ALTERNATIVES TO SLASH & BURN

A Global Strategy

Special Project for Presentation to the
Global Steering Group (GSG)

prepared by:

International Center for Research in Agroforestry - ICRAF

International Fertilizer Development Center - IFDC

International Institute for Tropical Agriculture - IITA

International Rice Research Institute - IRRI

Tropical Soil Biology and Fertility Programme - TSBF

Centro Internacional de Agricultura Tropical - CIAT

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EXECUTIVE SUMMARY

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

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

The proposed mode of operation is 1) a joint strategic research effort of CIAT, IITA, ICRAF, IFDC, IRRI and TSBF at selected benchmark sites on socioeconomic and biophysical aspects of Slash and Burn in partnership with national research institutes and non-governmental organizations, 2) validating, testing and disseminating options via regional networks, involving public/private organizations and effective policy dialogues in each collaborating country 3) extrapolation of the global change implications by making the research results available to IGBP-related programs and 4) training and institution-strengthening to enhance the capacity of the deforesting nations to build a sustained effort to alleviate the crisis.

Selected benchmark sites, two or three per continent, will be selected to encompass the range of biophysical and socioeconomic conditions in the humid tropics. In Africa, one site will be in the equatorial Congo rainforest which is a zone of rapid demography, social and environmental change and one will be in the dystrophic Miombo woodlands, where Chitemene is practised. In Latin America, two sites in the Amazon are proposed, one in semideciduous evergreen rainforests with rapid development, and another in a typical rainforest with poor infrastructure and migration from the Andean region. A third site in Mexico will be considered. In Asia, one site is envisioned in the equatorial rainforests, where both primary forest clearing and degraded alang-alang grasslands are abundant, another in the tropical monsoonal

region, and a third in the hill country of mainland Southeast Asia in an area of extremely rapid deforestation and rapidly eroding slopes.

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

1. FOREWORD

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

Sequentially the First Global Workshop on Alternatives to Slash and Burn, financed by UNDP, was held at Porto Velho, Rondonia, Brasil from 16-21 February 1992 to determine the feasibility of developing a global, coordinated effort on alternatives to slash and burn agriculture in tropical rainforest areas. Participants consisted of 26 environmental policy makers and research leaders from 8 tropical countries and representatives from 5 non-governmental organizations, 6 international research centres, 3 regional research organizations and 6 donor agencies. The major conclusions were:

- A global effort is needed
- Approach for planning and implementing the program will be collaborative
- Emphasize socio-economic policy and biophysical issues
- Focus on broad global issues as well as those of specific regional concerns
- Eight locations were selected as ecoregional benchmark sites
- Creation of a Global Steering Group (GSG) to ensure continuity and global coordination
- Requested ICRAF to continue to play the overall coordinating role.

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

2. THE PROBLEM

2.1. Characteristics of Slash and Burn

Slash and burn (or shifting cultivation), the traditional farming system over large areas of the humid tropics for centuries, still remains the dominant land use practice in about

30% of the arable soils of the world and provides sustenance for an estimated 250 million of the world's poorest people and additional millions of migrants from other regions (1)1.

Throughout the world, traditional shifting cultivation practice are remarkably similar. Small forested areas are cleared by axe and machete during periods of least rainfall and are burned shortly before the first rains. Without further removal of debris, crops such as corn, rice, beans, cassava, yams, and plantains are planted in holes dug with a planting stick or in mounds for root crops in Africa. Intercropping is very common, and manual weeding is practised. After the first or second harvest the fields are abandoned to rapid forest regrowth. The secondary fallow may grow for 10 a 20 years before it is cut again (2,3).

Traditional shifting cultivation is based on nutrient cycling and weed and pest suppression during the fallow period. In regards to nutrient cycling burning releases to the soil about half of the nitrogen and phosphorus of the burning biomass, and practically all of the other nutrients in the from of ash which also causes a liming effect. Higher soil temperature following burning also accelerates oil organic matter decomposition. These factors provide high nutrient availability for one or two years to grow food crops, depending on the native fertility status of the soil (4,5,6). Burning also helps to control pests and diseases and enables cultivators to clear land quickly and efficiently with minimal labour requirements. (Alternative forms of clearing land are usually too expensive and labour-intensive, especially for poor farmer). As nutrients are removed by crop harvests or lost to leaching, overall fertility declines. Nutrient deficiencies as well as increasing weed pressure impede further cropping, and the fields are abandoned to a secondary forest fallow. The secondary forest grows rapidly, tapping nutrients remaining in the soil, including those released slowly by unburned decomposing forest biomass, accumulating them above ground for 10 to 20 years, until the cycle begins again (2,7).

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

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

The fallow period therefore does not improve soil fertility per se. Except for some reaccumulation of carbon in the soil organic matter and fixation of atmospheric

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

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

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

Soil erosion is seldom a significant problem in traditional shifting cultivation, because the land area is relatively small and is always covered by some sort of vegetative cover such as fallen logs, crops, weeds or forest fallows. When shifting cultivation is practised by newcomers to the humid tropics, the land is often devoid of soil cover for considerable time. This can lead to major erosion and siltation of rivers, particularly in hilly areas (6).

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

As the time available for secondary forest fallow growth decreases, the fertility and productivity of the soils, which are mostly low, continue to decline. Furthermore, when the fallow period is shortened, it generates a disequilibrium of carbon input-output ratios and intensifies nutrient mining. Complex and often adverse ecological changes occur, such as invasion of Imperata grasslands and reductions in the number of native seeds left viable for regrowth. Re-establishment of secondary forest fallow

vegetation is slowed or stopped, some soil becomes bare, and erosion begins. This situation is typified by the so-called "derived savannas", which occupy more than three-fourths of the previously tropical moist forest of West Africa. In turn, these declines in productivity contribute to increasing economic hardship and impoverishment for shifting agriculture under conditions of disequilibrium. Moreover, people in these situations tend to lack access to alternative economic opportunities, are isolated from development programs and, in some areas, are marginalized further from the expansion of large-scale producers such as cattle ranchers. The trends towards expansion of the cropping cycle and a decrease in the fallow period are central to the problem of non-sustainable production. They are also the key trends affecting the contribution of slash and burn to global warming. In particular the net reduction in soil organic matter and plant biomass through intensification and modification of traditional systems are the main mechanisms by which slash and burn is, if anything, increasingly contributing to the greenhouse effect. The two problems, and their solution, go hand in hand.

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

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

2.2 Environmental Context

Recent estimates indicate that about 18% of global warming is due to the clearing of tropical rainforests, which is occurring now at a rate of 14 million hectares of primary forest per year (22). Most of the deforestation is presently occurring in tropical America and tropical Asia, accounting for 40 and 37% respectively of estimated net carbon emissions from deforestation in 1980. Tropical Africa ranks third, with 23% of the emissions (24). Deforestation rates have almost doubled during the last decade: from 7.6 million hectares per year in 1979 to 13.9 million hectares per year in 1989 (25). Deforestation from slash and burn agriculture in disequilibrium can lead to several negative environmental consequences, including erosion and degradation, leaching, watershed degradation, and loss of biodiversity. These repercussions at the local level

signify resource depletion and declines in production. In addition, diverse forest products are greatly underutilized. At a wider level, the loss of forest cover also contributes to changes in rainfall patterns and climate change.

