce the destruction of forests
- Supporting economic development and market opportunities that are environmentally sound, both at the forest margins and at the sources of migration
- Establishing more equitable land-tenure systems, and securing tenure rights for slash-and-burn farmers
- Encouraging migration to less fragile areas
- Preserving remaining forests by a vast network of well-protected national parks
- Allowing the sustainable use of some forests as extractive reserves
- Establishing and enforcing land-use and forestry laws.

While policies that promote these strategies should continue, they are not in themselves sufficient to mitigate deforestation. A more realistic and practical approach could be provided by linking environmentally-oriented policies with economic ones. New efforts in this direction are beginning to emerge (Gillis and Repetto 1988; Bouwman 1990), and have resulted in much lively debate. A few deforesting countries have developed policies to contain deforestation, primarily in response to national and international environmentalist pressures. Some of these policies are far too radical to be workable and can sometimes backfire, with severe negative effects on the economy, triggering increasing deforestation in neighbouring countries.

The need for policy research on slash-and-burn agriculture is as critical as that for biophysical research. This should be linked with research on technological options and their socioeconomic

viability. There is also a need to assess how economic growth affects rates of forest clearance, how agricultural intensification influences migration, and how new technology affects both deforestation and migration.

B. PROJECT JUSTIFICATION

This project proposal addresses urgent global problems. By initiating worldwide research and action, it could significantly lower the rate of tropical deforestation caused by slash-and-burn agriculture. This would protect biodiversity and reduce global warming by limiting the destruction of forest sinks for greenhouse gases. It would also improve the wellbeing of dwellers at the forest margins by means of a joint technology-policy approach aimed at developing workable land-use alternatives in a highly participatory manner.

1. Problem to be addressed and the present situation

For millions of indigenous people, shifting agriculture still provides the basis for subsistence, cultural values, and social stability, as long as population density remains low. These systems are varied in form, ranging from classic swidden systems to such altered forms as the taungya system. Features of these systems, such as nutrient cycling and crop diversity, are useful for understanding sustainable land use in the humid tropics.

Traditional shifting cultivation systems are currently being replaced very rapidly by shifting cultivation in disequilibrium, which leads to the cultural and social disruption of traditional societies. These unsustainable slash-and-burn systems are 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 process. *The central concern in this project is the unsustainable slash-and-burn agriculture practised in areas where alternatives are urgently needed—distinct from the traditional systems practised by indigenous peoples in forest areas.*

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

Shifting cultivation fails to be sustainable when significant increases in land productivity are required to support higher human population densities and an 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, less significant in Africa, is a major cause for concern in Latin America and Asia.

As the time available for secondary forest fallow growth decreases, the fertility and productivity of the soils, which are generally low, decline further. A shortened fallow period also generates a disequilibrium in carbon input-output ratios, and intensifies nutrient mining. Complex and often adverse ecological changes can occur, such as the invasion of *Imperata* grasslands, and a

reduction in the number of viable native seeds left for regrowth. The re-establishment of secondary forest fallow vegetation is slowed or stopped, some soil becomes bare in patches, and erosion begins. This situation is typified by the "derived savannas" which occupy more than three-fourths of the previously tropical moist forests of West Africa. With time, these declines in productivity contribute to increasing economic hardship and impoverishment for shifting cultivators. Moreover, people in these situations often 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 trend towards expansion of the cropping cycle and decrease in the fallow period are central to the problem of unsustainable production. They also play a key role in the contribution of slash-and-burn agriculture to global warming because of the net reduction in soil organic matter and plant biomass.

Environmental degradation due to deforestation often affects production and subsistence systems in rural areas. Erosion, flooding, ground water depletion, and silting affect agricultural productivity, decreasing the availability of food, employment, and income. Forests also serve as "food banks" for poor communities, and often provide the main source of household energy for cooking. All these resources are lost in the process of degradation.

Population growth and poverty are not the only reasons for the increased rates of deforestation. External factors such as the expansion of commercial plantations or farms, ranching, logging, and mining can also attract or push migrants into slash-and-burn deforestation. In Africa the expansion of cash crops (such as groundnut, cotton, coffee, and cocoa) for export has considerably reduced the amount of land available 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 Bolivia, Brazil, Central America, Côte d'Ivoire, Indonesia, Malaysia, Nigeria, and the Philippines, mainly to supply markets in Europe, Japan, and the United States.

In Latin America, clearing the forest is a way for settlers to claim title to state lands, since the laws limit land ownership to unforested lands only. This encourages uneconomic forest clearing, where the motive for clearing the forest is ownership or land speculation, rather than the use of trees or land for agriculture. Construction of roads and other infrastructural facilities supporting development strategies has also contributed to accelerated rates of deforestation. The recent destruction of forests in the Brazilian Amazon can be attributed mainly to commercial logging, plantations, land speculation, and mining. Agriculture accounts for only about 10 percent of total deforestation in the region.

Conclusions from current research

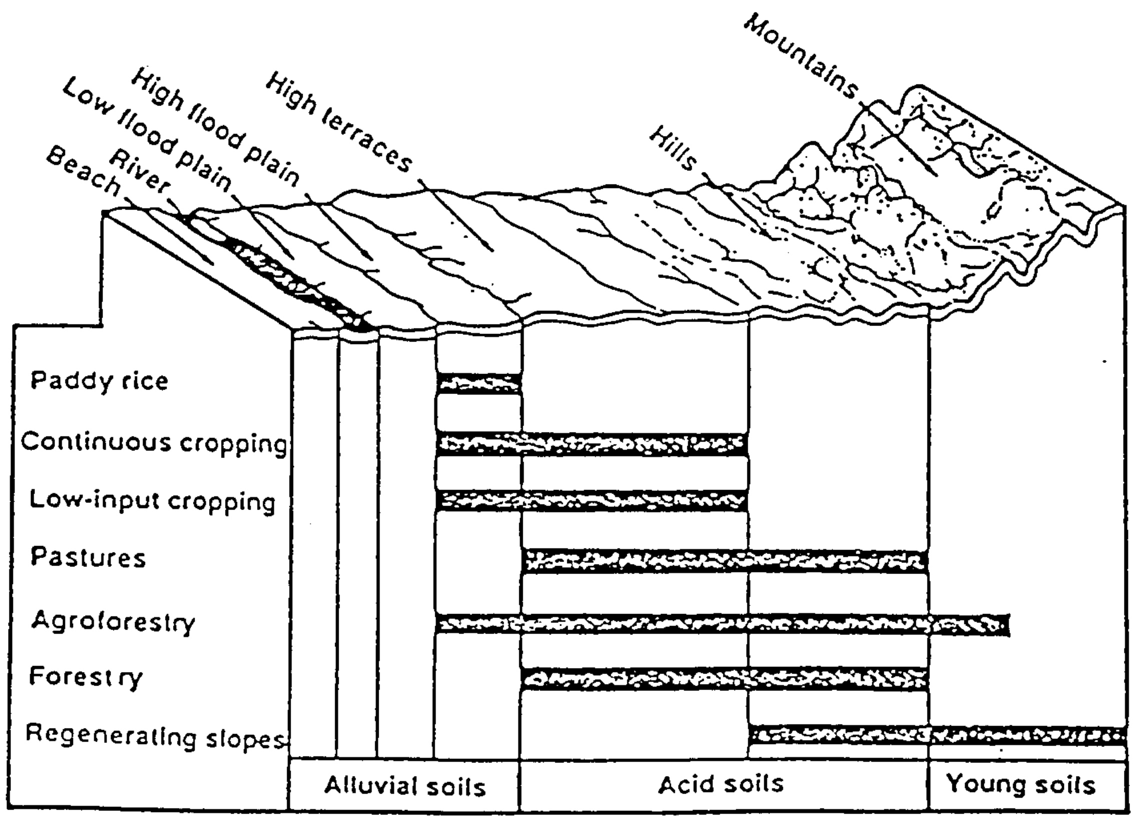
Efforts have been initiated by many institutions to alleviate problems caused by slash-and-burn and other resource degradation practices. Research programmes, extension projects, and policies have been developed in some regions. For example, a recent change in strategy led the Brazilian government to eliminate incentives to Amazon cattle development, resulting in a substantive reduction in the rate of deforestation.

However, in many cases, these efforts have been ineffective in alleviating problems and providing alternatives. Forestry programmes assume that rational and sustained exploitation in suitable areas, using appropriate technology, will lead to economic benefits. Their assumptions about social institutions, markets, costs, alternative land uses, agroclimatic conditions, and available technologies have often been erroneous. They sometimes fail 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. *Very few of the efforts to date have used participatory methods or genuinely considered the needs of farmers.* On the other hand, forestry activities that make complementary use of farmers' land, time, and other resources, in a manner integrated with other agricultural activities, stand a far greater chance of being adopted.

Existing institutions undertaking research and extension in this area also lack coordination. NGOs and farmers' groups are often not directly involved in research and development activities. In many cases, the "top-down" model of technology transfer has failed to have any impact. Efforts have also sometimes been duplicated. All these elements need to be overcome through coordinated and comprehensive research and action, taking into account lessons learned from both the weaknesses and successes of previous efforts.

Sustainable management options for acid soils of the humid tropics have been developed to suit different landscape positions (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 in alluvial soils, low-input cropping, continuous cultivation, legume-based pastures, agroforestry, perennial crop production (rubber, oil palm) and plantation forestry. The suitability of different management options according to landscape are illustrated below.

Figure 1 Management options for acid soils of the humid tropics



The recycling of nutrients must be enhanced in all systems in order to maximize their efficiency and minimize the need for external inputs. The management of crop and root residues is therefore critical (Swift 1987). The Tropical Soil Biology and Fertility Programme (TSBF) is focusing on research to quantify the nutrient release of organic input and to manage soil organic carbon, nitrogen, and phosphorus as the major components of low-input cropping, agroforestry, and pastures. Promising results have been obtained in predicting the rate of release of nutrients from leguminous materials based on their polyphenolic contents (Palm and Sanchez 1991), providing for the first time an opportunity for the quantitative management of organic inputs 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 fertilizers to maintain productivity. Research conducted by the International Fertilizer Development Center (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. In cases 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 of tropical rainforests will be saved each year from the shifting cultivator's axe, because of their higher productivity. Estimates at Yurimaguas, Peru, for various management options are given below (Sanchez et al. 1990). These estimates will vary with climate and soils.

Table 1 Deforestation prevented through various management options (Peru)

One hectare in sustainable management options	*Hectares 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 suited 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 high priority, because in many areas they are a viable alternative to primary forest clearing. Many of the degraded or unproductive pasture or croplands resulting from poor management practices can also be reclaimed by using some, but not all, of these available technologies.

Research also needs to focus further "upstream" and become more process oriented to better understand the "why" questions that underlie the "whats" listed in the preceding section. In particular, there is a 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 questions related to the ways in which farmers will: adopt new technologies or adjust to them, choose between short-term gain and long-term resource conservation, and make decisions on forest clearance in the light of new technologies. Finally, research efforts should be more inclusive of farmers and farmer organizations, extension services, national agricultural research systems (NARS), NGOs, and advanced institutions in developed countries. They should also be linked effectively with the global community involved in climate change research and biodiversity conservation efforts. (Conservation International has expressed interest in collaborating with the Consortium in their "hot spot" rainforest areas throughout the world. This project will also maintain links with similar projects elsewhere, such as the Indian project on sustainable alternatives to shifting cultivation.)

This review of the status of research, technologies, and policy suggests that *deforestation from slash-and-burn agriculture must be controlled* in situ *by eliminating the need to clear additional land, and by rehabilitating degraded land and resources.* This can be achieved by:

- Providing sustainable and adoptable technology and policy alternatives to slash-and-burn agriculture based on a thorough understanding of farmers' needs and decision processes

- Reclaiming and managing abandoned and degraded lands that are declining in productivity, including secondary forest fallows and unproductive grasslands

- Addressing the socioeconomic and policy factors that affect slash-and-burn agriculture and the adoption of alternatives, including gender-specific constraints to adoption.

Land-use management options are urgently needed to improve the economic status of subsistence farmers, maintain agricultural productivity on deforested lands, and restore the productivity of degraded lands. Such options should provide sustainable development at 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, focus should be maintained on 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 on the role played by government policies. Activities will focus on the interactions of slash-and-burn processes at the local level but also take into account broader processes and systems (zonal, national, regional, and global). In this context, the agroecological foundations of sustainable agriculture will be established to provide a basis for developing biologically-based management systems within a user-friendly policy environment.

2. Project strategy

Slash-and-burn agriculture has been identified as the major cause for tropical deforestation, contributing substantially to global warming with annual emissions of over 140 million tonnes of

carbon dioxide. It is also a human equity issue, being practised mainly by the very poor, largely displaced rural population. This project will address these issues by identifying important sites for research on alternatives to slash-and-burn, and undertaking a comprehensive programme that includes policy options, management issues, and the strengthening of institutions.

Benchmark sites

Among the countries in the humid tropics currently undergoing the destruction of primary forests, twelve account for over 80 percent of total deforestation. The Slash-and-Burn Consortium has identified NARS representing the major forest ecosystems to provide essential infrastructure for the proposed research on alternatives to slash-and-burn. Each site is best described as a base of operations, with on-station and on-farm research and policy development taking place in the surrounding regions. The sites are described below. Only the ones indicated in Phase I will participate in this proposal.

Table 2 Benchmark sites for Phases I, II and III

Phase and duration	*Ecosystem*	*Benchmark sites*
Phase I (this proposal) (1 year)	Congo rainforest	M'Balmayo, Cameroon
	Amazon basin	Rondonia/Acre, Brazil
	Dypterocarp forests	Sumatra/Kalimantan, Indonesia
Phase II (above plus 3 new sites) (2 years)	Miombo woodlands	Kasama, Northern Zambia
	Amazon/Andean interphase	Yurimaguas, Peru
	Hill country of S.E. Asia	Chiang Mai, Thailand
Phase III (above plus 2 new sites) (2 years)	Mayan forests	Chiapas/Yucatán, Mexico
	Monsoonal forest	Claveria, Philippines

Objectives

The project has six principal objectives that apply to all three phases:

- To assess the biophysical and socioeconomic processes leading to deforestation, including gender issues and decision-making patterns among farmers practising slash-and-burn.

- To identify and develop improved production systems that are economically feasible, socially acceptable, and environmentally sound alternatives to current slash-and-burn practices, on the basis of highly participatory research and development methods.

- To identify policy options and institutional management issues that facilitate the adoption of such systems and discourage further deforestation.

- To validate and transfer successful experiences in prototype technologies and policies through farmers' groups and adaptive networks in Asia, Africa, and Latin America. To liaise with extension services, NGOs, and appropriate policy-makers at the local and regional levels to ensure the implementation of policies.

- To facilitate the quantification of the contribution of slash-and-burn and its alternatives to global environmental changes.

- To train professionals and strengthen institutions to establish a well-founded research and policy infrastructure.

The international centres participating in this project will focus on methodology development, training, and baseline research, while NARS and NGOs will focus on the monitoring, validation, and dissemination of potential alternatives to mitigate deforestation, conserve the natural resource base, implement corrective policy initiatives, and address the social problem of inequity. The project will be globally coordinated by ICRAF, and implemented by scientists of the Consortium for Slash-and Burn, in collaboration with local participants.

3. Expected end-of-project situation

Given the long-term nature of the problems addressed, this project will provide only the first phase of outputs, as listed below:

- Participatory research methodologies will be standardized and their implementation achieved at three sites in Brazil, Cameroon, and Indonesia

- Adequately trained multidisciplinary teams of national and international staff will be in place at each location

- Strategic priorities in biophysical and socioeconomic research will be established

- Research on alternatives to slash-and-burn agriculture and the reclamation of degraded lands will be initiated

- Standardized and centralized geo-referenced databases concerning slash-and-burn agroecosystem characterization will be created for the delineation of extrapolation domains for each benchmark area.

The major outputs expected over the medium term (phases II and III) are:

- Improved and culturally acceptable land-use practices and technologies that raise productivity while conserving and enhancing the resource base

- Guidelines for the design and implementation of policies and policy tools (such as specific laws, regulations, subsidies, and incentives that encourage farmers to adopt ecologically sound and economically viable alternatives to slash-and-burn agriculture)

- Information disseminated to key policy-makers, scientists, and farmers, about policies, investments, and technologies that will lessen slash-and-burn deforestation and help reverse the degradation of land.

4. Target beneficiaries

Farmers and consumers in developing countries will be beneficiaries of this project. Farmers at the forest margins will benefit through the adoption of technologies that provide sustainable crop yields and sufficient firewood, fodder, and fibre, as well as an increased income and improved living standards. Consumers will benefit through the greater availability of produce at lower prices.

At the national and global levels, the benefits derived through decreases in deforestation and soil degradation will be a major contribution to the environment. Human society will benefit from the long-term conservation of natural resources, the preservation of biodiversity, and the reduction of greenhouse gas.

The immediate beneficiaries of Phase I will be the NARS and NGOs of Brazil, Cameroon, and Indonesia; there will be spin-off effects for the national programmes at the five other proposed benchmark sites in Mexico, Peru, the Philippines, Thailand, and Zambia. Other immediate beneficiaries will be national and regional networks, national universities, international programmes (such as IGBP), and advanced institutions collaborating in the project.