After deforestation, soil organic matter may act as an additional source of carbon dioxide to the atmosphere or as a sink where carbon dioxide may be sequestered depending on how the land is managed. There is little reliable quantitative knowledge about fluxes of carbon dioxide, nitrous oxides or methane due to shifting agriculture. Hard data from well-replicated experiments and surveys are needed to determine the current extent of slash and burn agriculture, the process of change in land use and the extend and nature of the environmental impact of these systems. The contribution of tropical land use to global change is one of the uncertainties in current models (24).

Although every country with humid tropics is undergoing deforestation of primary forests, 12 countries account for over 80% of the total. They are:

Country	Annual Deforestation (1000's ha/year)	Rate (%/year)	CO_2 emitted (Million tonnes C/yr)
1. Brasil	5000	2.1	46
2. Indonesia	1200	1.4	12
3. Myanmar	800	3.3	8
4. Mexico	700	4.2	6
5. Colombia	650	2.3	6
6. Thailand	600	8.4	6
7. Malaysia	480	3.1	5
8. Zaire	400	0.4	5
9. India	400	2.4	4
10. Nigeria	350	14.3	6
11. Peru	350	0.7	3
12. Vietnam	350	5.8	3
World Total	13860	1.8	140

Source: 25. Estimates for 1989.

Deforestation rates are expected to increase in the next decades and the overall contribution to global warming is expected to equal or exceed that of fossil fuel combustion by the second or third decade of the 21st century. If this trend continues,

much of the remaining tropical forest will be gone by the end of the 21st century. Deforestation is also decimating the world's largest depository of plant and animal genetic diversity (25). Recent discoveries of rainforest plants as new sources of food, or as ingredients in chemotherapy for certain types of cancer, underscore the need to preserve rainforest biodiversity. Therefore, finding practical ways to preserve tropical rainforests in one of the principal global environmental concerns of our times.

2.3 Socio-economic, policy and Equity Context

Tropical deforestation by slash and burn is also a major human equity concern, because slash and burn is largely practised by the poorest, largely displaced rural populations of the tropics. Moreover poor people usually bear the main costs of environmental degradation. The process of deforestation is driven by a complex set of demographic, biological, social, geopolitical and economic, forces as well as policy pressures (27). Population growth in developing countries continues at a high rate, while most of the fertile and accessible lands are already intensively utilized.

A variety of governmental policies often exacerbate and contribute to resource degradation, land scarcity, and inappropriate land uses. For example, land use policies allow gross inequities in land tenure. These factors result in an increasing landless rural population that essentially has three choices: stagnate in place, migrate to the cities, or migrate to the rainforests that constitute the frontier of many developing countries. Similarly, land tenure policies often do not enable people to have secure title to land, which may discourage producers from adopting methods that are sustainable in the long term. Although urban migrations are spontaneous, national policies in key countries include colonization programs which encourage the occupation of their tropical rainforests, notably Brasil, Peru and Indonesia often motivated by geo-political reasons.

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

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

Migration to the cities in search of a better life results in bitter disappointments, and coupled with limited urban infrastructure, produces unmanageable cities with populations far exceeding their carrying capacity and infrastructure.

People migrating to the humid tropics seldom find a cornucopia. The equilibrium of traditional shifting cultivation, with is long forest fallows, is broken by the migrants, and is some countries by land speculators as well. The result is shifting cultivation in disequilibrium, which quickly turns into various forms of unsustainable agriculture. Traditional societies are disrupted, economic failures abound, and migration to urban centers increases.

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

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

2.4 Responses

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

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

Moreover, existing institutions undertaking research and extension in this area tend to lack coordination. There is a lack of direct involvement of non-government organizations and farmers groups in the research and development activities. In many cases, the model of technology transfer has failed to have an impact in a "top-down" mode of diffusion. Duplication of efforts also occurs. These constraints need to be overcome through coordinated and comprehensive research and actions. Lessons

can be learned from both the weaknesses and successes of previous efforts, but there is still a great deal of work to be done to alleviate the problems.

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

3. CURRENT STATUS

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

3.1. Technologies

Research of shifting cultivation has been conducted since the 1920s in Africa on replacement of Chitemene nutrients from sources other than burning. The work in the 1950s by Jurion and Henry (8) in Zaire, and of Nye and Greenland (2) in Ghana are widely known. The anthropological basis of shifting cultivator cultures have been widely studied in Asia, Africa and Latin America. Agronomic research on a long-term basis has been conducted since the 1970's primarily, but not exclusively, by four groups: at Yurimaguas, Peru and Manaus, Brasil by North Carolina State University (9, 10, 11, 12); at Ibadan, Nigeria by IITA (13, 14, 15); in northeast India by Ramakhrishnam and associates (16, 17, 18); and Sumatra by AARD and associated institutions (19, 20, 21). These efforts have provided several kinds of information:

- They have quantified the nutrient transfer process from biomass to ash and into soil, and monitored the changes in soil properties upon cropping.

- Analysis of the dynamics of soil organic matter have shown that judicious management of inputs, vegetation cover and harvest residue can result in a sustained level of soil organic matter (SOM).

- They have determined that bulldozer clearing is inferior to traditional slash and burn in providing suitable physical and chemical soil properties for planting of food and tree crops. Detrimental effects of bulldozer clearing include topsoil carryover, soil compaction and the absence of ash as a nutrient-transfer process. Several major colonization projects are no longer based on bulldozer land clearing.

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

- They have also determined that crop rotations allows crops to be grown continuously with judicious use of lime, fertilizer and green manures, producing sustainable yields in well managed systems. With poor management,

however,attempts of continuous production have resulted in sharp drops in productivity, soil compaction and erosion even in flat areas.

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

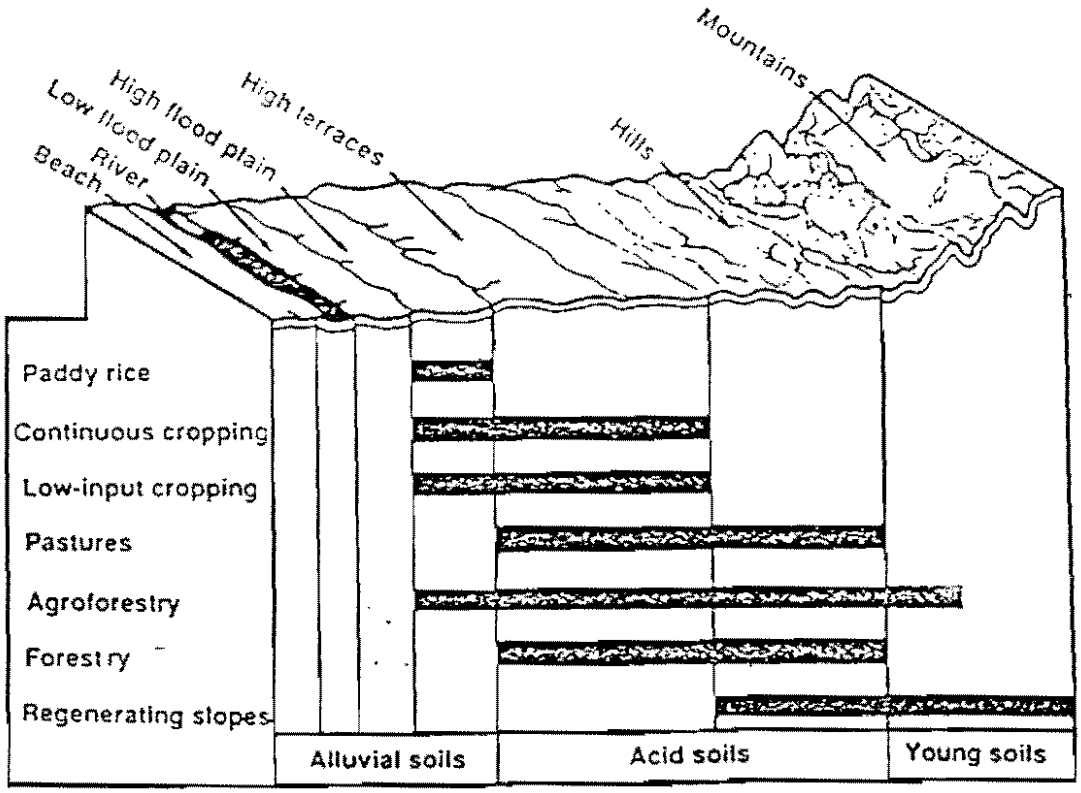
- Keeping the soil surface covered at all times is a key principle for sustainability in the humid tropics. Soil erosion can be controlled with the use of agroforestry systems, including alley-cropping on slopes, live fences in pastures, annual crop-tree crop systems, and managed forest fallows. The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

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

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

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

Sustainable management options for acid soils of the humid tropics have been developed to fit different landscape positions, soils and levels of socioeconomic infrastructure development (26). For instance, the principal sustainable management options and alternatives to slash and burn for one region, the Selva Baja of Peru are: paddy rice production of alluvial soils, low input cropping, continuous cultivation, legume-based pastures, agroforestry, perennial crop production (rubber, oil palm) and plantation forestry. Their place in the landscape is shown as follows:



Nutrient recycling must be enhanced in all systems in order to minimize the need for external nutrient inputs and maximize their efficiency. The management of crop and root residues is crucial in this regard (29). Approaches proposed by TSBF on quantifying the nutrient release of organic input and the management of soil organic carbon, nitrogen and phosphorus are major components of low-input cropping, agroforestry and pastures research. The promising results in predicting the rate of nutrients released from leguminous materials based on their polyphenolic contents (31) provide for the first time an opportunity for the quantitative management of organic input in a manner comparable to the management of chemical fertilizers.

However, even in situations where nutrient cycling is possible on a significant scale, it is necessary to employ supplemental fertilizer in order to maintain productivity. Research conducted by IFDC in Africa has shown that judicious use of fertilizers in combination with a program of crop residue management is superior to 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, five to ten hectares per year of tropical rainforests will be saved from the shifting cultivator's axe, because of their higher productivity. Estimates at Yurimaguas, Peru for various management options are given below (27). These estimates will vary with climate and soils.

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

Furthermore research must also focus upstream, more process-orientated to better understand the "why" questions and focus beyond the "whats" listed in the preceding section. In particular, there is need to understand the processes that link agricultural and forestry management of these ecosystems to sustainable conservation of the surrounding environment. In addition, socio-economic research should address the "how" will farmers adopt/adjust new technologies, "how" will farmers and communities make decisions on short term gain versus long-term resource conservation, and "how" do new technologies affect farmer decisions on forest clearance. Finally, research efforts should be more inclusive, with greater participation of NARS, NGO's, and advanced developed country institutions and should be effectively linked with the global climatic change community (44) and biodiversity, aiming at a common research agenda.

3.2. Policy

None of these technologies, however, is likely to be used without significant policy changes that provide adequate market and infrastructure development and at the same time protect the remaining rainforests from being cut. Deforestation is a relatively new field in the policy sciences, but some of its underpinnings are beginning

to emerge. Analysts in this field generally cite six or seven major policies to decrease tropical deforestation. These are:

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

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

Linking environmentally oriented strategies with economic ones provides a practical, realistic approach. New efforts in this direction are beginning to emerge (44, 46) and have resulted in lively dialogues. A few deforesting countries have developed policies to contain deforestation primarily in response to national and international environmentalist pressures. Some of them are far too radical to be workable and in some cases backfire, with severe negative effects on the economy and trigger increasing deforestation in neighbouring countries.

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

3.3. Guiding Principle

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

This can be done by:

- Providing sustainable alternatives to slash and burn, and
- Reclaim and manage abandoned and degraded lands that are declining in productivity, including secondary forest fallows and unproductive grasslands.

- Address policy factors which affect slash and burn agriculture and the adoption of alternatives.

Land-use management options are urgently needed that improve the economic status of subsistence farmers, maintain agricultural productivity on deforested lands and recuperate productivity of degraded lands. Such options will provide sustainable development of the forest margins in a way that satisfies human needs and preserves the ecosystem. These options must be compatible with the different socioeconomic needs of specifics areas so that they are readily and widely adopted. In addition we should be concerned with how and why deforestation occurs, how the people living in and around forests are affected by deforestation processes, how they react individually and collectively, and what role is 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 and regional). In this context, the agroecological foundations of sustainable agriculture will be established, as a basis to develop biologically-based management systems.

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

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

4. PROJECT PURPOSE

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

4.1 GOAL

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

4.2 Objectives

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

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

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

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

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

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

4.3 Target Areas

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

4.4 Time Frame

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

4.5 Biophysical Research Agenda

4.5.1 Objective 1 To assess the biophysical processes leading to deforestation, and its environmental implications.

- Activity 1 Characterize the biophysical environment of the target areas.

This activity will be undertaken at each of the proposed study areas, and will include the collection and collation of existing information on climate, soils, vegetation and the principal land use systems associated with slash and burn agriculture. Specific emphasis will be given to an analysis of conditions under which farmers have already started to modify slash and burn systems and intensify land use. Such information will be derived from prior studies at both the land use system level and more specific reviews of farms within these land use systems.

Activity 2 - Regional and Global information synthesis

Using outputs from Activity 1, and from activities of the Socioeconomic and Policy Research Agenda, Objectives 1, a regional, geographically referenced data base will be developed with the purpose of synthesizing regional information and identifying key socioeconomical and biophysical determinants and processes leading to slash and burn agriculture and deforestation. The regional GIS data base will provide the global framework under which the research will be conducted and have potential impact.

4.5.2 Objective 2. Identify and evaluate, at the global level, land use systems that are environmentally sound, and at the local level, economically viable and socially acceptable.

Activity I Develop criteria for evaluating the relative sustainability of existing land use systems.