5. Reasons for assistance from GEF/UNDP

The collaborative nature of this project builds upon the existing resources of the international research centres, NARS, NGO networks, and advanced developed-country institutions. No new "bricks and mortar" institutions will be required. Resource needs for the project will therefore be in the form of incremental funding for existing institutions.

It is anticipated that NARS that have accepted the responsibility to host the benchmark strategic research sites will receive incremental funds directly to support the project's initiatives. International centres and NGOs will also receive incremental funds for their input to: the sites; farmers' participation and dissemination activities; and network coordination, training, and linkages with the environmental community. Bilateral funding agreements with other sources could provide complementary funds for advanced institutes in developed countries.

A coordinated effort to provide alternatives to slash-and-burn agriculture provides a user-friendly tool to reduce tropical deforestation and thus attenuate global warming and preserve biodiversity. Given the environmental and human equity dimensions of this project, considerable interest has been expressed by the international donor community, including the Ford and Rockefeller Foundations; the Asian, African, and Inter-American Development Banks; the United States Agency for International Development (USAID), the Norwegian Agency for International Development (NORAD), and the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD). Strong interest has also been expressed by government representatives of the participating countries. This is clearly an idea whose time has come, and a coordinated global effort could achieve important results.

It is estimated that the total cost of a five-year project will be US$ 90 million, and that approximately half this amount is likely to be available from the core budgets of the Consortium institutions, from national governments, and donor organizations. GEF funding, targeted at US$ 30 million for the five-year period, will provide the "glue" for the project. Support from other donors will be sought by the Consortium institutions. It is likely that an application for the next phase of this project will be presented in August 1993.

6. Special considerations

This project proposal builds upon a firm foundation of national programmes conducted by six international centres: Centro Internacional de Agricultura Tropical (CIAT), ICRAF, International Institute for Tropical Agriculture (IITA), International Rice Research Institute (IRRI), International Food Policy Research Institute (IFPRI), and the Centre for International Forestry Research (CIFOR) in Indonesia. These provide excellent scientific expertise in the management of many alternative land-use systems. Other entities involved in the project include the Tropical Soil Biology and Fertility programme (TSBF); IFDC, with expertise in inorganic fertilizers; and the World Resources Institute (WRI), which has been involved in research in social and national resource economics and the development of farmer participatory methods for the past decade.

In the first phase, GEF funds will be available only for CIAT, ICRAF, IITA, TSBF, and WRI. IRRI will finance its own activities. The remainder of funds for the project will be provided in subsequent phases. The proposed project could be supplemented through collaboration with several components of the International Geosphere-Biosphere Programme (IGBP), in particular the Global Change and Terrestrial Ecosystems (GCTE) Core Project. GCTE will undertake research on the global environmental impacts of slash-and-burn agriculture.

7. Coordination arrangements

Operational framework

Conceptually, an operational framework should not only involve institutional mechanisms but also be looked upon as a process for setting priorities for research activities. The process of generating new ideas for research within a project's activities can originate from a number of sources. In general, the process should be bottom-up, so that research is driven by the needs of those directly affected. In this case, it will be the needs of farmers, as identified by the participatory

approach to be used throughout the project. Ideas for research are also likely to originate with scientists or others in the field (an "opportunity-pull" approach). Regional and global implications also need to be considered to provide a common focus on issues such as global warming and biodiversity.

The framework for this project involves the joint efforts of four groups of institutions:

- The international centres and programmes, which will provide a resource pool of expertise that is not available in developing countries
- The NARS of participating countries, which have endorsed the project and will host primary sites representative of major agroecologies where slash-and-burn systems are widely used, and where improved systems can be developed and evaluated
- A network of national institutions from additional developing countries, which will be engaged in practical field evaluation of policies and technologies that will have been identified in subsequent phases of the project
- Appropriate local and regional NGOs, which will provide liaison with farmers' groups and extension services, and facilitate follow-up and the execution of interventions.

Local Steering Group (LSG)

Local Steering Groups (LSGs) will eventually be created at each of the eight benchmark sites shown below (for Phase 1, only the three sites marked with an asterisk will be considered):

- In Latin America:
  Porto Velho, Rondonia, Brazil*
  Yurimaguas, Loreto, Peru
  Merida, Yucatán, Mexico
- In Africa:
  M'Balmayo, Cameroon*
  Kasama, Zambia
- In Asia:
  Bogor, Indonesia*
  Chiang Mai, Thailand
  Claveria, Mindanao, Philippines.

LSG membership

Members will include: representatives from farmer associations, state governments, national governments, NGOs, public and private universities; community leaders; and local, national, and international research and extension staff.

Terms of Reference for LSG members

- Problem identification and prioritization
- Activity planning, implementation, and evaluation
- Financial requirements, including counterpart funding
- Preparation of activity reports.

Regional Steering Group (RSG)

Three RSGs will be established, one each for Africa, Latin America, and Southeast Asia. An ecoregional approach will be followed, and CIAT, IITA, and IRRI will be the coordinating institutions for their respective regions. These will be established in the second phase after more than one site per region has been selected.

RSG membership

- Chairmen of LSGs
- Representatives from the Consortium for Slash-and-Burn
- Representatives from regional organizations and institutions
- One NARS representative from each benchmark site
- Global coordinator.

Terms of Reference for RSG members

- Activity appraisal, endorsement, and approval
- Resource allocation: counterpart, grant, and cofinancing
- Regional coordination, monitoring, evaluation, and dissemination of results
- Identification of institutional responsibilities
- Setting of regional research priorities
- Preparation of annual reports.

Global Steering Group (GSG)

GSG membership

- Chairmen of RSGs
- Benchmark-site country representatives
- International Consortium for Slash-and-Burn
- NGO representatives
- Donor agency representatives
- Global coordinator.

Terms of Reference for GSG members

- Setting of global research priorities
- Project activities and project budget approval

- Project monitoring and evaluation
- Concurrence on a comprehensive annual report
- Dissemination of information.

International centres and programmes

This project brings together the experience and expertise of four centres belonging to the Consultative Group on International Agricultural Research (CGIAR), an affiliated centre, and an international programme, all of which are briefly described below.

- *CIAT.* The Centro Internacional de Agricultura Tropical, headquartered in Cali, Colombia, is the first CGIAR centre to have adopted a full-scale ecoregional approach. It is implementing a land-use programme focusing on the relationships between policy, land use, and sustainable agriculture that are compatible with resource conservation and preservation of the environment. This programme is being conducted in three Latin American and Caribbean agroecosystems: the tropical forest margins, the savannas, and the hillsides. Among the International Agricultural Research Centres (IARCs), CIAT is unique in having a Geographic Information System (GIS) on climate, soil, vegetation, cropping, physical access to the land, population, and other biophysical, political, and social variables. This GIS will provide a strategic input to this project. CIAT has a team working on soil–plant relations that is currently focusing on the pasture–crop complex in acid tropical soils, and on pasture-based reclamation of degraded, deforested land. CIAT also possesses the world's largest collection of acid soil–tolerant germplasm of forage and food crops used in shifting cultivation. The centre has long-standing experience in large-scale collaborative, inter-institutional research with NARS in the humid forests of Latin America.

- *ICRAF.* The International Centre for Research in Agroforestry, headquartered in Nairobi, Kenya, focuses on the global mitigation of deforestation in the humid tropics and the large-scale depletion of land in subhumid and semiarid tropics. This is achieved through sustainable agroforestry systems so that farmers' needs for food, fibre, browse, and firewood are met without depleting the resource base. ICRAF's senior scientists include leaders in developing alternatives to slash-and-burn in research conducted in the Amazon and Southeast Asia. ICRAF scientists currently operate in seventeen countries around the world, many of which practice slash-and-burn in their humid tropics.

- *IFDC.* The International Fertilizer Development Center is headquartered in Muscle Shoals, Alabama, in the United States. Its Africa Division is located in Lomé, Togo, and its Asia Division in Dhaka, Bangladesh. IFDC has extensive expertise in research on the efficient use of fertilizer; in developing and testing alternate fertilizer materials; and on fertilizer manufacturing technology, marketing, and distribution. IFDC conducts nutrient efficiency research throughout the tropics, and has scientists in Africa, Asia, and Latin America. IFDC scientists have considerable expertise in modelling, and in socioeconomic and policy research. IFDC is placing a high

priority on nutrient cycling in major agroecosystems.

- *IITA.* The International Institute for Tropical Agriculture, headquartered in Ibadan, Nigeria, has worked on slash-and-burn agriculture since the early 1970s. IITA currently focuses on developing alternative practices that greatly prolong the fertility of tropical soils and reduce the need for bush fallow and the clearing of new land for permanent agriculture. The new IITA Humid Forest Station at M'Balmayo, 40 kilometres south of Yaoundé, Cameroon, is situated in a typical Congo Basin deforestation site, and focuses primarily on strategic research on alternatives to slash-and-burn.

- *IRRI.* The International Rice Research Institute, headquartered in Los Baños, Philippines, is focusing on rice-based upland cropping systems in Southeast Asia. Its goal is to rehabilitate upland ecosystems and increase the stability of upland rice-farming systems. IRRI senior scientists with expertise on this subject coordinate effective research networks in the region. In Phase I, IRRI will participate without GEF funds.

- *TSBF.* The Tropical Soil Biology and Fertility Programme, headquartered in Nairobi, Kenya, focuses on the maintenance of soil productivity through the manipulation of soil organic matter and organic inputs (such as mulches, residues, and green manure). Its principal investigators, located throughout the world, have extensive expertise in nutrient cycling under humid tropical conditions, and seek to maximize the efficiency of nutrient use through the combined use of inorganic and organic inputs.

NARS and strategic benchmark sites

Strategic research will be conducted at three benchmark sites in full collaboration with the relevant NARS. Each site will be representative of the range of biophysical and socioeconomic conditions where slash-and-burn plays an important role. They are termed ecoregions because they represent humid tropical situations in specific geographical areas with contrasting socioeconomic conditions, both at the macro (policy) and micro (farm) levels.

All researchers at candidate benchmark sites for each ecoregion are conducting studies on alternatives to slash-and-burn. Although the scale of research is insufficient, all sites have significant strengths in research facilities and staff, and some have long-standing research projects where changes in soil properties and crop yields have been monitored for years, representing an invaluable research resource.

Africa

Congo Basin. The remaining tropical rainforests of Africa are concentrated in Central Africa, starting in eastern Nigeria and covering most of southern Cameroon, southern parts of the Central African Republic, most of Gabon, northern Congo, and northern Zaire. Food production is still largely dependent on shifting agriculture but with ever-shortening fallow periods. While tree

crops represent the highest potential for the area in the long term, their use will be possible only if adequate food is imported from the surrounding savanna zones, where the potential for food production is greater. In the short term, there is a pressing need to alleviate a growing food deficit in an agroecological zone where the transfer of conventional, high-input technology has failed badly in the past, and where the rate of degradation of the environment is very high.

Considering the severe logistic constraints of countries such as Zaire, which has the largest area of this zone, and Madagascar or eastern Nigeria, which have the highest urgency as they approach total deforestation, southern Cameroon seems the best location for a long-term strategic soils research initiative seeking alternatives to slash-and-burn. There has been no systematic research effort on acid soils of Africa since the Belgians left Yangambi, Zaire, in the 1960s.

The benchmark site for this ecoregion is M'Balmayo in Cameroon, about 1½ hours south of Yaoundé by road. This is the location for a new IITA research station in collaboration with the Institut de la recherche agronomique (IRA) of the Government of Cameroon. M'Balmayo was selected as an acid-soil forest location for the IITA Resource Management Research team. It is also the location of the continuing plantation forest management programmes of the Cameroon Organisation national du développement des fôrets (ONADEF), with the Overseas Development Administration (ODA) and the Institute of Terrestrial Ecology (ITE). Laboratory and office facilities have been completed at the research station site of IRA at Nkolkisson, just north of Yaoundé. The core of the project in Cameroon will be a partnership between IITA and IRA, with additional collaboration with ICRAF, GCTE, TSBF, and other international organizations. M'Balmayo would serve as the host station for scientists posted to Cameroon. This joint effort would make M'Balmayo a central focus of research and training for the equatorial rainforest zone of Africa.

Soil management requirements for this acid-soil, humid, rainforest zone are based on two main imperatives. The first derives from the particular socioeconomic circumstances of this agroecological zone, which is characterized by a heterogenous mosaic population density that includes areas with the highest number of people per unit area in Africa. The region is dominated by small-scale farmers, most of whom still practise shifting cultivation in various forms. Alleviation of the increasing food deficit in this zone in the short to medium term can be achieved only by increasing productivity per unit area, as population pressures increase and the availability of land for fallow decreases. Moreover, increased productivity can realistically be attained only by incremental improvement of organic and inorganic management practices included in the research agenda.

The second imperative derives from the particular soil problems characteristic of this zone—high acidity and aluminum toxicity—together with relatively low nitrogen reserves and extremely low phosphorus availability. Improved productivity in the presence of these constraints cannot be achieved by organic management alone. The utilization of inorganic fertilizers and other amendments must also be considered as necessary components of soil management.

Latin America

Brazilian Amazon

Efforts in Latin America will concentrate on the Amazon, which constitutes the largest area in the world undergoing deforestation. The Amazon is undoubtedly one of the world's greatest

reservoirs of plant and animal genetic diversity, holding one of the largest carbon stocks in its vegetation and soils. The region is rapidly being penetrated by roads, not only from the Brazilian side, but also across the Andes in the neighbouring countries. The major road penetration of the 1980s, BR 364, connecting Sao Paulo with the states of Rondonia and Acre, links Brazil's major economic centre with its excess population to an area with a population vacuum. By 1988, 24 percent of Rondonia's land area and 13 percent of Acre's area had been deforested (Mahar 1988). This road will be linked to the Peruvian road system shortly, further enhancing the threat of deforestation.

The Amazon is characterized by two main agroecological zones within the humid tropics: the typical tropical rainforest with little to no dry season and sandy to loamy Ultisols, and the semideciduous forests with a short but pronounced dry season and predominantly clayey Oxisols. The rainforests predominate roughly west of Manaus, Brazil, while the semideciduous zone is more common east of Manaus. The main causes of deforestation are cattle ranching and food production under extensive and intensive shifting cultivation systems, which lead to the abandonment of land, primarily in the form of degraded pastures or degraded secondary forests called "juquira" (Hecht 1979; Serrão et al. 1979).

Agroforestry is a management option for the humid tropics that provides many ecological and economic advantages compared with other options. Trees provide a continuous soil cover, protecting the soil from erosion; they also recycle nutrients from the subsoil, preventing leaching. In addition, trees can provide many products for on-farm use such as mulches, fodder, fruits, and fuelwood. Many of these products can be sold throughout the year, giving the farmer a year-round income. There are of course some major obstacles to harnessing the potential benefits of the system. In depleted acid-soil areas, there will be few nutrients to recycle. Woody perennials may cause excessive shading, and compete for water and nutrients. Woody perennials may also have adverse allelopathic effects on food crops, and play host to pests that damage the associate crop (Lal 1991).

Agroforestry systems relevant to the Amazon are divided into three broad categories: agrosilvicultural, which combine trees and crops; silvopastoral, which combine trees and animals; and agrosilvopastoral, which combine trees, crops, and animals. Many of these systems could readily be adopted by Brazilians because of their strong tradition in mixed cropping systems, and their well-developed markets in native fruits and beef.

For many years CIAT has been conducting collaborative research with various Brazilian entities, especially with Empresa Brasileira de Pequisa Agropecuária (EMBRAPA), on pastures, rice, beans, and cassava. CIAT is recognized as one of the main sources of expertise in these areas.

This project can therefore build on existing strengths by adding senior staff positions in the areas of nutrient cycling, weed management, anthropology, and silvopastoral systems. Preliminary contacts between EMBRAPA and ICRAF scientists indicate a strong interest from EMBRAPA in developing a collaborative research project on slash-and-burn, with the inclusion of the international centres represented in this project. Emphasis will be placed on Manaus, Rondonia, and Acre. Headquarters in Centro de Pesquisas Agroflorestais da Amazônia (CPAA) in Manaus could be used as a regional training centre for Amazonian scientists, in collaboration with the Cooperative

Programme on Technology Generation and Transfer for the South American Tropics (PROCITROPICOS) of the Inter-American Institute for Cooperation on Agriculture (IICA).

Southeast Asia

Deforestation in Southeast Asia is mostly limited to three agroecological zones: the equatorial rainforests, the steeplands of mainland Southeast Asia, and a tropical monsoon zone. The equatorial rainforests are located primarily in Indonesia and Malaysia. Indonesia is the second largest country where deforestation is occurring, because of extreme population densities in Java and vast underpopulated rainforests in the outer islands. The current primary forested area is 109 million hectares, and deforestation rates are estimated to be about 1.2 percent per year (Kartasubrata 1991).