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

Activity 2 Development of a global and geographically referenced data base of existing land use systems which present viable and sustainable alternatives to slash and burn agriculture.

Based on the information gathered at the regional level and synthesized at the global level under Objective I, and utilizing the sustainability criteria, potential alternatives to slash and burn agriculture will be identified and documented in a geographically referenced data base. This data base will provide a global reference point for the sharing and transfer of information for regional and local research initiatives, and the potential relevance and introduction of new alternatives.

Activity 3 Identification of priority recommendation domains for the targeting of on-station and on-farm research.

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

Activity 4 Evaluation of existing candidate systems in specific ecoregions and their sustainability.

At each study area, candidate systems will be evaluated under field conditions in priority recommendation domains, and their relative sustainability will be determined

utilizing the sustainability criteria developed under Activity i. Such evaluations may occur both on-station, or where appropriate, in farmers' fields and will include systems currently practised in the study area and sustainable systems practised in other ecoregions but of potential relevance to new situations.

4.5.3 Objective 3 To further develop land use systems that are economically viable, socially acceptable and environmentally sound alternatives to current slash and burn, and associated land use systems.

Activity I Conduct strategic interdisciplinary research to evaluate improved technology components and their interactions, and to better understand the principles governing their function.

Based on the perceptions and aspirations of farmers in priority recommendation domains, and the biophysical and socio-economic factors affecting their decision-making processes, key interventions for the improvement of components will be identified. The potential of such improvements to contribute to enhanced system sustainability and productivity, and the principles governing their function will be evaluated through strategic process orientated on-station research. Such research is essential to provide the basic understanding required to predict performance and impact of improved technology over a wider range of environments. Such studies may include agroforestry and/or legume based systems with specific studies on components and processes such as nutrient cycling, crop and soil organic matter management, weed dynamics and management, multi-purpose tree improvement and management, and resource sharing or competition for light, water and nutrients.

Activity 2 Conduct on-station and on-farm assessment of crop based and tree based systems incorporating improved component technologies.

Strategic research on improved components and their interactions will generate information which allows the design of improved and/or new production systems. These systems must be evaluated on a long-term basis and their productivity, sustainability, environmental soundness and social acceptability will be monitored and assessed. Such research will be undertaken both on-station, where the emphasis will be on biophysical monitoring, and on-farm where the focus will be on assessing the social acceptability, potentials and constraints to adoption. This on-station and on-farm research will provide a sound framework for studies on the emission of greenhouse gases, land degradation, and identifying policy interventions which would enhance both the adoption and sustainability of improved alternatives to slash and burn agriculture.

4.5.4 Objective 4 To quantify the contribution of slash and burn, and associated land-use systems, to major features of global change, such as loss of biodiversity, emission of greenhouse gases and soil degradation (to be conducted in collaboration with GCTE).

Activity 1 Provide a framework for the study of the impacts of slash and burn on biodiversity.

This project would provide a framework, through support facilities and staff, for GCTE to undertake research on the impact of land-use change, through slash and burn agriculture, on biodiversity. GCTE's approach is first to investigate the implications of loss of biodiversity on ecosystem function (nutrient cycling, carbon fluxes, etc.). Then, studies of the interactive effects of global change, particularly land-use change, on biodiversity and ecosystem function will be undertaken. GCTE's program will also emphasize research on the viability of isolated populations. This is particular appropriate for slash and burn since this activity normally leaves forest remnants of various sizes and configurations.

Activity 2 Provide a framework for quantification of green house gas emissions from slash and burn and associated land-use systems.

As part of it's effort to determine the effects of land clearing and agricultural intensification on quantities and pathways of carbon and nutrient loss (and their regulation) in the humid tropics, GCTE will measure emission of greenhouse gases (CO2, CH4, N2O) to the atmosphere, from slash and burn and associated land-use systems. Emission-controlling processes, such as the effects of cattle grazing on soil structure and the effects of an altered microclimate following land clearing on fire frequency and on litter decomposition in residual forest fragments will be quantified; associated microbial processes will also be measured. The work on emission of greenhouse gases to the atmosphere will be undertaken in collaboration with the IGBP International Global Atmospheric Chemistry (IGAC) Core Project, with this project providing well characterised sites and support facilities, where appropriate.

Activity 3 Quantify changes in soil quality in slash and burn and associated land-use systems, including changes in soil organic carbon balances and related nutrient changes and erosion.

One of the major aims of this project is to determine the extent and type of soil degradation associated with slash and burn practices. Particular emphasis will be placed on understanding the dynamics of soil organic matter and the cycling of nutrients, particulary nitrogen and phosphorus, through the system. The key issue in the latter is to determine the quantities and pathways of nutrient loss from the system. Another important aspect of soil degradation that will be studied is the physical loss of soil material through hydrological pathways and by water erosion. GCTE can add a further global change component to this work by investigating soil organic matter dynamics under elevated CO2 and by determining soil erosion potentials under altered rainfall regimes

4.6 Socio-economic and Policy Research Agenda

4.6.1 Objective 1 - To assess and prepare diagnosis of the socioeconomic factors, and the policy environments which affect decision making processes leading to slash and burn and deforestation.

Activity 1 To collect, collate, and organize existing information on socioeconomic and cultural factors that affect farmer's decisions and behaviour towards slash and burn and deforestation. At the macro level, information on infrastructure, markets, land tenure, land use regulations, and other policies affecting slash and burn and deforestation will be collected.

Activity 2 To conduct farmer participatory surveys and investigations to collect micro-level information and understand the nature of the socioeconomic, cultural, and policy constraints or incentives that farmers have and/or perceive as determinants of the practice of slash and burn and deforestation.

These activities will be fully integrated with similar activities established as part of the biophysical research agenda to characterize the biophysical environment and processes leading to slash and burn and deforestation in the target areas (Activity 1 of Objective 1 in Biophysical Research Agenda).

4.6.2 Objective 2 To design and evaluate policy alternatives to eliminate or reduce the practice of slash and burn and deforestation, promote the establishment of sustainable agriculture, and protect the environment.

Activity 1 To study assessments and diagnoses of socioeconomic/cultural factors and the policy environment (Objective 1) to design policy alternatives that can be established to reduce or eliminate slash and burn and deforestation.

Activity 2 Socioeconomic evaluation of the most promising technically feasible and environmentally sound sustainable land use alternatives to slash and burn.

Activity 3 Evaluation of policy alternatives to reduce or eliminate slash and burn and deforestation in terms of their impact on economic efficiency, equity, growth, and the conservation of the resource base and environment.

4.6.3 Objective 3 Development of methodologies and tools for policy evaluation to facilitate decision making process for the implementation of policy alternatives.

Activity 1 Design methodologies to assess the potential impact of policy alternatives on economic efficiency, equity, growth, and conservation of the resource base and environment.

Activity 2 Develop and test in case studies computer programs that can be used to evaluate policy alternatives for policy decision.

4.6.4 Objective 4 Identification and adaptation of successful policy experiences from other countries and locations to the circumstances that characterize the project areas where slash and burn is practised and field research is conducted.

Activity 1 Review of literature and investigation to identify successful policy experiences that have potential to be adapted to the circumstances where field research is conducted.

Activity 2 Adaptation and validation of successful policy experiences.

4.6.5 Objective 5 Assessment of the policy decision making processes and identification of critical intervention points and means to promote implementation of policy alternatives.

Activity 1 To obtain information about mechanisms used in selected countries to make decisions on the implementation of policy alternatives.

Activity 2 Evaluation of decision making processes to determine strategies for interventions that can facilitate the implementation of policy alternatives.

4.6.6 Research Approach - In order to maintain the holistic nature of the project, and to keep the multiplicity of issues and linkages in perspective, the following procedural mechanisms will be adopted for conducting policy research:

- Factors and policies will be considered at the local, regional, national, and international levels.
- Research will be conducted as much as possible with the participation of the farmers.
- Policy research will be conducted in continuous interaction with the biophysical research aimed at technology development.
- A multidisplinary approach will be used in the implementation of research activities.
- Consideration will be given to intersectorial and intrasectorial linkages and to the relationships among on-site and off-site factors.

Important items to be included in the specific and more focused policy research are:

- Fiscal policies (taxes, subsidies, etc)
- Trade and market policies (imports and exports regulations and taxes)
- Monetary policies (credit, interest rates)
- Organization policies (farmer's associations and participation, NGOs)
- Tenure and property rights policies (land, trees, water, biodiversity)
- Regulatory policies (regulations on use of land and natural resources)
- Processing and marketing (agricultural products and inputs)
- Services (extension, transport, education, health, communications)
- Population growth and related policy issues
- Gender and family issues

- International institutions (development organizations, donors, etc)
- Indigenous cultural/rights issues
- Valuation of environmental benefits/costs
- Off-the land alternatives for economic activity and employment
- Labour and employment issues

The matrix presented in Table _ shows the levels at which socioeconomic and policy research activities will be conducted to achieve the objectives of the project.

Matrix of Policy Research Objectives and Levels of Analyses

Objectives	Levels of Analyses			
	Global	National	Regional	Local
1. To assess and prepare diagnosis of the socioeconomic and cultural factors and the policy environment affecting decision making processes leading to slash and burn and deforestation.				
2. To design and evaluate policy alternatives to eliminate or reduce the practice of slash and burn and deforestation, promote the establishment of sustainable agriculture, and protect the environment.		x	x	x
3. Development of methodologies and tools for policy evaluation to facilitate decision making process for the implementation of policy alternatives.	x	x	x	x
4. Identification and adaptation of successful policy experiences from other countries and locations to the circumstances that characterize the areas where slash and burn is practised and field research is conducted.	x	x	x	x
5. Assessment of the policy decision making processes and identification of critical intervention points and means to promote implementation of policy alternatives.	x	x	x	x

5. OPERATIONAL FRAMEWORK

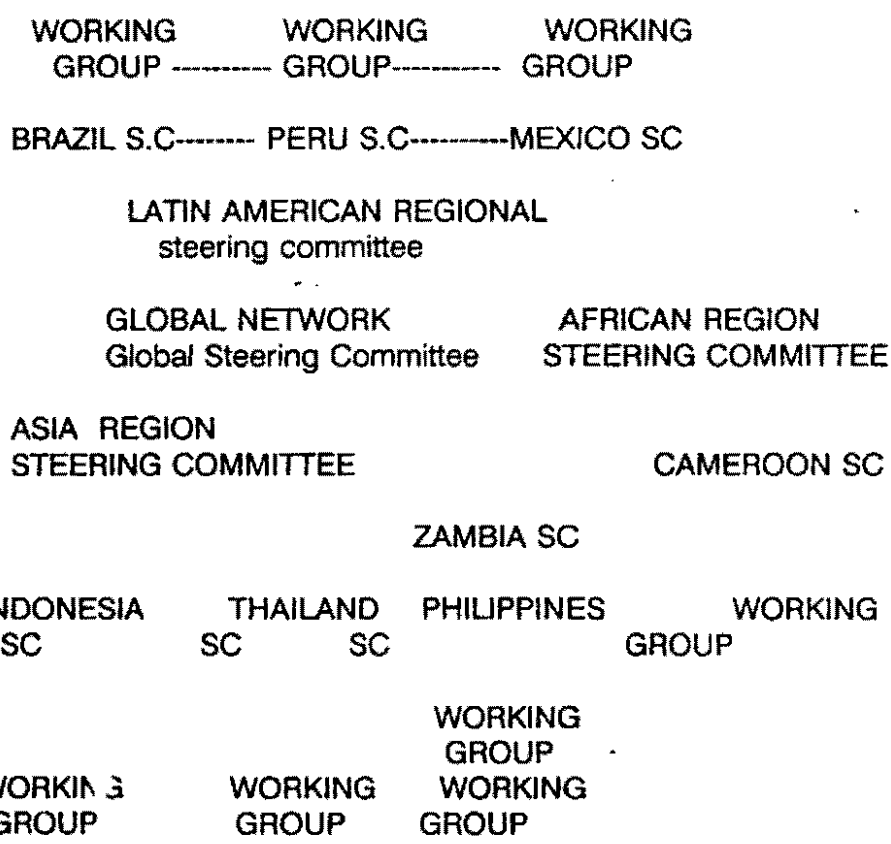
This research and development proposal involves joint efforts among three groups of institutions:

- The consortium of international centres shall serve as a resource pool of expertise not available in developing countries.

- Eight developing countries with designated national research institutions 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 research institutions from additional developing countries will be engaged in practical field evaluation of policies and technologies that will have been identified in the project.

5.1 Committee Structure



NOTE: Arrows link up appropriate boxes

The linkage is at four levels:

5.1.1 WORKING GROUP LEVEL

a) Suggested Membership

Farmers, Representatives of Non - Governmental Organisations (NGOs), Representatives of Research Staff, Extension Staff.

b) Terms of Reference (suggested)

i) Problem identification;
ii) Project planning, implementation and evaluation;
iii) Financial requirements identification; and
iv) Preparations of Project reports.

5.1.2 NATIONAL STEERING COMMITTEE

a) Suggested Membership:

Chairman of local Working Group, Representatives of participating Agencies (NGOs, National Research Institutes, Farmers, Representatives of Key Government Ministries (Finance etc), private organizations.

b) Suggested Terms of Reference:

i) Project appraisal endorsement and approval;
ii) Counterpart funding and resource allocation;
iii) Project coordination, implementation, monitoring, evaluation; and dissemination of results;
iv) Research prioritisation; and
v) To receive project reports.

5.1.3 REGIONAL STEERING COMMITTEE

a) Suggested Membership:

Chairmen of National Steering Committees, one national scientist from each country, NGO representative Farmers, Global coordination of project.

b) Suggested Terms of Reference:

i) To receive national Steering Committee project reports;
ii) Project coordination (regional) evaluation;
iii) External funding;

iv) Setting regional research priorities;
v) Dissemination of research results; and
vi) Regional project approval.