The shortening of the fallow period is brought about by fast-growing cities and an increase in the local population through transmigration schemes; by logging roads and logging camps; by the clearing of larger plots for commercial plantations, facilitated by mechanization; and by ready markets for the sale of agricultural products. The shorter fallow period (and in some areas it has now been reduced to 1-3 years) causes the formation of extensive unproductive alang-alang (*Imperata cyclindrica*) grasslands, especially after fires (Kartasubrata 1991). There are approximately 20 million hectares of alang-alang in the outer islands of Indonesia.

It is recommended not to clear primary forests but to utilize unproductive forests. Logging operations and forest industries, while having contributed much to the economic development of the country, have also caused severe damage to the condition of forests in several localities. Logging operations do not cause outright deforestation. But the new network of logging roads has improved access to forest land for migrants who resort to shifting cultivation. Moreover, after removal of the large marketable trees, the clearing of smaller trees becomes easier for shifting cultivators.

The government of Indonesia has embarked on various programmes to stop deforestation. Most are directed towards the rationalization of shifting cultivation. During the 1970s, efforts were directed at moving shifting cultivators into resettlement areas. Because of many constraints, technical as well as cultural, a new *in situ* approach is now being directed to rationalization of the system itself (Kartasubrata 1991). Research on alternatives to slash-and-burn has been concentrated around various transmigration regions in West and South Sumatra, where tall primary *Dypterocarp* rainforests have been cleared, and a considerable amount converted into alang-alang pastures. Appropriate crop rotation schemes with moderate fertilization have been devised, based on upland rice, cassava, and grain legumes (McIntosh et al. 1981; Wade et al. 1988). A novel approach of implanting managed fallow of *Pueraria phaseoloides* immediately after slash-and-burn has been used to stabilize relatively large clearings for estate crops, capturing nutrients in the ash and allowing unburned vegetation to decompose until planting materials become available (Von Uexkull 1984). The reclamation of alang-alang grasslands is being researched with promising results (Kartasubrata 1991; Sajise 1980; Von Uexkull 1990), primarily through agroforestry techniques with trees that grow well and provide shade.

For this project, Sitiung, West Sumatra, and several sites in Kalimantan have been selected. The focus will be on:

- Systematic investigations of the reclamation of alang-alang degraded grasslands

- Long-term changes in soil properties and greenhouse gas emissions upon conversion of *Dypterocarp* virgin forests

- Nutrient cycling and organic input management of selected systems, with emphasis on agroforestry systems.

Extrapolation from benchmark sites

This research proposal has concentrated on an analysis of the problem, and the identification of benchmark sites where an intensive study will be made of traditional and alternative systems and practices. The programme must initially take account of the variation in environmental and socioeconomic conditions and management practices within the agroecological zones in which benchmark sites are situated. This will be achieved by adopting three approaches:

- Each agroecological zone will be characterized in terms of its soil, climate, and physiographic conditions, and the distribution of major areas of forest, and shifting and permanent cultivation. This will be obtained at a low level of resolution, using a combination of remote sensing and existing information, such as that provided by UNEP's Global Resource Information Database (GRID). The information will be integrated into a Geographic Information System (GIS) associated with each benchmark site and used for both research and planning. CIAT has already started the characterization of Latin America through the use of extensive databases, but there is further need for the analysis of social, demographic, and economic data. In addition, IITA and ICRAF for Africa and IRRI in Asia have made some progress on characterization of their respective ecoregions.

- A limited programme of observations will be undertaken at a selected range of sites within each agroecological zone. Most of these sites already have relevant research underway within each zone, mainly by NARS and other institutions. This project will undertake a coordinated set of measurements related to intensive studies at the benchmark sites to assess the effect of site-specific environmental or social variables.

- To best prepare for the extension of beneficial research findings, NGOs and farmers should be invited to join systems-research planning meetings.

These approaches will constitute a relatively small part of the overall programme, but they are designed to involve regional organizations in providing tests for the extrapolation of results from benchmark sites, and in initiating a framework for subsequent development of the programme.

Dissemination through networking

The participatory methods used in this project are designed to take advantage of the dynamics of farmer group processes. These source dynamics will result in the dissemination of solutions among farmers within all the benchmark areas. In addition, established research networks supported by one or more of the international institutions will provide the logical vehicle for widespread technology validation, training, and policy dialogue, as appropriate. These networks include the Africa-wide Alley Farming Network for Tropical Africa (AFNETA)—made up of IITA, ICRAF, and the International Livestock Centre for Africa, based in Nigeria—and the Agroforestry Research Networks for Africa (AFRENA), coordinated by ICRAF; the International Fertilizer Development Centers (IFDCs) in West Africa and TSBFs worldwide; the Red de Investigación de Suelos Tropicales (RISTROP), the Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE), and the Cooperative Programme on Technology Generation and Transfer for the South American Tropics (PROCITROPICOS) in Latin America; and Forestry/Fuelwood Research and Development Project (F/FRED) in Winrock, the Asian Rice Farming Systems Network, the International Network for Sustainable Rice Farming, and the International Board for Soil Research and Management (IBSRAM) in Asia and Africa. Such networks cover most of the tropical countries undergoing deforestation. The strengthening and expansion of regional and inter-regional networks will greatly facilitate training, data synthesis, data exchange, standardization, development, and comparison of research methods.

Links with related institutions

Collaboration will be maintained with appropriate institutions in developed countries with expertise in alternatives to slash-and-burn. This would be primarily on-campus through university programmes, but also include graduate student research at strategic sites. Examples include Reading University and the Institute of Terrestrial Ecology (ITE), both in the United Kingdom, for Africa; the North Carolina State University in the United States for Latin America and Madagascar; the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia for Southeast Asia; and the Edinburgh Centre for Tropical Forests in the United Kingdom for Africa and Asia.

Collaboration is also anticipated with national, developed-country research bodies like the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), and with other CGIAR centres such as the International Board for Plant Genetic Resources (IBPGR) on germplasm conservation. Links will also be maintained with the land resource evaluations and Tropical Forestry Action Plans (TFAPs) of the Food and Agriculture Organization of the United Nations (FAO). IBSRAM, an international organization that is not a part of CGIAR, will collaborate with IFDC as needed.

Links with private sector

In some regions the private sector is becoming increasingly interested in assisting research, both from a funding and an implementation perspective. Wherever possible, maximum collaboration with the private sector will be sought.

Links with global environmental programmes

This project will contribute significantly to global environmental research through collaboration with several components of the International Geosphere-Biosphere Programme (IGBP). In particular, there is scope for close collaboration with the Global Change and Terrestrial Ecosystems (GCTE) Core Project of the IGBP. GCTE will undertake research on the global environmental impact of slash-and-burn on biodiversity, soil degradation, and greenhouse gas emissions. In addition, collaboration with GCTE will link this project to GCTE's developing expertise on the dynamics of complex multispecies agricultural systems and the impact of global change upon them; it will also contribute research results of direct relevance to GCTE's international programme. This project will interact with GCTE on three levels:

Level 1—direct contributions to GCTE. Work characterizing and evaluating the environmental soundness of alternative agricultural and agroforestry systems in the humid tropics will contribute directly to GCTE's international programme in the areas of:

- Biogeochemical (nutrient) cycling
- Mitigation of soil erosion
- Weed dynamics and management
- Interactions between components (multispecies systems).

In addition to these specific areas of mutual interest, the thorough and standardized site characterization will offer baseline data to assist in the monitoring and detection of global change. The linkages of these activities to specific elements of the GCTE programme are listed earlier in this document.

Level 2—additional collaboration. Opportunities for additional research will arise to benefit both this project and GCTE. In particular, research on the hydrological pathways of nutrient loss from present and alternative production systems will be useful. In these cases, a joint GCTE/Alternatives to Slash-and-Burn proposal would be submitted to relevant agencies for additional funding.

Level 3—framework for GCTE research. One of the objectives of this project is to determine the contribution of slash-and-burn and associated land-use practices to global environmental problems. Research on global change itself is beyond the scope of this project. But the project will provide an excellent framework for GCTE to undertake the research through well-characterized sites, existing agroecological research, and where appropriate, support facilities. GCTE research will include:

- Relationship between loss of biodiversity and ecosystem function

- Global change impact on biodiversity

- Measurement of greenhouse gas emissions from present and alternate production systems (with IGAC, see below)

- Addition of global change component to ongoing agroecological research, for example, the impact of elevated carbon dioxide levels on soil-organic matter dynamics and crop–weed competitive interactions, and the risk of erosion under changed rainfall conditions.

Although this third level of work will be undertaken in close collaboration between this project and GCTE, the latter will ultimately be responsible for organizing, securing funding for, and conducting the research.

In addition to GCTE, there are links to other components of IGBP:

International Global Atmospheric Chemistry (IGAC). Measurement of greenhouse gas emissions will be undertaken jointly by GCTE and IGAC, and will contribute to the IGAC effort to quantify the global carbon cycle.

Biospheric Aspects of the Hydrologic Cycle (BAHC). This project will provide information to BAHC on the hydrological changes that result when land-use moves from forestry to other uses, including alternatives to slash-and-burn agriculture.

Global Change System for Analysis, Research and Training (START). The START programme is establishing a system of regional research centres and associated networks of experimental sites in all the major biomes of the world. The centres will be used for data gathering, analysis, interpretation, modelling, and training. Initial emphasis will be on three regions: Latin America, Southeast Asia, and Sub-Saharan Africa. There are obvious advantages to linking the benchmark sites of this project to the START network.

Data and Information Systems (DIS). Collaboration should be undertaken with IGBP-DIS, which will develop global databases on land-use, land-cover change, and the biophysical and ecological characteristics of the earth's surface.

C. DEVELOPMENT OBJECTIVE

To establish, in collaboration with national programmes in Brazil, Cameroon, and Indonesia, a scientific research base to foster sustainable alternatives to slash-and-burn agriculture, in order to reduce the rate of emission of greenhouse gases and environmental degradation, and to improve the economic wellbeing of the dwellers of the forests and forest margins, by providing the slash-and-burn farmer with technologies that are technically and socioeconomically feasible.

D. IMMEDIATE OBJECTIVES, OUTPUTS AND ACTIVITIES

IMMEDIATE OBJECTIVE 1

To establish at each target site interdisciplinary teams drawn from national and international institutions and NGOs, to complete the standardization of methods, and to conduct global training in methods appropriate for slash-and-burn research.

Output		Activity		Responsible party
1.1	Multidisciplinary teams established at each location	1.1.1	Establish multidisciplinary teams covering required areas for S&B activities at each site	ICRAF, CIAT, IITA, EMBRAPA, IRA, and AARD/AFRD
1.2	Publication of guidelines for site characterization and setting of research priorities	1.2.1	Develop operational guidelines for each team and for global and regional linkages	ICRAF, TSBF, WRI
1.3	Manuals for standard methods, procedures, and protocols for project implementation	1.3.1	Test candidate methods and procedures for calibrating and standardizing between sites	S&B Consortium
1.4	Scientists at each target site trained in appropriate and standard methods for full implementation of S&B research	1.4.1	Train and ensure institutional upgrading at each site in methods for S&B research by holding global (intersite) workshops on:	
			• Marketing survey methodology to define relationship of markets to land use	WRI, IFPRI, ICRAF, EMBRAPA, IRA, AARD/AFRD
			• Developing GIS methodology appropriate for S&B project, integrating social, economic, and policy determinants	IRRI, CIAT, IITA, TSBF
			• Research methods for carbon and nutrient cycling and greenhouse emissions for humid tropical areas	TSBF, GCTE, IFDC, ICRAF

IMMEDIATE OBJECTIVE 2

To develop prototype models of the processes determining deforestation, agricultural productivity, and sustainability for the three target zones.

Output		Activity		Responsible party
2.1	Interactive database and information system for each target zone	2.1.1	Synthesize preliminarily the data on policy, agricultural practices, land use, deforestation, and environmental degradation for the three target zones	S&B Consortium
2.2	Prototype models of the determinants of deforestation and environmental degradation	2.2.1	Integrate characterization data to develop preliminary models of the processes determining deforestation, land use, and environmental degradation	S&B Consortium

IMMEDIATE OBJECTIVE 3

To initiate strategic interdisciplinary processes and systems-level research to evaluate selected technology components and land-use systems with regard to their impact on agricultural productivity and environmental degradation.

Output		Activity		Responsible party
3.1	Identification of key constraints to agricultural production, environmental quality, and sustainable land use	3.1.1	Investigate component processes that contribute to agricultural productivity, e.g., weed pressure, soil fertility, resource competition, and soil erosion	TSBF, ICRAF, CIAT, IITA, EMBRAPA, IRA, AARD, and AFRD
3.2	Identification of priority policy constraints for sustainable land-use systems	3.2.1	Develop a framework for policy research related to alternative land-use systems	WRI, CIAT, ICRAF, and EMBRAPA
3.3	Initial estimates of carbon balance in three sites	3.3.1	Establish experiments to estimate carbon stocks and soil carbon lability and storage in alternative land-use systems	TSBF, IITA, CIAT, ICRAF, and EMBRAPA
3.4	Test of models for initial predictions of carbon storage/loss for three sites	3.4.1	Test dynamic models for simulating soil carbon change under changing land-use systems in the tropics	TSBF

E. INPUTS

1. Consortium for Slash-and-Burn

The input of the Consortium includes staff for the research and international programmes; laboratory and support facilities; and administrative and logistical support to conduct the research, training, and dissemination activities. The value of this cofinancing is US$ 4.42 million.

2. Participating countries

NARS in the relevant countries will provide field, laboratory, and support facilities; administrative and logistical support; and scientists to participate in the project's research, training, and dissemination activities. The value of this support is estimated at US$ 725,000.

3. GEF/UNDP

GEF/UNDP is requested to provide US$ 3 million to support the proposed programme to develop sustainable alternatives to slash-and-burn agriculture. Proposed budget allocations for Phase 1 starting in November 1993 are shown in the section on budgets.

F. RISKS

The benchmark sites in Brazil, Cameroon, and Indonesia were selected because of their strong links and long-standing collaboration with the Consortium for Slash-and-Burn. No major risks are anticipated, unless political unrest becomes a serious problem in Cameroon.

G. PRIOR OBLIGATIONS AND PREREQUISITES

The four international centres and two international programmes that comprise the Consortium for Slash-and-Burn have a well-established record of achievement that equips them to carry out the activities described in this project. The combination of skills and talent in the Consortium can provide the required staffing and backstopping to undertake the proposed activities. In addition, the six institutions have excellent links and outreach offices in Brazil, Cameroon, and Indonesia. The selected collaborating NARS too have skilled research staff and adequate research facilities to implement the proposed activities. The NGOs who will participate in the project also have strong capabilities in the relevant areas.

H. PROJECT REVIEWS, REPORTING AND EVALUATION

The proposed operational framework described earlier will ensure the timely and thorough monitoring and evaluation of progress through the steering groups established at the local, regional, and global levels. In addition, the four International Agricultural Research Centres (IARCs) have a standard review procedure involving the Programme Committee of the Board of Trustees, the programme leaders and coordinators within each institution, and finally, the Director General's office. ICRAF, as the global coordinating institution, will monitor research progress and budget expenditures regularly with NARS collaborators and the Slash-and-Burn Consortium.

All IARCs publish yearly programme reports and highlights of their research and international programmes. Individual scientists will report significant findings through international journals and meetings. A yearly progress report will be presented to UNDP.

I. LEGAL ASPECTS

ICRAF, in its role as global coordinator, will be responsible and accountable for actions undertaken in this proposal. ICRAF is an autonomous non-profit organization, international in character, and governed by a Board of Trustees.

J. BUDGET

The budgets for the project are attached.

Budget notes

Equipment and capital

- Cameroon: one vehicle, laboratory equipment
- Indonesia: laboratory equipment
- CIAT: GIS equipment
- TSBF: Laboratory equipment
- ICRAF: GIS equipment.

Training, workshops and monitoring

Three global workshops will be held on: marketing survey methodology; GIS methodology integrating socioeconomic and policy determinants; and carbon dynamics/nutrient cycling. The ICRAF budget will support the travel costs of national scientists and resource persons.

Overhead rates

Overhead rates will be charged at the standard rate of participating institutions and will be covered by their respective budgets.