5.1.4 GLOBAL STEERING COMMITTEE

a) Suggested Membership:

Chairmen of Regional Steering Committees;
Representatives of International Consortium;
Representative of NGO's;
Farmers;
Donor Agency representative; and
Global coordinator of project.

b) Suggested Terms of Reference:

i) Funding, project and project budget approval;
ii) Setting research Priorities;
iii) Receive project reports from regional Committees;
iv) Project monitoring, evaluation; and
v) Dissemination of information.

5.2 International Centers

This project brings together the experience and expertise of four CGIAR centers, an affiliated center, and an international program as follows:

- ICRAF. The International Center for Research in Agroforestry, headquartered in Nairobi, Kenya has global responsibilities for mitigating, via sustainable agroforestry systems, deforestation in the humid tropics and massive land depletion in subhumid and semiarid tropics in a way that farmer's needs for food, fiber, 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 14 African countries, many of which practice slash and burn in their humid tropics.

- IITA. The International Institute for Tropical Agriculture, headquartered in Ibadan, Nigeria has worked on slash and burn agriculture since the early 1970's. 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. Primary focus for its strategic research on alternatives to slash and burn is the new IITA Humid Forest Station at M'balmayo 40 km south of Yaounde, Cameroun, in a typical Congo Basin deforestation situation.

- IFDC. The International Fertilizer Development Center is headquartered in Muscle Shoals, Alabama, U.S.A., with its Africa Division located in Lome, Togo, and an Asia Division in Dhaka, Bangladesh. IFDC has extensive expertise in fertilizer use efficiency research; in developing and testing alternate fertilizer materials; and on fertilizer manufacturing technology, marketing, and distribution. With scientists outposted in Asia, Africa and Latin America, IFDC is therefore heavily involved in nutrient efficiency research throughout the tropics. IFDC scientists have considerable expertise in modelling, socioeconomic, and policy research. IFDC is placing high priority on nutrient cycling in major agroecosystems.

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

- IRRI. The International Rice Research Institute, headquartered in Los Banos, Philippines is placing priority on rice-based upland cropping systems in Southeast Asia. It's goal is to rehabilitate upland ecosystems and increase the stability of upland rice farming systems. IRRI senior scientists have expertise on this subject and coordinate effective research networks in the region.

- CIAT. The Centro Internacional de Agricultura Tropical, headquartered in Cali, Colombia, is the first CGIAR Center having adopted a full-scale ecoregional approach. In this context it is implementing a land use program (focusing on the relationships between policy, land use and sustainable agriculture compatible with natural resources/environment preservation) in three Latin American/Caribbean agroecosystems programs, relevant to this project, for the tropical forest margins, the savannas and the hillsides. Unique among the IARCs is CIAT's geographic information system on climate, soils, vegetation, cropping physical access to the land, population, and other biophysical, political and social variables, which will be a strategic input to this project. The Center has a team on soil-plant relations, currently working on the pasture/crop complex on acid tropical soils; and on pasture-based reclamation of degraded deforested land. It also features the largest collection of acid soil tolerant germplasm of forage and food crops used in shifting cultivation. On interinstitutional work the Center has long-standing experience for large-scale collaborative research with NARS in the humid forests of Latin America.

5.3. NARS and Strategic Benchmark Sites

Strategic research will be conducted at eight key benchmark sites in full collaboration with the respective NARS. Each selected site will be representative of the range of biophysical and socioeconomic conditions where slash and burn is important. We call them ecoregions because they represent humid tropical situations in specific

geographical areas with contrasting socio-economic conditions, both at the macro (policy) and micro (farm) level.

Researchers at candidate benchmark sites for each ecoregion are all 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-term research plots where changes in soil properties and crop yields have been monitored for years, representing an invaluable research resource. The proposed choice of sites for Africa are based on the recommendations of a Rockefeller Foundation funded soils study group which included scientists actually working in four of the collaborating international centers (32). The proposed sites in Latin America and Southeast Asia included those where NARS and bilateral partners are currently conducting long-term research. A short description of the proposed ecoregions and major research thrusts follows.

Africa

Two contrasting benchmark sites for Africa are proposed. One is to be located in the equatorial rainforest of the Congo basin and the second in the adjacent acid Miombo woodlands.

. Congo Basin: The remaining tropical rainforests of Africa are concentrated in Central Africa starting in eastern Nigeria and covering most of southern Cameroun, southern Republique Centrafricaine, 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 only be possible under circumstances of adequate food import from the surrounding savanna zones, where food production potential 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 logistical 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 Cameroun seems the best location for a long-term strategic soils research initiative looking for 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 1960's.

A possible benchmark site for this ecoregion is M'Balmayo, about 1 ½ hour drive south of Yaounde in Cameroun. This is the location of a new IITA research station in collaboration with the Institute de Recherche Agronomiques (IRA) of the Government of Cameroun. 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 programs of the Cameroon Organisation Development Agricole et Recherche Environment et Foresterie (ONADEF) with the UK 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 Yaounde. The core of the project in the Cameroon will be a partnership between IITA and IRA with additional collaboration from ICRAF, GCTE and other international organizations. M'Balmayo would act as 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 socio-economic circumstances of this agro-ecological zone which is characterized by a heterogenous mosaic population density which includes patches with the highest number of people per unit area in Africa. The area is dominated by small-scale farmers most of whom still practice shifting cultivation in varying forms. Alleviation of the increasing food deficit in this zone in the short to medium term can only be achieved by increasing productivity per unit area as population pressures increase and the availability of land for follow decreases. Moreover increased productivity can only be realistically attained by incremental improvement of organic and inorganic management practices in the research agenda.

The second imperative derives from the particular soil problems characteristic of this zone i.e. 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 amendments must also be considered as necessary components of soil management.

. Miombo: The dystrophic Miombo woodlands of southern Africa are a large contiguous agroecological zone, covering about 100 million hectares east of the Congo rainforest and south of the East African highlands. It is a woodland savanna with typical broadleaf "Miombo" vegetation but is situated on red, acid soils, most of which are classified as Ultisols and Oxisols. Rainfall during the wet season is reliable, temperatures are cool due to the 1000 meter elevation, and much of the topography is favourable to agriculture. Soils, vegetation, climate and topography are remarkably similar to the woodland savannas of the Cerrado of Brasil, which lie directly west of the Miombo across the Atlantic. This zone has a low population of indigenous large animals, probably due to the low calcium and phosphorus levels of the soils as compared to adjacent areas with higher base status soils where game is abundant. Erosion hazard is substantially less than other zones because of the generally favourable topography with long, gentle slopes and low erodibility of the main soils. There are, however, steep slopes and severe erosion in some areas such as parts of northern Malawi.

The acid Miombo woodlands are best expressed in the northern half of Zambia and adjacent Shaba province of southern Zaire. They extend well into northern and central Malawi, parts of southern Tanzania, large areas of northern Mozambique and a large part of Angola.

This agroecological zone is not readily identified in most maps, and thus it is difficult to delimit its western and eastern borders. Vegetation maps with the notation of Dystrophic (i.e. acid) Miombo Woodlands dominated by the genera Brachystegia and Julbernardia area probably the best source (33). This excludes Eutrophic (i.e. nonacid) Miombo woodlands which are primarily located on sandy Alfisols and Entisols to the south.

Two particular kinds of shifting cultivation are the main land-use system of this region: chitemene and fundikila. The natural resources are relatively well conserved. The acid soils have conventionally been regarded as low agricultural potential. Modern research, particularly on comparable soils and climate in the Cerrado of Brasil has, however, revealed a high sustained productivity potential under appropriate cropping systems and management practices. The zone is therefore ideal for the establishment of a long-term program for development and adaptation of soil management practices. The existence of traditional organic-based farming systems provides the base for innovative research with the aim of developing transitional and sustainable technologies. This agroecological zone is among the highest in food production potential in Africa, because it is largely devoid of drought-induced soil degradation and lacks the biodiversity fragility of the rainforests. The success of large increases in sustained crop production in the Cerrado of Brazil (34, 35) lends credibility to its potential.

A Possible benchmark site would be the Misamfu Regional Research Station of Zambia's Agricultural Research and Extension Program (ZAREP) in its Ministry of Agriculture, located in Kasama, Northern Province. The present staff and capabilities of this center are considerable, having an adequate infrastructure supported by NORAD, the Norwegian Agency for International Development.

The station recently doubled its land area and has improved its laboratory and computer facilities. The Soil Productivity Research Programme includes teams working on soils survey, soil fertility, soil microbiology, and agroforestry. In addition, the Adaptive Research Planning Team works with smallholder farmers throughout the Northern Province and includes agronomists, socio-anthropologists and economists. The goal of the station is to find alternatives to the present and highly complex local shifting cultivation systems: chitemene and fundikila. Research is published in annual reports and technical bulletins, which provides an unusually upto date record of activities (36, 37).

Research areas include soil survey, soil survey, soil physics, soil fertility, soil biology, agricultural anthropology, economics, agroforestry, ecology, focusing on the gas emission consequences of chitemene and fundikila, and soil-plant laboratory development. Trainers and research scholars will come primarily from Zambia, Malawi, Zaire, Tanzania, Angola, Mozambique, Congo, and Madagascar.

The expertise of headquarters-based scientists at the international institutions will be tapped as needed to provide short-term on-site advise or serve as advisors for the junior scientists in the various disciplines.

Latin America

The Amazon constitutes the largest deforesting area in the world and therefore efforts in Latin America will concentrate there. The Amazon is undoubtedly one of the world's greatest reservoirs of plant and animal genetic diversity and holds one of the largest carbon stocks in its vegetation and soils. This region is rapidly being penetrated by roads, not only from the Brasilian side, but also across the Andes in the neighbouring countries. The major penetration road of the 1980's, BR 364, connecting Sao Paulo with the states of Rondonia and Acre links Brasil's major economic center with excess population to a population vacuum. By 1988, however, 24% of Rondonia's area and 13% of Acre's land area was deforested (38). 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, Brasil while the other 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 land abandonment primarily in the form of degraded pastures or degraded secondary forests called "juquira" (39, 40).

Two benchmark sites are proposed, one for each major agroecological zone of the Amazon, the semideciduous forest and the humid tropical rainforest. The first zone is in Brasil and the second in the Andean region.

. Semideciduous Forests: Recent changes in the EMBRAPA structure has assigned Manaus the leadership role in agricultural research for much of the Brasilian Amazon. On March 1989, two adjacent research stations merged into a single unit, the Centro de Pesquisas Agroflorestais da Amazonia (CPAA), headquartered at Manaus. Its mandate is to coordinate, both technically and financially, all agroforestry research centers in Rondonia, Acre and Roraima. CPAA inherits quality baseline information on management of the individual agroforestry components.

Agroforestry is one management option for the humid tropics because it provides many ecological and economic advantages compared to other management options. Among other services trees provide a continuous soil cover protecting the soil from erosion and recycles 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 also be sold throughout the year giving the farmer a year-round income source. Of course there are major obstacles to harnessing the potential benefits of the system. For depleted acid soil areas there will be very little 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 may even host pests that cause damage to the associate crop (47).

Agroforestry systems relevant to the Amazon are divided into three broad categories: agrosilvicultural, that combine trees and crops; silvopastoral, that combine trees and

animals, and agrosilvopastoral that combine trees, crops, and animals. Many of these systems would be readily adopted by Brasilians because of their strong tradition and well developed markets in native fruits and beef.

For many years CIAT has been conducting collaborative research with various Brasilian entities, especially with EMBRAPA, on pastures, rice, beans and cassava and is recognized as one of the main sources of expertise in such components.

In September, 1990 EMBRAPA and North Carolina State University (NCSU) initiated a project titled "Agroforestry Alternatives to Slash and Burn in Western Amazonia" with support from the Rockefeller Foundation at the rate of US $0.3 million annually for the three years. NCSU has stationed a senior scientist (a soil/agroforester) and several graduate students to work in the States of Amazonas and Rondonia on tree selection, soil fertility, socio-economic surveys and greenhouse emissions from potentially sustainable alternatives to slash and burn starting from virgin rainforests and from degraded pastures.

This proposed 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 indicated a strong interest from EMBRAPA in developing a collaborative research project on slash and burn with the inclusion of the international centers represented in this project Emphasis will be in Manaus, Rondonia and Acre. CPAA headquarters could be used as a regional training center for Amazonian scientists in collaboration with the PROCITROPICOS program of IICA.

Rainforest: The other half of the Amazon, the true tropical rainforest region is well exemplified by the Instituto Nacional de Investigaciones Agropecuarias y Agroindustrial's (INIAA) Yurimaguas Research Station in Peru. This is where North Carolina State University and INIAA have been conducting a sustained strategic research effort on alternatives to slash and burn on acid tropical soils since 1972. Research seeks to develop, refine, extrapolate and validate soil management technologies suitable for changing land currently under shifting cultivation into agronomically, ecologically, and economically sound agricultural production systems. Investigations have focused on 1) soil characterization in relation to landscape and constraints to crop production, 2) clearing methods for both primary and secondary forest vegetation, their consequences, and correction in subsequent cultivation, 3) long-term dynamics of physical, chemical and biological soil properties with time of cultivation under various production systems, 4) selection and evaluation of tree, crop, grass, and legume germplasm for tolerance to acidity and low nutrient reserves, 5 comparisons of cropping systems involving intercropping, continuous crop rotations, agroforestry, mulching, green manuring and composting, 6) management of fallows derived from natural regeneration or introduced species and their effects on subsequent cultivation cycles, 7) watershed hydrology, 8) compatibility and persistence of grass-legume associations under variable grazing pressure trials, 9) recuperation of degraded pastures, and 10) economic interpretations.

Current resources at Yurimaguas include a well mapped 135 hectare station, laboratory facilities capable of analyzing 10,000 soil samples and 2,500 plant samples annually, facilities for monitoring soil moisture, compaction and erosion plus a biological laboratory capable of quantifying root dynamics, mineralization, microbial biomass, soil faunal biomass and other TSBF methodologies. The most important asset is the existence of well monitored long-term plots on continuous crop rotations (since 1972), legume-based pastures (since 1979); low input transitional systems with managed fallows (since 1980), and agroforestry systems (since 1982) plus a systematic comparison between some of the these systems with shifting cultivation and secondary forest fallows (since 1985). These long-term plots represent an invaluable resource for sustainability studies.