PROJECT BUDGET COVERING UNDP CONTRIBUTION
(in US$)

Project Title: Alternatives to Slash-and-Burn
Project Number: GL0/93/G32/A/1G/31

Code description		Total	1994
10.00	**PROJECT PERSONNEL**		
16.00	Mission Costs	15,000	15,000
19.00	Component Total	15,000	15,000
29.00	Subcontract with ICRAF	2,687,700	2,687,700
90.00	Total	2,702,700	2,702,700
93.00	AOS OPS	297,300	297,300
99.00	GRAND TOTAL	3,000,000	3,000,000

ICRAF BUDGET

Project Number: GL0/93/G32/A/1G/31

Project Title: Alternatives to Slash-and-Burn

Code description	Total	1994
10.00 **PROJECT PERSONNEL**		
11.01 Global Coordinator (12 mos)	111,000	111,000
11.02 Soil Scientist - Brazil (12 mos)	111,000	111,000
11.03 Statistician/Programmer (12 mos)	12,000	12,000
11.04 Research Assistant - Brazil (12 mos)	12,000	12,000
11.05 Research Assistant - Indonesia (12 mos)	9,600	9,600
11.06 Field Technician - Brazil (12mos)	7,200	7,200
11.07 Field Technician - Indonesia (12 mos)	6,000	6,000
11.51 Soil Scientist - Indonesia (6 mos)	55,500	55,500
11.52 Social Scientist - Indonesia (6 mos)	55,500	55,500
11.53 Resource Economist (4 mos)	37,000	37,000
11.54 Agro Climatologist (6 mos)	37,000	37,000
11.55 Short-Term Consultant (3 mos) (GIS)	20,000	20,000
11.97 Short-Term Consultant - Brasil (3 mos)	8,000	8,000
11.97 Short-term Consultant - Indonesia (6 mos)	12,000	12,000
13.01 Administrative Support	28,600	28,600
15.00 Travel	54,900	54,900
19.00 COMPONENT TOTAL	577,300	577,300
20.00 SUBCONTRACTS with ICRAF:		
21.00 EMBRAPA	362,700	362,700
22.00 IRA	256,000	256,000
23.00 AARD/AFRD	372,000	372,000
24.00 CIAT	186,000	186,000
25.00 IITA	279,000	279,000
26.00 TSBF	186,000	186,000
27.00 WRI	93,000	93,000
29.00 COMPONENT TOTAL	1,734,700	1,734,700
30.00 TRAINING/PLANNING		
33.00 In-Service	17,500	17,500
34.00 Workshop + 3rd GSG Meeting	188,000	188,000
39.00 COMPONENT TOTAL	205,500	205,500
40.00 EQUIPMENT		
41.00 Expendable	35,500	35,500
42.00 Non-expendable	20,000	20,000
49.00 COMPONENT TOTAL	55,500	55,500
50.00 MISCELLANEOUS		
51.00 Office Supplies/Maintenance	47,100	47,100
52.00 Reporting/Monitoring/Publication	67,600	67,600
59.00 COMPONENT TOTAL	114,700	114,700
29.00 Subcontract with ICRAF	2,687,700	2,687,700

EMBRAPA BUDGET

Project Number: GL0/93/G32/A/1G/31
Project Title: Alternatives to Slash-and-Burn

Code description		Total	1994
10.00	**PROJECT PERSONNEL**		
11.97	Consultant; Characterization	11,000	11,000
11.97	Consultant; Diagnosis	8,000	8,000
13.01	Administrative Support	10,000	10,000
15.00	Travel	27,600	27,600
19.00	Component Total	56,600	56,600
30.00	**TRAINING**		
33.0	In-service	22,900	22,900
34.00	Workshops	26,200	26,200
39.00	Component Total	49,100	49,100
40.00	**EQUIPMENT**		
41.00	Expendable	98,400	98,400
42.00	Non-Expendable	75,000	75,000
49.00	Component Total	173,400	173,400
50.00	**MISCELLANEOUS**		
51.00	Office supplies/Maintenance	19,200	19,200
52.00	Reporting/Monitoring	64,400	64,400
59.00	Component Total	83,600	83,600
99.0	GRAND TOTAL	362,700	362,700

Note: OPS Central Service was previously deducted.

IRA BUDGET

Project Number: GL0/93/G32/A/1G/31
Project Title: Alternatives to Slash-and-Burn

Code	description	Total	1994
10.00	**PROJECT PERSONNEL**		
11.97	Short Term Consultants	15,700	15,700
13.01	Field Support	28,300	28,300
13.02	Coordinator/Liaison	5,000	5,000
13.03	Administrative Support	13,700	13,700
15.00	Travel	39,750	39,750
19.00	Component Total	102,450	102,450
30.00	**TRAINING**		
33.00	In-Service	16,250	16,250
34.00	Workshops	11,000	11,000
39.00	Component Total	27,250	27,250
40.00	**EQUIPMENT**		
41.00	Expendable	56,750	56,750
42.00	Non-Expendable	42,000	42,000
49.00	Component Total	98,750	98,750
50.00	**MISCELLANEOUS**		
51.00	Office Supplies/Maintenace	6,250	6,250
52.00	Reporting/Monitoring	21,300	21,300
59.00	Component Total	27,550	27,550
99.00	Grand Total	256,000	256,000

Note: OPS Central Service was previously deducted.

AARD/AFRD BUDGET

Project Number: GL0/93/G32/A/1G/31
Project Title: Alternatives to Slash-and-Burn

Code description		Total	1994
10.00	**PROJECT PERSONNEL**		
13.01	Field Support (Labourers)	20,000	20,000
13.02	Research Support	20,000	20,000
13.03	Administrative Support	18,000	18,000
15.00	Travel	30,000	30,000
19.00	Component Total	88,000	88,000
30.00	**TRAINING**		
33.00	In-Service	24,000	24,000
34.00	Workshops	31,000	31,000
39.00	Component Total	55,000	55,000
40.00	**EQUIPMENT**		
41.00	Expendable	110,000	110,000
42.00	Non-Expendable	13,000	13,000
49.00	Component Total	123,000	123,000
50.00	**MISCELLANEOUS**		
51.00	Office Supplies/Maintenance	26,600	26,600
52.00	Reporting/Monitoring	79,400	79,400
59.00	Component Total	106,000	106,000
99.00	Grand Total	372,000	372,000

Note: OPS Central Service was previously deducted.

CIAT BUDGET

Project Number: GL0/93/G32/A/1G/31
Project Title: Alternatives to Slash-and-Burn

Code description		Total	1994
10.00	**PROJECT PERSONNEL**		
11.01	Agropastoral Specialist	111,000	111,000
11.02	Research Assistant	12,000	12,000
11.03	Field Assistant	7,200	7,200
11.97	Consultant; Policy	8,000	8,000
13.01	Administrative Support	5,000	5,000
15.00	Travel	4,000	4,000
19.00	COMPONENT TOTAL	147,200	147,200
30.00	**TRAINING**		
34.00	Workshops	4,300	4,300
39.00	COMPONENT TOTAL	4,300	4,300
40.00	**EQUIPMENT**		
41.00	Expendable	16,000	16,000
49.00	COMPONENT TOTAL	16,000	16,000
50.00	**MISCELLANEOUS**		
51.00	Office Supplies/Maintenance	3,000	3,000
52.00	Reporting/Monitoring	15,500	15,500
59.00	COMPONENT TOTAL	18,500	18,500
99.00	GRAND TOTAL	186,000	186,000

Note: OPS Central Service was previously deducted.

IITA BUDGET

Project Number: GL0/93/G32/A/1G/31
Project Title: Alternatives to Slash-and-Burn

Code	description	Total	1994
10.00	**PROJECT PERSONNEL**		
11.01	Social Scientist	111,000	111,000
11.02	Research Assistant	7,200	7,200
11.03	Field Assistant	4,800	4,800
11.04	Laboratory Assistant	4,800	4,800
13.01	Field Support	15,000	15,000
13.02	Administrative Support	7,200	7,200
15.00	Travel	56,500	56,500
19.00	COMPONENT TOTAL	206,500	206,500
40.00	**EQUIPMENT**		
41.00	Expendable	62,500	62,500
49.00	COMPONENT TOTAL	62,500	62,500
50.00	**MISCELLANEOUS**		
51.00	Office Supplies/Maintenance	5,000	5,000
52.00	Reporting/Monitoring	5,000	5,000
59.00	COMPONENT TOTAL	10,000	10,000
99.00	GRAND TOTAL (UNDP Contribution)	279,000	279,800

Note: OPS Central Service was previously deducted.

TSBF BUDGET

Project Number: GL0/93/G32/A/1G/31
Project Title: Alternatives to Slash-and-Burn

Code	description	Total	1994
10.00	**PROJECT PERSONNEL**		
11.01	Program Liaison/Coordinator (2 mos)	18,500	18,500
11.02	Soil Scientist (Char.) (3 mos)	37,000	37,000
11.03	Soil Scientist (C-Dynamics) (6 mos)	54,750	54,750
11.04	Laboratory Assistant	6,900	6,900
11.05	Research Assistant	7,800	7,800
15.00	Travel	3,650	3,650
19.00	Component total	128,600	128,600
30.00	**TRAINING**		
33.00	In-Service	28,400	28,400
39.00	Component total	28,400	28,400
40.00	**EQUIPMENT**		
41.00	Expendable	20,000	20,000
42.00	Non-expendable	6,000	6,000
49.00	Component total	26,000	26,000
50.00	**MISCELLANEOUS**		
51.00	Office Supplies/Maintenance	3,000	3,000
59.00	Component total	3,000	3,000
	GRAND TOTAL	186,000	186,000

Note: OPS Central Service was previously deducted.

WRI BUDGET

Project Number: GL0/93/G32/A/1G/31
Project Title: Alternatives to Slash-and-Burn

Code description		Total	1994
10.00	**PROJECT PERSONNEL**		
11.01	Program Liaison/Coordinator (3 mos)	21,500	21,500
11.02	Short Term Consultant (Policy) (2 mos)	7,000	7,000
11.03	Short Term Consultant (PRH) (3 mos)	11,100	11,100
13.01	Administrative Support	12,990	12,990
15.00	Travel	25,350	25,350
19.00	Component total	77,940	77,940
50.00	**MISCELLANEOUS**		
57.00	Office Supplies	1,000	1,000
	Indirect Costs	14,060	14,060
59.00	Component total	15,060	15,060
	GRAND TOTAL	93,000	93,000

Note: OPS Central Service was previously deducted.

Annex 1: Workplan

Project Number: GLO/93/632/A/LG/31

Project Title: Alternatives to Slash and Burn

Global Work Plan

WORKPLAN

Programmed Activities	Duration (Months)	Responsible	Cost ($)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				1994											
1. Programme Staff															
Global Coordinator	12	ICRAF	111000	■	■	■	■	■	■	■	■	■	■	■	■
Backstopping Staff															
Statistician/Programmer	12	ICRAF	12000	■	■	■	■	■	■	■	■	■	■	■	■
Resource Economist	4	ICRAF	37000	--	--	--	--	--	--	--	--	--	--	--	--
Agro-climatologist	6	ICRAF	37000							--	--	--	--	--	--
GIS - Short term consultant	3	ICRAF	20000	--	--	--	--	--	--						
Programme Liaison	2	TSBF	18500	--	--	--	--	--	--	--	--	--	--	--	--
Programme Liaison	3	WRI	21500	--	--	--	--	--	--	--	--	--	--	--	--
2. International Workshop/Planning															
Marketing/Policy	1	IFPRI/ICRAF	70000											■	
Characterization & Diagnosis/GIS Methodology	1	ICRAF	45000						■						
3rd GSG Planning	0.5	ICRAF	10000			■									
3. Publication/Reporting	3	ICRAF	21700			■			■			■			■
4. Travel															
3rd GSG Meeting	0.5	ICRAF	50000			■									
Global Coordinator & Backstopping Staff	3	ICRAF	38900	--	--	--	--	--	--	--	--	--	--	--	--
5. Office Supplies/Communication	12	ICRAF	15000	■	■	■	■	■	■	■	■	■	■	■	■
6. GIS Equipment	1	ICRAF	20000				■								
7. Administrative Support	12	ICRAF	13200	--	--	--	--	--	--	--	--	--	--	--	--

Project Number: GLO/93/G32/A/LG/31
Project Title: Alternatives to Slash and Burn

Brasil Workplan

Programmed Activities	Duration (Months)	Responsible	Cost ($)	Jan 1994	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1. Characterization & Diagnosis															
1.1. Characterization															
Consultant	3	EMBRAPA	22100												
Secondary data collection	4	EMBRAPA, CIAT, ICRAF	20000												
Data processing	2	ICRAF	3000												
1.2 Diagnosis															
Consultant	3	EMBRAPA	12000												
Data collection; On-farm	6	EMBRAPA, CIAT	42000												
Data processing	2	ICRAF	3000												
2. Develop Alternatives to S&B															
2.1. Pastures & Livestock															
Germplasm trials	9	EMBRAPA, CIAT, ICRAF	30200												
Pasture/Crop rotations	5	EMBRAPA, CIAT, ICRAF	29600												
Live fences	6	EMBRAPA, CIAT, ICRAF	10000												
2.2. Annual/Perennials															
Germplasm trials	9	EMBRAPA, CIAT	40000												
Improved fallows	6	EMBRAPA, CIAT, ICRAF	30000												
Multi-strata systems	6	EMBRAPA, ICRAF	20000												
2.3 Forest management															
Inventory	6	EMBRAPA, ICRAF	15000												
Exploration	8	EMBRAPA, CIAT	15000												
3. Policy Research															
Policy analysis	2	EMBRAPA	3500												
Macroeconomic factors	4	EMBRAPA	11300												
Policy reformulation	4	EMBRAPA, CIAT, ICRAF	20000			-	-	-	-	-	-	-	-		
Publication	1	EMBRAPA	5000												
Workshop	0.5	EMBRAPA	15000												
Policy framework	3	WRI	12083	--	--	--	--	--	--						
4. Training															
PRA methodology	1	WRI, EMBRAPA, CIAT	26083												
Nutrient cycling	0.5	EMBRAPA, CIAT, ICRAF	4500												
TSBF methodology	1	TSBF	9466												
4.1. Carbon Dynamics/Modelling	12	TSBF, CIAT, ICRAF	52033	--	--	--	--	--	--	--	--	--	--		
5. Support costs															
Planning meetings	1.5	EMBRAPA, CIAT, ICRAF	22900		--		--		--		--		--		
Capital goods	2	EMBRAPA	75000												

Project Number: GLO/93/G32/A/LG/31 Cameroon Workplan
Project Title: Alternatives to Slash and Burn

Programmed Activities	Duration (Months)	Responsible	Cost ($)	Jan 1994	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1. Characterization & Diagnosis															
1.1. Characterization															
Household Surveys	4	IRA	7000		▒	▒	▒	▒							
Community Surveys	4	IRA	1050		▒	▒	▒	▒							
Secondary data collection	3	IITA, IRA	10000		▒	▒	▒								
Database development	2	IRA, ICRAF	2500						▒	▒					
1.2 Diagnosis															
Consultant	1	IRA	1500				--	--							
Data collection – On Farm	6	IRA	24200						▒	▒	▒	▒	▒	▒	
Data processing & analysis	2	IITA, IRA	8250											▒	▒
Database development	2	IRA, ICRAF	2500											▒	▒
Workshop	0.2	IRA	1000					–							
2. Develop Alternatives to S&B															
2.1 Intensification of Prod. Sys.															
Improved fallows	10	IRA, ICRAF	10000			▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Integrated Soil fertility Mgn't	10	IRA, IITA	8000			▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Integrated weed/pest Mgn't	10	IRA, IITA	8000			▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
2.1. Diversification of Prod. Sys															
Germplasm Trials: MPTs/Food crops	8	IRA	7000					▒	▒	▒	▒	▒	▒	▒	▒
Domestication/Silvoculture	8	IRA, ICRAF	5000					▒	▒	▒	▒	▒	▒	▒	▒
Integrated Tree/Crop Systems	8	IRA, IITA	10000					▒	▒	▒	▒	▒	▒	▒	▒
2.3. Forest resource Mgn't															
Inventory/Resource Use	3	IRA	4000							▒	▒	▒			
Exploration/Mgn't Tech.	4	IRA	4000									▒	▒	▒	▒
2.4. Stable land use system															
Multistrata/Homegardens	6	IRA, IITA	7000						▒	▒	▒	▒	▒	▒	▒
3. Carbon Dynamics															
Carbon/Biomass Char.	6	IRA, TSBF	16000			▒	▒	▒	▒	▒	▒				
Carbon dynamics/interaction	10	IRA, TSBF	20000			▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Modelling	12	TSBF	47033	--	--	--	--	--	--	--	--	--	--	--	--
4. Policy Research															
Economic Incentives Analysis	8	IRA, IITA	15000			▒	▒	▒	▒	▒	▒	▒	▒		
Resource Mgn't Policy Analysis	10	IRA, IITA	25000			▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Policy Framework	1	WRI	12083					--	--						
Policy reformulation	4	IITA	12550								▒	▒	▒	▒	
Workshop	0.5	IRA, IITA	10000											–	
Publication	–	IITA	2000												–
5. Training															
PRA Methodology	1	WRI, IRA	22083					▒							
TSBF Methodology	1	TSBF, IRA	19466			▒									
Nutrient Cycling	0.5	IRA, IITA	5250					▒							
6. Support costs															
Capital Goods/Installation	4	IRA	42000				▒	▒	▒	▒					
Planning meetings	1.5	IRA	11000		–		–		–		–		–		–
Administrative	12	IRA	13700	--	--	--	--	--	--	--	--	--	--	--	--
Coordinator/Liaison	12	IRA	5000	--	--	--	--	--	--	--	--	--	--	--	--

Project Number: GLO/93/G32/A/LG/31

Project Title: Alternatives to Slash and Burn

Programmed Activities	Duration (Months)	Responsible	Cost ($)	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
				1994											
1. Characterization & Diagnosis															
1.1. Macro-characterization															
Consultant	3	ICRAF	6000												
Secondary data collection	4	AARD, ICRAF	20000												
Database development	2	AARD, ICRAF	13000												
1.2. Micro-characterization															
Consultant	3	ICRAF	6000												
Household surveys	3	AARD, ICRAF	15000												
Database development	3	AARD, ICRAF	12000												
Data synthesis	1	AARD, ICRAF	7000												
1.3. Diagnosis															
Forest margin; data collection	6	AARD, ICRAF	8500												
Converted forests; data collection	6	AARD, ICRAF	8500												
2. Develop Alternatives to S&B															
2.1. Forest margins															
Complex AF systems	8	AARD, ICRAF	27500												
Forest prod. systems	8	AARD	30000												
2.2. Converted forests															
Fast growing timber	8	AARD	15000												
Rotational fallows/alley farming	8	AARD, ICRAF	14000												
Contour hedgerows	8	AARD, ICRAF	13500												
Annual crop systems	8	AARD	15000												
2.3. Development research															
Land reclamation	10	AARD	14000												
Soil/water management	10	AARD	15000												
Nutrient management	10	AARD, ICRAF	15500												
Crop management	10	AARD	15000												
3. Soil Carbon & Nutrients															
Carbon/biomass characterization	3	AARD	7000												
Carbon dynamics/modelling	12	TSBF	47033	--	--	--	--	--	--	--	--	--	--	--	--
Soil P fertility	6	AARD	10000												
Training	2	AARD, TSBF	7000												
4. Policy Research															
Policy synthesis/analysis	2	AARD, ICRAF	20000												
Macro-economic factors	4	AARD, ICRAF	15000												
Policy reformulation	4	AARD, ICRAF	22000												
Workshop	0.5	AARD	20000												
Policy framework	1	WRI	12083												
5. Training															
TSBF methodology	1	TSBF	9466												
PRA methodology	1	AARD, WRI, ICRAF	34083												
Characterization methodology	1	TSBF, AARD, ICRAF	12000												
Biophysical research methodology	3	AARD, ICRAF	27000												
Policy research methodology	1	AARD, ICRAF	14500												

Project Number: GLO/93/G32/A/LG/31

Project Title: Alternatives to Slash and Burn

Indonesia Workplan

Programmed Activities	Duration (Months)	Responsible	Cost ($)	1994 Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
6. Greenhouse gases															
GH gas emmision/land use	6	AARD	7000				--	--	--	--	--	--	--	--	--
7. Biodiversity															
Soil micro-organisms	6	AARD	3500				--	--	--	--	--	--	--	--	--
Flora & Fauna changes	6	AARD	3500				--	--	--	--	--	--	--	--	--
8. Support costs															
Capital goods	2	AARD	13000					▒	▒						
Planning	1.5	AARD	15000		-		-		-		-		-		-
Administrative (5%)	12	AARD	18000	--	--	--	--	--	--	--	--	--	--	--	--

Annex 2

THE SCIENCE CONTENT OF THE SLASH-AND-BURN PROJECT

A. Characterization and diagnosis of slash-and-burn environments

Understanding the processes and identifying the parameters which promote non-sustainable slash-and-burn practices offers tremendous potential for the development of sustainable land-use systems and a more efficient use of natural resources. Agroecological zonation is a static methodology which fails to provide sufficiently specific information. This project will use a dynamic, spatially oriented approach integrated with critical data on land-use systems, changing production frontiers (such as market accessibility and price policy), and social and economic parameters (for example, population densities, land tenure, and labour).

A major contribution will be the testing and use of an integrated characterization/ diagnosis methodology. This methodology incorporates biophysical, sociopolitical, and economic parameters at different scales of resolution. The success of such a project and the capability of conducting in-depth multidisciplinary research on sustainable land use, conservation, and development, requires the formation and operation of cohesive teams. The project is developing a methodological framework to facilitate these scientific interactions. Major components to be characterized at the different scales and the information required are as follows:

Current patterns of land use and vegetation biomass

- Major climatic, edaphic, demographic, and economic zones will be defined at the regional and national scale by use of a Geographic Information System (GIS). (Whenever possible, secondary data will be used; when not available, resources at the IARCs and NARS will be coordinated to fill in the information gaps.)

- At the benchmark areas, satellite remote sensing imagery will be employed (when possible) to map distribution of different land-use systems, including those occupied by forest, fallow, crops, and pastures. Remote sensing techniques will yield quantified, geo-referenced data concerning these systems. Ground truthing will include measurement of the composition and biomass soil carbon of different vegetation categories. Again, secondary data sources will be relied upon when possible.

- Surveys at the international, national, and benchmark level will be used to define current policies and determine their effects on forest clearing, agricultural practices, factor markets, subsidies, migration and resettlement, and land tenure.

Information from this characterization will provide a basis for establishing areas needing recommendations and for understanding patterns of deforestation. Carbon stocks for the different land-use categories will be used for modelling carbon losses. A synthesis paper will be produced that focuses on the policy dimensions and socioeconomic aspects that can provide insights for setting

specific research priorities to promote the adoption of more sustainable land-use practices and discourage continued deforestation.

Resource management/exploitation practised by slash-and-burn farmers

- Village- and farm-level surveys will be used to determine forest-clearing practices; cropping patterns, fallow management systems, and land abandonment and degradation.

- To understand the reasons behind current practices, more in-depth farm level surveys and trials will assess the biophysical and socioeconomic resources and constraints of the farmer. The analyses include: soil fertility and limiting nutrients; use and characterization of organic and inorganic inputs; pest and weed assessment; cropping calendars with seasonal labour demands versus availability; market access for inputs and products; types of markets; farmer perceptions and production (income) objectives relative to current levels; on-farm versus off-farm income; and farmers' decision-making processes.

- At a few of the sites, in-depth economic surveys and diagnoses will be conducted, and integrated ecological-macroeconomic models will be constructed for linking the deforestation and land-degradation processes to macroeconomic processes (such as trade policies, and supply and demand).

Subsequent diagnosis of the farm/household information for the various land-use systems and policy environments will be used for refining research priorities and agendas that link technologies, institutions, and policies. Mechanisms will be established and monitored to include the voluntary participation of farmers, extensions services, and local NGOs in the characterization and setting of research priorities and agendas.

Environmental degradation caused by unsustainable slash-and-burn and alternative land-use systems

The following issues involve both initial characterization and monitoring of natural forests, lands recently degraded under traditional slash-and-burn methods, and alternative agricultural practices. These parameters and underlying processes will be measured in ongoing long-term trials comparing different land-use practices in farmers' fields next to forest and degraded areas. New, controlled, and standardized experiments will be conducted for addressing specific issues, as described below.

- Changes in biological, physical, and chemical properties of soil under slash-and-burn and alternative agricultural practices will be measured, and key processes in the loss of productivity will be identified.

- Weed ecology and dynamics and their role in land abandonment and degradation will be characterized.

- An inventory of biodiversity losses, particularly in soil, will be compared in the different agricultural systems and natural forest. Soil will be the focus because of the important role played by soil organisms in nutrient cycling and soil fertility. There is also considerable expertise on soil biodiversity within the Consortium for Slash-and-Burn.

- The emission of carbon dioxide and other greenhouse gases from forests, deforestation, and derived agricultural systems will be measured in collaboration with the Global Changes in Terrestrial Ecosystems programme (GCTE) of IGBP.

- Models such as CENTURY will be used to simulate changes in carbon pools from deforestation, and the relative degree of carbon sequestration or losses in subsequent slash-and-burn and other agricultural practices.

- Natural resources accounting will integrate the above processes into an analysis of the social and environmental costs and benefits of deforestation and alternative agricultural practices.

B. Development and transfer of environmentally and economically sound and sus-tainable alternatives to current slash-and-burn systems

Research will focus on improving existing practices and developing new alternatives for the reclamation of abandoned lands, the sustainable use of deforested lands currently in production, and the sustainable management of forest lands. Methods will include farmer participatory analysis and research. Farmer-directed and researcher-directed trials will be designed, based on the analysis of perceptions and aspirations of farmers, and the biophysical and socioeconomic factors affecting their decision-making processes. The alternatives explored will include agro-silvicultural, agropastoral, agro-silvopastoral, and reforestation systems. The systems evaluated under more heavily populated conditions will include contour hedgerow intercropping that involves food crops in association with perennial crops, trees, or forages. Annual cropping systems will emphasize cereal crops in association with leguminous forage, intercropping, and relay cropping. In less densely settled areas, research will focus on sequential systems and improved rotational fallow systems involving legume cover crops or trees. Agroforestry systems will also include detailed study of multistrata homegarden systems.

The development of alternative systems will include specific studies on component selection and improvement, nutrient cycling and soil fertility management, and resource sharing (competition) and weed dynamics. Concurrent microeconomic analysis of the alternatives and of their respective environmental and social costs and benefits will be an integral part of the research trials. Specifics of some of the research activities are given below.

Selection of germplasm and utilization of improved local, stress-tolerant cultivars of crop and tree species

- Species components (such as varieties and provenances) for the specific sites and their respective agroecological-economic areas will be identified, based on prior trials,

market demand projections, or their role in systems improvement. Important components include acid-tolerant varieties of rice and maize (previously identified through selection trials and programmes); annual and perennial forage and pasture species; multipurpose leguminous trees and shrubs; indigenous fruit trees; and trees for fuel, poles, and timber. Economically valuable species will be of particular interest for agro-silvicultural systems.

- Promising new germplasm for both soil conservation and economic products will be characterized in relation to climate and edaphic environments through international trials.

- Marketing studies will be conducted for promising species to assess their market potential (regional, national, and international).

- Tree improvement programmes will focus on selected species and cultivars, focusing again on species of economic importance to systems improvement.

- Efficient seed multiplication and seedling propagation programmes will be established to ensure availability of key components to farmers. It is equally important that institutions and policies be identified to ensure the success of such programmes.

Development of integrated soil and nutrient management practices based on nutrient dynamics and improved nutrient-use efficiencies

- An important aim in infertile areas where fertilizer use is not feasible is to enhance nutrient-use efficiency for both inorganic nutrients (fertilizers and agrominerals), and organic residues (such as crop and tree residues, and manure), or a combination of the two. Studies will concentrate on the quality (or type), quantity, timing, and method of application or organic inputs, and on the interactions of inorganic and organic inputs. Guidelines or expert systems for their use and respective roles in maintaining or improving crop production will be developed.

- Phosphorus (P) is a particulary limiting nutrient in many soils of the humid tropics. Emphasis will therefore be placed on the management of P through the interaction between inorganic and organic P sources, nutrient cycling, and the maintenance of organic soil P pools.

- Soil tests currently used for assessing nitrogen (N) and P availability are not suitable for low-input or tree-based systems. New tests must be developed, incorporating certain inorganic/organic fractions of the two nutrients.

- The benefits of symbiotic relationships including biological nitrogen fixation (rhizobia), and P-absorption (mycorrhizae), will be exploited through the use of appropriate species components, and the maintenance of microbial populations.

- To maintain and increase soil organic matter is especially important for soil fertility management in low-input systems. Certain pools or soil organic matter, called the active or labile fractions, are believed to be particularly important in supplying nutrients (N and P). Definitive studies will be designed to establish possible correlation between these pools and soil fertility/crop productivity. In addition, experiments will be conducted for maintaining soil organic matter by varying the quantity, quality, timing, and application of organic and inorganic inputs.

- Integrated systems studies will investigate the spatial and temporal arrangement of different plant (crop) types and forms for increasing nutrient transfer from the soil to plants, while minimizing direct competition among the productive components, and minimizing nutrient losses through leaching. This involves both selection and management of each component. The ecological and economic sustainability of these management options will be assessed.

Development of improved systems is an iterative process and involves both on-station strategic research and adaptive on-farm participatory research. The intention is not to provide package technologies but to explore the range and integration of components into efficient, productive systems from which farmers can select specific components to incorporate into their preferred production systems.

Use of models to assist in planning research, extrapolation of results, and assessment of the impact of technology adoption at the local, regional, and global levels

- As a first stage, existing models (CENTURY) will be modified for slash-and-burn and related tropical agricultural systems to predict soil changes under different management practices. The use of such models will highlight gaps in the knowledge base of particular biological processes. This information will be used to help prioritize research areas that should receive attention during the project. In its turn, the information produced as a result of this research will be incorporated into the models.

- In the second stage, these improved models will be linked to crop models (IBSNAT) to estimate biological productivity and economic returns of different production systems. These will later be linked to farm systems models.

- The resulting systems models will be used to evaluate risk factors associated with different management systems and agricultural practices, as well as their sustainability. This will enable the isolation of climatic, environmental, and economic variables to allow a thorough assessment of risk for the various alternative production systems.

- Environmental impact, especially the losses or sequestration of carbon, will be assessed for the various alternative production systems in different agroecological zones by use of CENTURY and other systems models.

Development of policy guidelines and implementation strategies for facilitating technology adoption

Various policy options for facilitating the adoption of the alternative technologies will be analyzed to identify the most effective and equitable options and their means of implementation.

- Natural resource policy options such as regulations, prohibitions, taxes, and subsidies will be analyzed through the use of the ecological-macroeconomic models in terms of equity, i.e., the equal distribution of costs and benefits of the policy. The various policies will also be analyzed in terms of their effectiveness in achieving the goal of facilitating the adoption of technology.

- Marketing policy options will be analyzed in terms of their costs to the government and society, and their benefits to farmers by strengthening markets for outputs, including the local processing of primary products.

Annex 3

PROCEDURAL GUIDELINES FOR CHARACTERIZATION AND DIAGNOSIS FOR SLASH-AND-BURN

Contents

Part I

Part II

Part III

PART I

Introduction

The following guidelines provide a common approach for site characterization and the formulation of research agendas for the benchmark sites of this project. These guidelines evolved from two discussion papers, on biophysical and socioeconomic methods respectively, addressing parameters and methods for site characterization. These papers were discussed at a subsequent workshop and key methodologies were tested in the field in Indonesia.

Several points became clear during the workshop. It was emphasized that, given the complexity of the problem of slash-and-burn, there is a need to focus on issues unique to slash-and-burn practices. This focus is provided in the general objectives outlined in the initial slash-and-burn document produced at the February 1992 meeting in Rondonia, Brazil. Being an interdisciplinary project, interaction among the various disciplines must be ensured at each step. In addition, there are different scales of analysis; it is important to know what information is required at each level and how that information will be used and integrated into the overall programme.

In order to guide the research process, a conceptual framework is introduced that integrates the overall goals and objectives of the project. The work has been divided into two stages. The first, Stage 1, involves site characterization not only at the local, but also at the regional, community, and farm levels. Parallel diagnosis studies will also be conducted in the benchmark areas. The information from the characterization and diagnosis studies will be used for setting research priorities. The second, Stage 2, entails carrying out the actual research agenda.

Project goals and activities

The overall goals of this project are to reduce the rate of deforestation caused by slash-and-burn agriculture, rehabilitate lands degraded by slash-and-burn, and improve the wellbeing of slash-and-burn farmers by providing viable, alternative land-use practices. The general research activities required to attain this goal are listed below.

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

- Identify appropriate technologies and develop improved production systems that are economically feasible, socially acceptable, and environmentally sound alternatives to current slash-and-burn systems

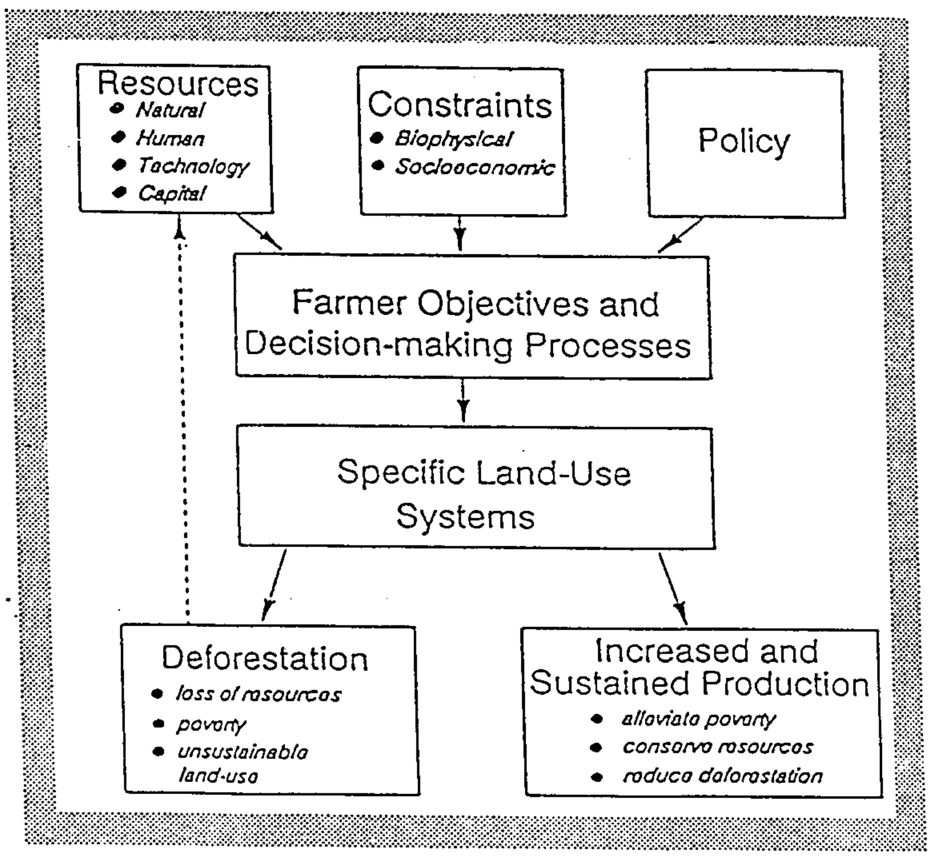
- Quantify the contribution of slash-and-burn agriculture and alternative land-use practices to global environmental changes

- Identify policy options and institutional management issues that facilitate the adoption of the improved systems and also discourage further deforestation.

A conceptual framework for the goals and activities is depicted in figure 2. In this model, the land-use system adopted by farmers depends on the interaction between the biophysical and

economic resources available to them, the limitations of the biophysical environment, and the social and economic constraints to the utilization of resources. Policies are also imposed on farmers that influence their decisions. The current trend is toward the continued cycle of deforestation, with poverty leading to resource degradation, which in turns leads to deforestation. One of the early activities of the programme is to characterize the biophysical, social, and policy factors that produce the deforestation environment at the benchmark areas (Stage 1). The follow-up research activities are intended to link technologies and policies that promote trends toward increased production on cleared lands, while simultaneously improving the standard of living and decreasing the rate of deforestation (Stage 2).

Figure 2 Conceptual framework for development of the Alternatives to Slash-and-Burn research programme

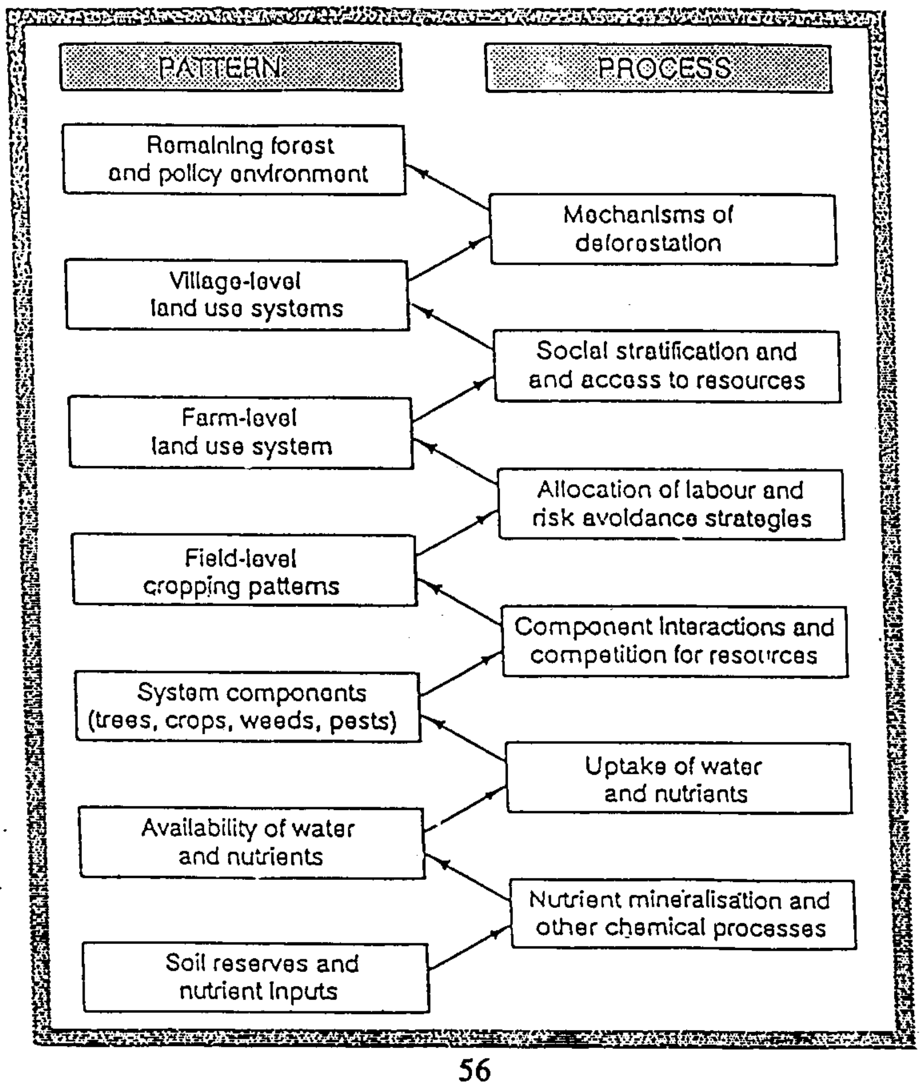


To state the problem briefly: what are the alternative land-use systems to slash-and-burn that reduce deforestation, poverty, and global environmental changes related to greenhouse gas emissions and biodiversity? And how can these alternative systems be promoted?

Research procedure

This project attempts to integrate a large range of scales and disciplines and levels of complexity. Given the geographical spread of the benchmark sites, it is necessary to have a common research approach that ensures meeting the project's objectives. To do so, the output required for each of the objectives and activities will be specified, and the sources of information and methods for measurement and analysis for obtaining the output will be given. We are interested in both the patterns of land use in slash-and-burn areas over time and the processes which produce these patterns. Figure 3 gives an example of the pattern/process ladder which could apply to a slash-and-burn situation. Patterns at each level can be linked with several lower levels, not just the one shown in this figure. At the upper scale in the figure, human decision-making dominates the processes, whereas at the lower scale the processes are of a biological, chemical, or physical nature. Stage 1 involves site characterization that describes the patterns of land use at several scales and then formulates hypotheses about the relevant underlying processes. Research carried out in Stage 2 aims at testing the hypotheses and using the pattern/process ladder to predict conditions under which the system may move in a more desirable direction, reducing poverty and deforestation.

Figure 3 An example of patterns and related processes leading to deforestation



Characterization and diagnosis of the benchmark sites serves several purposes:

- It provides baseline information on diverse slash-and-burn systems and identifies site-specific research priorities, as well as more generic, or global, research issues

- It provides a means for data synthesis and cross-site comparisons

- It provides a framework for the extrapolation of results and recommendations from the benchmark sites to similar sites, both at the regional and global levels.

Therefore the scale for this project ranges from global integration to the farm plot, with increasing detail of characterization as one moves to the farm (figure 4). The humid forests and deforestation fronts of the three continents where slash-and-burn agriculture is practised constitute the pattern at the global scale. The various agroecological-economic zones that are found in this global slash-and-burn environment form the basis of characterization at the regional scale. The land-use patterns that prevail within each of the agroecological-economic zones are the focus at the benchmark areas. Finally, the different farming systems found within these land-use systems constitute the farm level characterization. Not only is this local → regional → global approach necessary for the purpose of extrapolation, it also allows for the reverse flow of information that is necessary to indicate that factors impinging on farmer decision-making can be related to site-specific resources or constraints, or related to community- or national-level policies.

Scales of characterization

The different levels or scales for characterization will be referred to as global, regional/national, benchmark/community, and farm/household levels (figure 4). Descriptions of the different levels are as follows:

- *Global level.* This is a composite of the three continental regions. It is at this level that data are ultimately integrated for the identification of global trends and differences, and for extrapolation purposes.

- *Regional/national level.* The three regions are the lowland humid tropics of Southeast Asia, Latin America, and Sub-Saharan Africa. Within each of the regions there may be two or three distinct agroecological and economic zones. For example, within the regions there are national boundaries that can include distinct policies that then influence the characterization profile.

- *Benchmark/community.* These are the actual target zones of the project. They were chosen because they represent, at the regional and global levels, large active areas of deforestation caused by slash-and-burn practices. Within each benchmark area, there may be one or more distinct land-use patterns resulting from the biophysical and socioeconomic and policy environment. The units of study in the benchmark areas are communities or villages. The communities are generally representative of an aggregation of land-use systems.

- *Farm or household level.* This refers to the farming systems practiced in the community, again including the specific biophysical and socioeconomic environment. Examples of the benchmark sites placed into the different scales for slash-and-burn are presented in figure 5.

Figure 4 Scales of site characterization and their activities

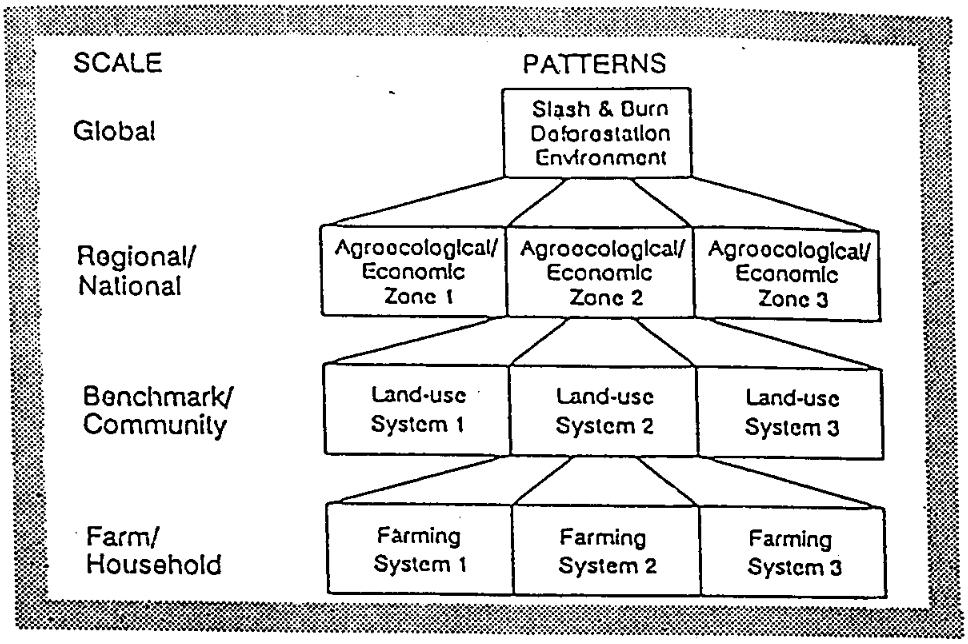
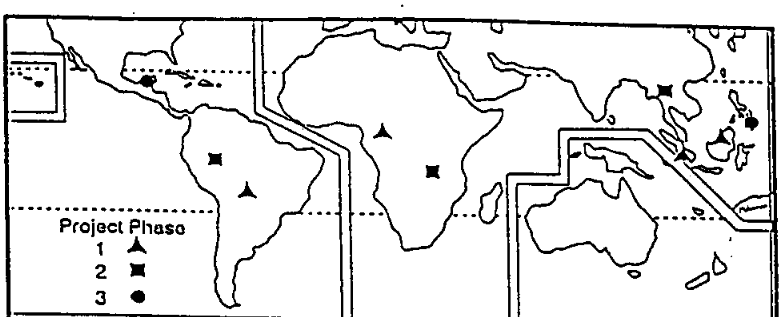


Figure 5 Different scales and locations of slash-and-burn activities

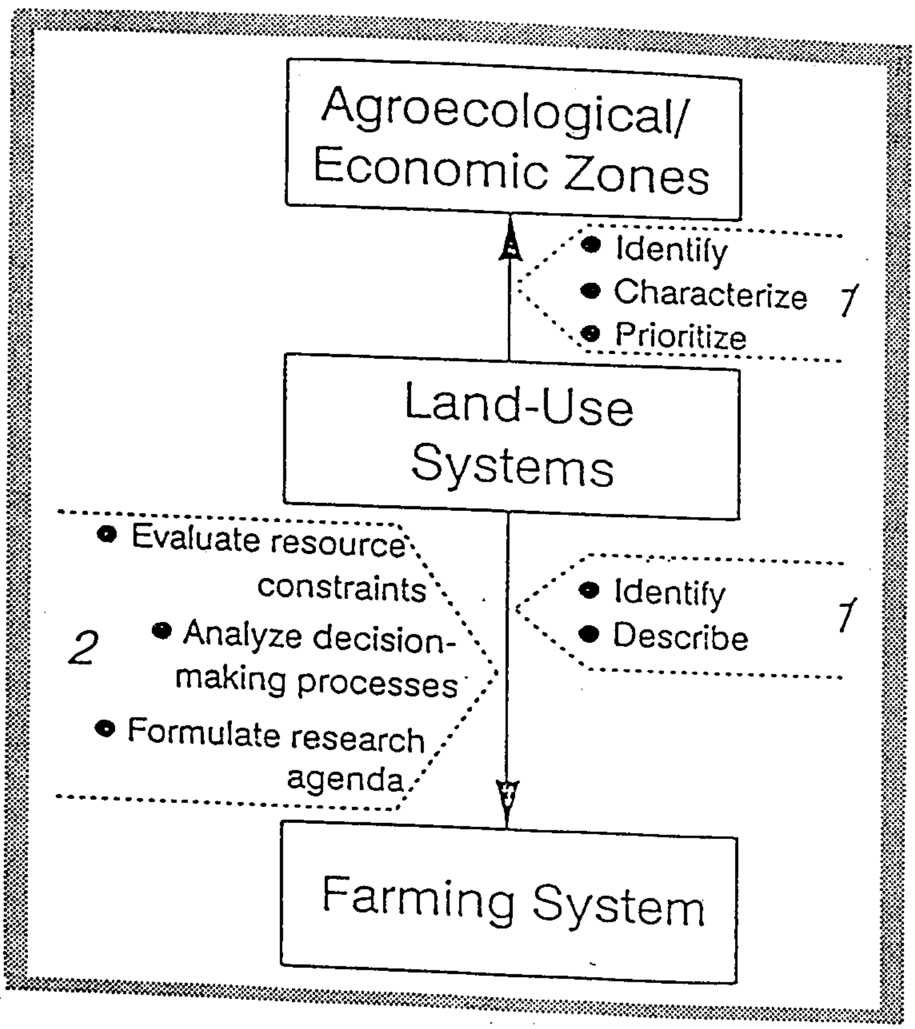


Region	Nation	Benchmark Area	Community
Latin America	Brazil	Acre/Rondonia	Novo California Theobroma
	Mexico	Mayan Zone	to be selected
	Peru	Upper Amazon Basin	Yurimaguas Iquitos Pucallpa
Southeast Asia	Indonesia	West Sumatra	Sitiung
		Kalimantan	to be selected
	Philippines	Mindanao	Claveria
	Thailand	Northwest	Chiang Mai
Sub-Saharan Africa	Cameroon	Humid Forest Zone	M'Balmayo
	Zambia	Wetter Miombo	Kasama

The actual scales or levels of characterization may not completely coincide for the biophysical and socioeconomic and political patterns. For example, the agroecological zones of the benchmark area may extend beyond national boundaries, or the community sphere of influence may extend beyond any natural biophysical (landscape) unit. It is therefore sometimes necessary to define the boundaries of a particular scale of characterization in terms of social or political influence.

Site characterization is a multi-level process. Characterization at the different levels can and must proceed simultaneously if rapid progress towards system improvement is to be made. At the macro level, the benchmark areas are characterized into agroecological-economic zones according to the criteria explained in Part II, Section C. From this information, the benchmark sites are placed into a national, regional, and global context by use of geographically referenced databases. At the meso/micro level, the benchmark areas are characterized by the dominant land-use systems (figure 6).

Figure 6 Characterization (1) and diagnosis (2) of land-use systems in benchmark areas



The land-use systems are identified and characterized according to the criteria explained in Part II, Section D. The land-use systems are then prioritized by area represented, relevance to the global project, and chances of improvement. Whether we have the human resources needed to place land-use systems in a geographically referenced database is currently under discussion. Within the selected land-use systems, parallel characterization and diagnosis studies are conducted at the farm/household level (figure 6). The criteria for characterization at the farm level are explained in Section C. The diagnosis studies evaluate and quantify the available resources, as well as the constraints and opportunities at the community and farmer scales, and analyze the resulting decision-making processes. This more detailed and rigorous diagnosis involves in-depth surveys at the farm level, the methods and criteria for which will be presented in a later section.

The scale, parameters, required outputs, and sources of information (or methods) of each of the objectives relevant to Stage 1 of the project are outlined in detail in Part II of this annex.

PART II

PROTOCOL FOR INTEGRATED CHARACTERIZATION AT SEVERAL SCALES FOR THE SLASH-AND-BURN PROJECT

SECTION A: Introduction

General concepts

Characterization and diagnosis are two distinct but highly related sets of activities. The overall objectives of characterization are to:

- Identify research sites which are representative of larger areas, so that results can be extrapolated to *recommendation domains*.

- Identify common characteristics and differences across sites, so that a working *typology* of sites is developed. The typology is refined as research proceeds but is initially needed to justify the choice of different sites.

The overall objectives of diagnosis are to:

- *Quantify* the major problems/constraints/bottlenecks/resources at a site
- *Prioritize* research issues for the research agenda of the site.

Links between characterization and diagnosis for the slash-and-burn project can be represented as follows:

Characterization at the global scale
yields identification of humid tropical forest areas
affected by slash-and-burn practices
↓
Characterization at the regional (national) scale
yields broad agroecological-economic areas
within the slash-and-burn areas
↓
Characterization at the community scale (benchmark sites)
yields working typology of land-use systems
within agroecological-economic zones
of target areas
↓
Characterization at the household/farm scale
yields typology of households/farms
within the land-use systems
↓
Diagnosis at the household/farm scale
yields quantification of problems, opportunities, constraints and resources
and research priorities within land-use systems.

Methods for characterization and diagnosis are somewhat different given the purpose and use of the data. Characterization identifies and defines the patterns (agroecological-economic zones, land-use systems and patterns, and farming systems) and therefore requires gathering very specific data detailed in data survey sheets and questionnaires. Specific types and units of data are necessary to allow for comparisons among sites. Diagnosis builds functional typologies of the farming systems and consequently requires a reliance on participatory appraisal and research methods (see Part III).

Methods of characterization

Lists of parameters are provided in the following sections for characterization at the different levels. It is important to emphasize that the lists provide *minimum datasets* for describing the biophysical, socioeconomic, and political environment where slash-and-burn agriculture is the dominant land-use system. The information gathered at the different levels is integrated, with more detail in the same categories required at the lower levels. Whenever possible, the same methods and units for gathering and presenting data must be used at each site to allow for valid comparisons.

The methods for characterization differ somewhat for each level, but secondary data are used whenever possible. From a glance at the lists, it appears that each of them is long and detailed, despite the fact that they provide the minimum dataset. A closer look reveals that much of the data already exists in some form, and only needs to be reworked for the purposes of this project.

A crucial point is that we are *aiming* for the construction of *geo-referenced* databases for this programme. The starting point will be existing GIS databases for the local, regional, and global levels. Additional data, unique to the slash-and-burn project, will be incorporated in a standardized form into these databases as they become available.

When required data are not available, further data collection could take varying amounts of time. In some cases, particularly at the regional and global levels, we will be limited by the databases that already exist. Examples of the data sources, methods, and time for characterization at the different levels are given below:

Continental scale
Secondary data + GIS at CIAT, IRRI, IITA and ICRAF

Most data are immediately available as secondary sources and in the GIS databases at CIAT, IRRI, IITA, and ICRAF. Time will be required to reconcile the scales, units, and methods among the different centres. If certain data are not available, decisions must be made concerning the time required to gather these parameters versus their importance.

↓

Regional/national scale
Secondary data + GIS + remote sensing
As with the continental scale, many of the data are available; however, policy information must be incorporated at the national levels. If remote sensing is used, this level could take up to six months to complete.

↓

Benchmark area/community scale

Secondary data + GIS + remote sensing + aerial photos + one time interviews with community officials and/or groups of farmers.

Although many of the data at this level are available from regional databases, this level and the next will require more time for putting finer resolution data into geo-referenced databases, and for gathering more socioeconomic and policy data.

↓

Household scale

Secondary data + individual farmer interviews (two interviews per farmer with a sample size of 70 will take about three months)

↓

Diagnosis

Secondary data + diagnostic trials + diagnostic surveys (over one year, assuming that the year is "typical").

Once all data are obtained from all sites for all levels of characterization and diagnosis, they will need to be measured in a comparable way across sites, entered in a centralized data bank, and analyzed in two ways:

- By the team of scientists at each site in collaboration with their regional partners
- By the global teams, for the purpose of making comparisons across sites and investigating general trends and differences in patterns and processes among the sites.

The protocol for the integrated characterization (including diagnosis) of the slash-and-burn sites does not in any way imply that research activities at these sites can only be initiated once the characterization is completed. Indeed, enough is known at each site to initiate some research activities. The *raison d'être* of this protocol is to organize the collection of standard data across sites to build a global dimension into the research through cross-site comparison and analysis. As research proceeds at each site, it will feed relevant data into this characterization; as the characterization proceeds, it will provide useful inputs for refining and focusing the research agenda at each site.

SECTION B

PARAMETERS FOR CHARACTERIZATION AT THE GLOBAL AND REGIONAL LEVELS

The objective of the regional characterization and subsequent global synthesis is to provide a geographically referenced database for identifying key socioeconomic and biophysical determinants and processes leading to slash-and-burn agriculture and deforestation. The existing GIS facilities at CIAT, IRRI, and IITA, and the proposed facilities at ICRAF, will be used to map out all humid and subhumid tropical forests and their associated buffer zones (forest margins for Southeast Asia (action: IRRI), Sub-Saharan Africa (action: IITA), and Central and Latin America (action: CIAT). A humid tropical forest has a growing season equal to or greater than 270 days, as defined by CGIAR, but the inclusion of seasonal tropical forests is necessary to cover many of the areas being deforested, and includes areas with up to but not more than a six-month consecutive dry season. Buffer zones or forest margins are areas where the tropical forest is being cleared—or has been during the last ten years—and where land use is resulting in resource degradation. These areas should be highlighted as potential areas for the extrapolation of research from the benchmark areas.

The boundaries of the regional scale are not limited by the countries in which the benchmark areas are included—they include all the countries with humid forest/subhumid forest zones characterized by slash-and-burn agriculture. This scale will also incorporate the areas in the benchmark countries not included in the benchmark characterization scale. As an example, the benchmark area for Brazil includes only the states of Acre and Rondonia. The remainder of the Brazilian Amazon will not be characterized at such fine resolution but will be included in the regional/national scale.

The regional/global characterization will be conducted by the regional International Agricultural Research Centre. The activities must be coordinated among the regions so that the databases are comparable. This coordination will be managed through a workshop and the development of the standardized database. The parameters included in the database at these levels will be determined to an extent by the existing GIS databases, but a particular aim will be to include more socioeconomic and policy data including population density; infrastructure, roads, and markets; and national or regional policies.

SECTION C

PARAMETERS FOR BENCHMARK AREA CHARACTERIZATION

The benchmark area is defined as a homogeneous area in terms of the biophysical and socioeconomic factors that influence slash-and-burn activities. The area must not be so large as to preclude fine resolution characterization, but not so small that the benchmark area and the community scale overlap. Preliminary minimal boundaries have been established and are presented in figure 5; these areas may be expanded (or contracted) if the groups working at the sites believe it is desirable and feasible to do so in order to provide information from representative, homogeneous areas.

The objective of the benchmark area characterization, along with the following community level characterization, is to provide information on the dominant land-use systems and the biophysical and socioeconomic conditions that produce the specific land-use system. It is also at this level that the national-level policy dimensions are incorporated into the characterization.

The benchmark area characterization is the responsibility of the national teams working at the sites within each area. Training on the specific methods and datasets to be used will be provided by a joint international/national team. This team will actually help initiate the characterization process and test methods. Subsequent completion of the gathering of data will be the responsibility of the national members. As with the previous level, many of the data are already available on maps (such as soil, vegetation, and land-use maps from previous research and surveys). Data synthesis will be handled as much as possible at the sites, but to ensure comparable data sets among the sites, this will be done with the assistance of the dataset formats and with members of the international centres when necessary.

The units of sampling at the benchmark level will be at the district level (or administrative equivalent) and aggregated to include all districts in the benchmark level. The frequency of sampling will be annual, or at five- to ten-year intervals since 1970. Often the data are only available at certain frequencies, and we are once again restricted by the resolution of the data. Again it must be stressed that, whenever possible, data should be provided in a way that will allow geo-referencing, i.e., with the latitude and longitude of the location to which the specific data refer.

Parameters required for characterization are provided in the following tables and questionnaire.

Table 3 Parameters for benchmark area characterization

TYPE OF DATA	OUTPUT AND UNITS *FREQUENCY OF MEASUREMENT	METHOD OR SOURCE OF INFORMATION	JUSTIFICATION/COMMENTS
VEGETATION (LAND USE OR LAND COVER)	All information in this section is to be geographically referenced; therefore if not already available in this form the data must be presented with maps or other means of referencing location.		
Total area of region	Total area (ha), sum of the following land-use categories. Assume all were derived from forest.	Secondary data. Maps.	To define the area of relevance in the region for the Slash-and-burn project.
Undisturbed forest	Total area (ha and %) of humid tropical forest (ha) found within national boundaries, divided into forest types (evergreen vs semi-evergreen) where distinct. *5 year intervals from 1970.	Secondary data. Agricultural and forestry census, existing GIS or remote sensing.	To determine rates of deforestation.
Forest fallow	Area (ha and % of total area) found in forest fallows, does not included degraded scrublands.	Same as above.	Indicates the importance of fallow systems, trends in fallow area indicate relative stability of system.
Cropland Annual crops Perennial crops (plantations)	Net area (ha and %) in annual crops. Area in perennial crops. *5 year intervals.	Same as above.	Net area does not include multiple cropping, only count multiple cropped lands by the area of the land, not the total area planted during the year.
Grassland	Area (ha and %) and stocking rates (animals/ha). *5 year intervals.	Same as above.	
Degraded areas	Area (ha and %) of other major land cover not included above. *5 year intervals.	Same as above.	Indicates the formation of degraded area and indicates current practices are unsustainable.

Other			
Biomass, above and below ground	Tons/ha dry matter representative of each of land-use categories.	Secondary data or biomass and root sampling	For estimating carbon pools and changes with changes in land use. Necessary for carbon models.
SOILS			
Soil Taxonomy (US system preferred)	Area (ha) of the major soil types of the region, soils classified to the great group level, or to the subgroup level if the soils are not too heterogeneous.	Secondary data. As above.	Partially defines the ecological-agro-economic zones.
pH	Area by pH of soils.	Same as above.	Indicates potential soil fertility constraints.
% soil carbon	Area by %C (0-20 cm), by soil type and land use.	Secondary data; it is essential to know the soil type and land use from which the soil was analyzed.	For calculating changes in carbon stocks with changes in land use; also for use in carbon models.
Texture	Area (ha) by surface horizon texture.	Secondary data (directly from soil classification pedon data).	Important for estimating potential erosion. Necessary input for carbon modelling.
Slope	Area (ha and %) found in different slope categories: 0-8 %, 8-30%, >30%, 0-30% and to denote dissected landscapes 0-8>30%; 8-30>30%; and 0-8,8-30,>30%.	Secondary data. Existing GIS and land-use maps.	Provides information for land use and erosion potential.
CLIMATE			
Rainfall	Mean monthly rainfall (mm) from long-term records. If the region contains distinct rainfall regimes they should be reported and given by % or area in each.	Secondary data from meteorological stations.	For defining the growing season and for using in crop and ecosystem (carbon) models.

Temperature	Mean and standard deviation of monthly minimum temperature (°C) and monthly maximum temperature. As with rainfall, if distinct temperature regimes exist in the region they should be reported and given by % area.	Same as above.	Same as above.
DEMOGRAPHIC			
Population size and distribution.	Total population and population densities (people/km²). Population density maps *10 year intervals since 1970.	Census data. Reported on 10 year basis for previous 20 years.	Partially defines the agroecological-economic zones.
Population growth rates and net migratory fluxes	Annual population increases/decreases and percent of increase/decrease due to migration. *10 year intervals.	Secondary data, calculated from above information.	Provides information on the demographic driving forces of deforestation.
INFRASTRUCTURE			
Roads: density and quality	Kms. of roads/area; ratio of paved to unpaved roads. *5 year intervals.	Secondary data. GIS or Ministry of Commerce.	For determining accessibility to markets and potential impact of increased production, accessibility to forests for further deforestation.
Markets	Density of commercial markets. Number of markets/area. *5 year intervals.	Same as above.	Same as above.
ECONOMIC INDICATORS			
Income	Average per capita yearly income in urban and rural areas. *annually for last 10 years.	Secondary data. Census.	Provides a rough indication of the economic development of the area.
Inflation crops, animal products, wood products	Annual rate of inflation, in %. *Annually for last 10 years.	Secondary data. Ministry of Finance.	Indicates stability/instability of the economic environment for farmers.

POLICY INDICATORS			
International trade policies 1. Effective rates of protection: annual crops perennial crops wood products animal products	Tariff rate (%) on each of the major products - by product •annually for last 10 years	Ministry of Agriculture (Forestry)	Indicates whether national agricultural markets are insulated from foreign competition.
International trade policies 2. Export supports for agricultural outputs: (as listed above)	Rate of subsidy (%) for each of the major agricultural exports. •annually for the last 10 years.	Same as above.	Indicates whether farmers have financial incentives to produce for the export market.
Input subsidy policies: fertilizers fuel machinery irrigation	Rate of subsidy for the major inputs. If this information not available provide national prices of the inputs, in US$ equivalent. •Yearly average for the last 10 years	Ministry of Agriculture	Indicates whether farmers have a financial incentive to utilize purchased inputs.
Price support policies: annual crops perennial crops wood products animal products	Average yearly prices received by farmers for each of the major products, US$ equivalent and as % of corresponding world prices. •Yearly average for the last 10 years.	Ministry of Agriculture	Indicates whether farmers have a financial incentive to produce more of a given product. Also indicates stability/instability of the economic environment for farmers.

Policy indicators (continued from table 3 above)

Forest management policies: Determine whether there exist government policies (legislation, regulations, taxes, subsidies) concerning: (i) the clearing of forests/watersheds; (ii) the burning of forests; and (iii) reforestation.

If such policies exist, obtain a copy of the law, of the regulations, and the amounts of taxes and subsidies used. Obtain this information for current policies only; indicate if and how the policies have changed in the last few years.

Justification: This is to determine whether the existing legislation provides incentives to deforest/reforest.

Natural resource management policies: Determine whether there exist government policies (i.e., legislation, regulations, taxes, subsidies) which give farmers incentives/disincentives to better manage/conserve: (i) soil; (ii) forested areas; (iii) wildlife and biodiversity; (iv) watersheds; (v) abandoned/degraded areas; and (vi) carbon stocks (reduce carbon emissions).

If these policies exist, obtain a copy of the law, of the regulations, and the amounts of taxes and subsidies used. Obtain the information on current policies only.

Justification: This is to determine whether existing legislation provides incentives/ disincentives to conserve natural resources for farmers.

SECTION D

PARAMETERS FOR COMMUNITY LEVEL CHARACTERIZATION

The community or village scale is defined as the composite of all the lands that are used by the farmers and forest users in a given community, or by the farmers belonging to a given local community in countries where there are no identifiable villages in the countryside. The boundary thus defined would appear to be diffuse, but it is necessary for this project's teams to demarcate the boundaries clearly on a map so that total areas and position are clearly defined. Within each benchmark area, several (three to ten, depending on the size) communities should be sampled in order to obtain representative information.

The community area characterization is also a responsibility of the national/local teams in collaboration with the international centres when necessary. Many of the data will be available, but at this level more effort will be needed to complete the characterization dataset. Many of the additional data can be obtained by interviews with community officials. At this level, geo-referenced information is again needed. Aerial photographs of the area will be particularly helpful in characterizing land-use patterns.

The unit of sampling will be the local/community level and the frequency of sampling should be annual (whenever possible) since 1970.

Parameters for community characterization are presented in the following tables and questionnaire.

Table 4 Parameters for local/community characterization

TYPE OF DATA	OUTPUT/UNITS *FREQUENCY OF MEASUREMENT	METHOD OR SOURCE OF INFORMATION	JUSTIFICATION
LOCATION	Most of the data needs to be presented in a manner which allows geo-referencing.		
Longitude, latitude, altitude	Boundaries of periphery of community. Topography of area.	Delineated on highest resolution maps of the area or Global Position Locators. Aerial photographs preferred.	To allow integration into GIS database
Total	Area included within the boundaries of the community area.		Defines the boundaries of the community scale.
VEGETATION (LAND USE OR LAND COVER)			
Forest	Area (ha) and biomass (t/ha) and general description of vegetation (forest types and dominant species) *area annually or 5 year intervals since 1970	Secondary data. Existing GIS or from aerial photos or remote sensing. Biomass from secondary data or sampling.	Provides more precise information on rates of deforestation and loss of carbon.
Forest fallow	Area (ha), biomass (t/ha), description of vegetation. *area annually or 5 year intervals	Same as above.	Provides carbon storage and indication of decreasing or stable fallow periods.
Cropland Annual crop Perennial crops (plantations)	Net area and biomass in annual crops, by crop. Area and biomass in perennial crops, by crop. *annually or 5 year intervals	See comments on farm-level survey for net area.	To determine if deforested areas are put into crops or if crop area is converted into other categories.
Grassland	Area, biomass, and stocking rate in natural grassland/pasture and in managed pastures. Description of dominant vegetation. *area annually or 5 year intervals	Same as for other aerial measurements.	To determine if deforested areas are being put into pastures, or if grassland/pasture areas are converted to other categories.

Degraded land	Area and biomass and description of dominant vegetation. *area annually or 5 year intervals	Same as for other aerial measurements.	To determine if degraded areas are increasing or if being put into productive categories.
Clearing and burning	Area (ha) cleared and burned each year and from what vegetation type.	Secondary data or remote sensing. If not available obtain from community officials or aggregate from farm-level surveys.	Provides specific information on deforestation. Necessary for calculating carbon fluxes.
Cropping and fallowing	# of crops before abandonment (specific from which vegetation land was cleared). Crop/fallow ratio. Length of fallow now, 5, 10, and 30 years ago.	Same as above.	Provide information on the current sustainability of shifting agriculture.
Average size and range of holdings and cultivated land.	Hectares of holding and % under cultivation.	Secondary sources or survey data.	Rough economic indicator. Indicates forest area remaining on farms, possibilities for expansion of cultivated area.
Average yields and ranges for: annual crops, perennial crops, animal production.	T/ha by crop, live weight gains, kg/ha. *5 year intervals since 1970	Agricultural Census, Agricultural Extension, previous research and surveys	Indicates if yields are increasing/decreasing and if they are obtaining the yield potential.
Inputs: fuel fertilizers pesticides machinery	% of farmers using each of the inputs. Average quantity used/ha, composition (fertilizers and pesticides). *5 year intervals	Same as above.	Indicates level of agricultural intensity and changes with time.
Pests: weeds, insects, other pests	List of major pests in the area by crop	Same as above.	For reconciling information of pesticide use.

Land tenure	Regulations and opportunities (see attached sheet)	Secondary data or interview of appropriate community officials.	Indicates degree of land security and opportunities for development and agricultural investments
SOILS	This information must be presented by the specific land-use types in which the soil (parameters) are found		
Classification, soil taxonomy to family level	Area of major soil families in the community by land-use type (see categories above) pH, ECEC, %Al saturation, see categories	Soil maps.	Provides information on the relative fertility of soils in different land-use categories.
pH, ECEC, %Al saturation	Area (ha and %), same categories as for regional level.	Soil maps with detailed pedon information.	Indicates area where Al toxicity is a problem.
P adsorption capacity	Area (ha and %) soils with free iron oxide/%clay > 0.15 only required for soils with surface clay >35%.	Previous research or from pedon data for soil taxonomy.	Indicates Fe-P fixing capacity of soil, problems for P availability.
Soil carbon	% C, to 20 cm (or deeper) by the major soil types in each land-use category	Previous research.	Provides information on carbon stocks and changes with land use.
Texture	For surface horizon, same categories as for regional scale, reported by current land-use categories	Soil maps. Previous research.	Indicates potential for erosion.
Slope	Same categories as for regional scale; reported according to current land use and topsoil texture. Or fine resolution topographical maps.	Land-use maps.	Indicates potential for erosion.
CLIMATE	There can be distinct climatic zones within the benchmark areas		
Rainfall and temperature	Same units and frequency as regional data.	Secondary data, from closest meteorological station.	Describes local rainfall patterns, necessary for model simulations.
Evaporation	Mean monthly evaporation, mm water	Same as above, give method. Class A pan evaporation preferred.	
Radiation	Mean monthly hours of direct sunlight (energy units if available MJ/M^2)	Same as above, give method.	

DEMOGRAPHIC			
Age of the village/community	Age in years of village or date of settlement	Local community officials.	Indicates if "frontier" settlement.
Total population	Number and distribution of people within community area. *10 year intervals since 1970	Secondary sources, census data.	Indicates changes in population pressure.
Ethnic composition	% of local population in each ethnic group, including migrants *10 year intervals since 1970	Secondary data. Interviews with appropriate community officials.	Indicates degree of social homogeneity and may be important for explaining differences in land use.
Average household size and range	Number of people per household, average and range.	Secondary data or from interviews with community officials	
INFRASTRUCTURE			
Roads: density and quality	Km and distribution of roads, distinguished as paved or unpaved	Existing maps, Ministry of Commerce *5 year intervals	Prerequisite (constraint) to market integration
Markets	Location/type of markets (frequency: daily, weekly, monthly). Distance to market (type)	Interview with appropriate community officials.	Same as above.
Transport	Availability, frequency, and type (size) of commercial transport from village to market types (#times/week)	Interviews with community officials and farmers	Same as above.
Services			
Extension	Number of offices, agents and distribution	Same as above	Indicates potential and method for transfer of agricultural information
NGOs	Number and kinds	Same as above	Same as above
ECONOMY/POLICY			
Credit	% of farmers who have borrowed money from a bank	Interview with appropriate community officials	Indication of market integration

Land tenure indicators

The following information should be obtained from the appropriate officials in the community:

1. Explain if and how people in the community can buy land.

2. Explain if and how people in the community can rent land.

3. Explain how people in the community obtain the right to use land.

4. Explain if people have titles to the land and if they have the right to sell land.

5. Is the right to buy, rent, sell, or use land the same for migrants to the area and local people? If it is different, please explain how.

6. Are there rights to the use of resources (water, trees, etc.) that differ from the use of land? If so, please explain.

SECTION E

PARAMETERS FOR HOUSEHOLD/FARM LEVEL CHARACTERIZATION

At this scale, parameters are monitored at the level of individual households. These parameters concern all the plots managed by a household, as well as those which are communally managed and used by this household (for example, forested lands and woodlots).

The sample size should be seventy households, spread over two or three different communities. The sampling technique will be decided upon after we hold discussions with the local team of scientists at each slash-and-burn site. At this scale, the data are collected through two individual interviews, conducted with the head of each one of the seventy households. Each head of household is thus interviewed twice. The length of each interview should be at most one hour.

The interviewer contacts the farmers to make an appointment and ascertains his/her willingness to answer our questions. It is made clear to each farmer that we seek their collaboration purely for research activities and not for extension activities. We will not give them fertilizer, seeds, or any other inputs. Their only "reward" is that they will contribute to agricultural progress in the region by helping us understand their problems better, so that our research is made more relevant through their own inputs. Their collaboration will consist of their answering our questions, which will be demanding of their time.

The two interviews are made up of a series of open-ended questions which attempt to get farmers to speak about their perceptions of issues, their motivations, and their reasons for doing what they do. Interviewers need to record *exactly* what the farmers say, without changing the words they use. They also need to ensure that farmers give *all* their reasons for doing what they do. When the farmer stops talking, the interviewer says "Is there another reason?" If the farmer says no, the interviewer reads out loud to the farmer what the farmer has answered so far and asks, "Is it correct then that these are the only reasons?" This also provides a check for the accuracy of the recorded answers. If the farmer gives an answer which does not make sense to the interviewer, the interviewer needs to probe into what the farmer really means.

<u>Interview 1.</u> <u>Household level characterization</u>

Instructions to interviewer: the purpose of this interview is to obtain data on what farmers grow, where they grow it, how they grow it, when they grow it, what they do with the produce, as well as information on their burning strategies and production objectives.

Tell the head of the household at the beginning of the interview, "I would like to ask you some questions about your farming activities and the different kinds of lands you use and how you use them. This is to enable us to better understand your farming practices so that we can research issues which are real problems for you."

Interviewer: Note the location of the farm. This should be done with a Global Position Locator (GPL) or, if this is not available, give the distance of the farm from nearby landmarks, and locate the farm on a topographic map.

Question 1

What is the size of your household (how many people in it)?	What is your age?	Sex of farmer	How many years of formal education/schooling did you have?

Question 2

Can you please tell me what are: (some of this information can be obtained by having the farmer and interviewer together draw a map and transect of the farm, including slopes and soils with the different categories below):

Major types of land uses currently on your farm (including communal lands) [1]	Area covered by each[2]	Whether on a,b,c,d,e, landscape position[3] and soil type[4]	Distance from your dwelling[5]	How do you use the harvested product[6]	What kinds of inputs do you use[7]
ANNUAL CROPS (indicate which)					
GARDENS					
Vegetable (indicate products)					
Home gardens (indicate major products)					
PERENNIAL CROPS (indicate which)					
PASTURE (indicate stocking rate)					
Natural					
Improved					
FOREST					
Natural					
Logged forest					
Extractive (indicate products)					
Plantations					
DEGRADED AREA					
FOREST FALLOW (length of fallow) -					
OTHER					

Footnotes for table

1. In the columns below, specify the major land-use practices on the farm. *Annual crops* include cassava but exclude banana, sugar cane, etc., which belong in the perennials. If mixed (or inter-) cropping is dominant then indicate the two or more crops that are grown on the same piece of land either simultaneously or sequentially, to avoid double counting for the same plot of land. For rice, indicate if upland or paddy rice. *Gardens* are divided into pure vegetable gardens or mixed annual/perennial, or home gardens; *perennials* can be divided into field crops such as banana and sugar cane or tree and shrub crops; for *pastures* indicate the stocking rate (animals/hectare (ha)), improved pasture is defined as those derived from improved grass (or legume) species; *forests* are divided into natural (not used for economic benefits or food), logged (those areas where timber harvest occurs), and extractive (areas where non-timber forest products are harvested). Plantations are planted for timber or other wood products. If the forest areas have multiple uses do not double count but do indicate the multiple uses; *abandoned areas* are those that are no longer productive or managed such as degraded grasslands or shrublands. Fallow areas (forested and non-forested) are those areas which farmers do not cultivate for a few years before cultivating again; include the length of the fallow period.

2. In this column, place the total area that is dedicated to each of the land-use categories. The land areas can be divided into the totals found in each of the major categories (annual crops, forest, pastures, etc.) or can be subdivided into the specific annual crops or type of pasture. The information in the subdivisions is most desired but it must not be larger than the total area in the major category, this could happen if there are crop rotations on the same piece of land or multipurpose forest areas (timber and non-wood products (see explanation in footnote above).

3. Refers to both the position on the catena and the drainage. Categories include: a) well-drained uplands, b) slopes, c) alluvial soils (temporary or seasonal inundation), d) permanently waterlogged (lowland) areas, e) intermittently waterlogged areas (inland valleys).

4. Soil type refers to the relative fertility of the soils—acid infertile or fertile; if farmers have more information, the local names of the soils should be indicated.

5. Distance from the dwelling should be in kilometres; also indicate if the plots are on the same piece of land or scattered around the community. If possible, draw a sketch of the household lands, showing the location of the dwellings/houses, relative to the different types of areas used by the household.

6. "Use" refers to the destination of the products obtained from the different land-use categories, such as: consumed by the household, exchanged or bartered, stored, or sold or given away to friends/relatives.

7. Inputs refer only to purchased inputs: fertilizers, pesticides, seeds and seedlings, hired labor, and machinery and tools. If the farmer can tell you how much of each input he/she uses, so much the better. Indicate the kinds of machines and tools used.

Question 3

Can you please explain to me why you cultivate the crops you have just told me about? What are you trying to accomplish with these crops? Are the yields you are getting satisfactory for you, do they enable you to accomplish what you want? If not, can you tell me why?

Question 4

Can you please explain to me why you have cattle/goats (or whatever animals the farmer has)? What are you trying to accomplish with these animals? Are you able to accomplish these things? If not, can you tell me why?

Question 5

Can you please explain why you collect fruits/wood products from the forest? What are you trying to accomplish with these fruits and wood products? Are you able to achieve your objectives? If not, can you tell me why?

Question 6

Can you please explain why you use the forest for ... {interviewer: this is for farmers who said they use forested areas for purposes other than fruit and wood collection, such as hunting}? What are you trying to accomplish with ... ? Are you able to actually fulfil your objectives? If not, can you tell me why?

Question 7

How large an area do you clear and burn every year? How do you select the area? Can you explain to me why you clear and burn every year? Can you tell me what kind of vegetation (type, age) you normally clear and burn? How do you burn, by stacking or spreading the vegetation?

Question 8

For how many years after clearing do you use an area for crops or pastures? What happens after that, do you fallow the area for a while, or do you abandon it? Can you explain to me why?

Question 9 (This is a question and also should be an observation by the interviewer.)

Is there erosion on your farm? If so, in what fields do you observe erosion? During which part of the year do you observe erosion? Is the erosion associated with any particular cropping system or rotation? Do you think that the erosion is affecting your crop or pasture productivity? Do you think that erosion is a problem on your farm?

Interviewer: As you walk around the farm, make a note of any signs of erosion. Note the type of land use, slope, vegetative cover, and the type of erosion (slight to moderate rill erosion, slight to moderate sheet erosion, slight, moderate, or severe gully erosion).

Question 10

Can you please explain to me what you and your household do at different times of the year?

Month of the year	Description of activities (farming, livestock, non-farming) undertaken by household members
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

Interviewer: At the end of the interview, thank the farmer for his/her time and willingness to contribute to our research. You might also mention that you will be back for a second interview.

Interview 2 Household level characterization

Instructions to interviewer: the purpose of this second interview is to obtain data on each household's income, spending, production of surplus (of food or cash), and on each of the priorities and production objectives of the head of the household.

At the beginning of the interview, tell the head of the household, "Today I would like to ask you some additional questions about the results of your farming/livestock activities. This is to enable us to better understand the circumstances in which you farm, so that our research work can better address your problems."

Question 1

Please tell me whether in the last year you produced on your land, and harvested from the forest, enough food to feed your family to your satisfaction. If not, please explain to me what happened and what you did.

Question 2

Were you able to buy enough food last year to feed your family to your satisfaction? If not, can you please explain to me what happened and what you did.

Question 3

What is the proportion of your family's total cash income which is spent buying food for your family in any normal year? (Use percentages or simple fractions, or whatever the farmer can relate to best.)

Question 4

Do you or anybody in your household earn money from non-farming activities? If so, can you please explain what activity and whether it is a regular activity? What is the proportion of your family's total cash income which comes from non-farming activities?

Question 5

Can you please try to think of the various things you buy in a normal year for yourself and your family? Can you explain what these different things are (food, farming inputs, school fees for the children, clothing, and so on)?

Question 6

In a normal year, once you pay for the food needs of your household, as well as for their basic needs (such as taxes, medicine, transport, and house repairs), do you have any cash left? If so, what do you normally do with it?

Question 7

In a normal year, do you generally have any unused storage food/produce left at the end of the year? If so, please explain what this is.

Question 8

Imagine that last year you produced enough to feed your family well and to pay for all the basic necessities (such as taxes and school fees), and that you are now left with a small surplus of cash. Please describe and explain how you would use this small surplus.

Question 9

What if it is a medium surplus? How would you use it? And why?

Question 10

Now, if it is a large surplus, what would you do with it? And why?

Question 11

Under which specific circumstances would you decide to expand your agricultural activities:

- By using more land and growing more crops/having more animals
- By using better tools or machinery to save on labour and increase yields
- By buying more fertilizer/pesticides to increase yields
- By hiring more labour to work on your land.

In each case, please explain why.

Question 12

Have you ever obtained credit from a bank?

Question 13

Can you please tell me, in a normal year, how many hours per day and how many days per week you spend engaged in the following activities:

Activity	*Wet season*		*Dry season*	
	hours/day	*days/week*	*hours/day*	*days/week*
Farming activities				
Relaxing/resting				
Religious/social activities				
Non-farming, cash-earning activities				

Question 14

Can you please explain how you obtained all the lands which your household is using?

Question 15

Can you please explain whether you are paying rent, in cash or in kind, for any of these lands? Please explain how it is done.

Question 16

If you wanted to, could you sell any of the lands you are using? Please explain why or why not.

Question 17

If you needed more land, how would you get it?

Question 18

How far is your dwelling from the nearest:

	Distance in kilometres	*Distance in time*
Medical centre		
School		
Bank		
Market		

Question 19

Are you regularly visited by, or do you regularly go and see, an agricultural extension officer? Please explain why or why not.

Question 20

Can any of your children inherit your lands from you? Please explain why or why not.

Question 21

Would you like all, or at least one of your children, to be a farmer here? Can you please tell me why or why not?

Interviewer: At the end of the interview, thank the farmer for his/her contribution to our research.

PART III

DIAGNOSIS AT HOUSEHOLD LEVEL

The purpose of this diagnosis is to develop an understanding of farmers' problems in the context of the agroecosystem and farming system within which they farm. As mentioned earlier in this protocol, this understanding will lead to a quantification of constraints *and* resources, and to the identification of bottlenecks and leverage points in the system. It is an essential step in the whole research process, where data are collected to generate a full understanding of the functioning of our target land-use systems and farming systems. It is at this stage that researchers learn how and why farmers make decisions (concerning fallows, forest burning, and so on) and understand the dynamics of slash-and-burn systems. Such an understanding is a key to the development of appropriate alternatives to slash-and-burn.

Diagnosis is conducted by a multi-disciplinary team of researchers, in participation with the farmers included in the sample (see below). The researchers will need to invest a large part of their time in interactions/discussions with these farmers. This is not adaptive, but strategic research, where on-farm experimentation (see below) is used as an analytical tool: researchers observe and monitor what farmers do and discuss with them why they do it.

Using a smaller sample than for the household level characterization (forty instead of seventy), stratified to be representative of the general farmers' population in the area, diagnosis involves the following principal activities:

(i) Identify (through observations) and monitor farmers' management practices concerning: pests, water, soil, forest management, crop management, and fallow management.

(ii) Supplement (i) by individual farmer interviews to elucidate the reasons for these practices, farmers' perceptions of problems, and farmers' decision-making processes. Obtain, through interviews, an understanding of the changes over time of farmers' forest management and fallow management strategies, as well as an understanding of the reasons for these changes.

(iii) Set up trials, on farmers' fields and under their management, to measure yields of annuals, perennials, animals, and yield losses due to pest/weed infestation, low soil fertility, limiting nutrients, and so on.

(iv) Monitor inputs used and costs and benefits of major agricultural activities.

The specific methods which can be used to carry out these activities will be discussed with the teams at each slash-and-burn site.

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