Preliminary scope of work remains to be discussed in detail but it is likely to include the following areas:

- Socio-economic analysis of slash and burn alternatives.
- Nutrient cycling efficiency and biological soil management.
- Breeding of a key high value - low volume tree crops.
- Integrated pest management.
- Silvopastoral systems.
- Export market development.

Peru is currently experiencing severe economic and security problems. Although research continues at Yurimaguas, alternative sites in the Amazonian region of Ecuador may be considered.

A third potential site in Latin America is rapidly deforesting regions in Central America (Nicaragua, Panama, Honduras) in collaboration with CATIE or in Mexico (Chiapas, Yucatan).

SOUTHEAST ASIA

Deforestation is largely limited in Southeast Asia to three agroecological zones: equatorial rainforests, the hill country in mainland southeast-Asia and a tropical monsoon zone.

The equatorial rainforests are located primarily in Indonesia and Malaysia. Indonesia is the second largest deforesting country, because of extreme population densities in Java and vast underpopulated rainforests in the outer islands. The current primary forested area is 109 million hectares, deforestation rates are estimated to be about 1.2% per year (41).

The source of deforestation is mainly traditional shifting cultivation. This practice is considered as an adaptation of existing limited resources and low level technology to the fragile local environmental condition. As long as the fallow period is of sufficient length (15 to 20 years) the practice is deemed ecologically sound. However, if the fallow period becomes shorter, in some areas reduced to 1 - 3 years, formation of extensive unproductive alang-alang (Imperata cyclindrica) grasslands takes place in

particular when accompanied by fires (41). There are approximately 20 million hectares of alang-alang in the outer islands of Indonesia.

The shortening of the fallow period is brought about by increase of the local population by transmigration, logging roads, clearing of larger plots facilitated by using mechanical means, such as chain saws, ready markets for selling of agricultural products, logging camps and fast growing cities. Deforestation by shifting cultivation is at an estimated 500-750,000 hectares per year.

Agricultural development schemes, such as estate crops and small holder crops, besides transmigration, also have brought about deforestation. It is recommended not to clear primary forest but utilize unproductive forest for continuation of the program. Logging operations, and forest industries, though having contributed much to the economic development of the country, have brought about damage to the forest condition in several localities. Logging operations do not cause out-right deforestation, however the new network of logging roads, has improved accessibility to forest land for shifting cultivation and migrants. Moreover, after removal of the large marketable trees, clearing of smaller trees becomes easier to shifting cultivators.

The government of Indonesia has embarked on various programs to stop deforestation. Most programs are directed towards rationalisation of shifting cultivation. During the 1970s this program was in principle directed to move shifting cultivators into resettlement areas. Because of many constraints technical as well as cultural, a new in-situ approach is directed to rationalisation of the system itself (41). Research on alternatives to slash and burn has been concentrated around various transmigration regions in West and South Sumatra, where tall primary Dypterocarp rainforests are cleared and after some cultivation a considerable amount is converted into alang-alang pastures. Appropriate crop rotation schemes have been devised, based on upland rice, cassava and grain legumes with moderate fertilization (19, 21). A novel approach of implanting a managed Pueraria phaseoloides fallow right after slash and burn has been used to stabilize relatively large clearings for state crops, capturing the nutrients in the ash and allowing unburned vegetation to decompose until the planting materials are available (20). The reclamation of alang-alang grasslands is being researched with promising results (41,43,48), primarily through agroforestry techniques with trees that outcompete and outshade the grass.

Sitiung, West Sumatra and several sites in South Sumatra, and Kalimantan may be suitable locations.

Regardless of the sites chosen, this project should focus on the following topics:

- Systematic investigations on reclamation of alang-alang degraded grassland.
- 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 ones.

Hill Country of Mainland Southeast Asia

The second site in Asia will represent the totally contrasting region that includes the vast northern tropics hill country of the interior of mainland southeast Asia. This region encompasses a continuous belt from Assam, India, through northern and eastern Burma, to northern Thailand, Laos, Vietnam, and southern China. The climate is strongly monsoonal with long dry winters that are slightly cooler. Shifting cultivation is still the prevalent agricultural system. Major land degradation has occurred as a result of agricultural intensification on the steep terrain. Possible sites with infrastructure suitable for intensive research are located in northern Thailand and southern China. Potential collaborating institutions in northern Thailand are Chiang Mai University, and the Departments of Land Development, Agriculture, and Forestry. In southern China the Red Soils Institute would be a potential collaborating institution.

The third benchmark site in southeast Asia would represent the mid-tropical monsoon latitude belt including the Philippines and southern Thailand, where population densities in the uplands are rapidly increasing, and steep terrain is being clean-cultivated in short grass fallows and incipient permanent annual crop systems on strongly acidic or shallow calcareous soils. A possible benchmark site would be the Eastern Visayan island of Leyte, in collaboration with the Visayas State College of Agriculture (VISCA) and the Departments of Agriculture, and Environment and Natural Resources.

Regarding site selection, we shall have to develop a list of criteria for making a definitive choice. The above sites are relatively favoured if the selection is based on current research infrastructure upon which to base strategic and applied research, accessibility, logistical support, and living environment for expatriate staff; The availability of efficient NGOs and extension agencies must also be assessed when finally considering site selection. Myanmar and Laos should definitely be network research sites, but do have major limitations for strategic research. Dr. Tuong relates that Vietnam is still enforcing a ban on all foreign access to the uplands.

5.4. Extrapolation from Benchmark Sites

The research proposal has concentrated on analysis of the problem and identification of benchmark sites. The benchmark sites will provide the main research thrust with intensive study of traditional and alternative systems and practices. The program must initially take account of the variation in environmental and socio-economic conditions and management practices within the agroecological zones in which benchmark sites are situated. This will be covered by two approaches:

1. Characterization of the distribution of major soil, climate and physiographic conditions within the agroecological zone and of the distribution of major areas of forest, shifting and permanent cultivation. This will be obtained, at a low-level of resolution, using a combination of existing information, eg the UNEP GRID, and remote sensing. The information will be integrated into a GIS system associated with each benchmark site and used for both research and planning purposes. CIAT has already started characterization of Latin America through

the use of extensive databases but further analysis of social, demographic and economic data are needed. In addition, IITA, and ICRAF for Africa and IRRI in Asia have made some progress on characterization of their respective ecoregions.

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

3. To best prepare for 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 program, but they are designed to involve regional organisations and experience and experience to provide tests for the extrapolation of results from benchmark sites and to initiate a framework for subsequent development of the program.

5.5. Extension

The aim of this project is not extension, but to maximize the potential for extension (i.e. the adoption of beneficial research findings), links with extension agencies must be formed at the earliest opportunity.

5.6 Dissemination through Networking

Established research networks supported by one or more of the international institutions would be the logical vehicle for technology validation, training and policy dialogue, as appropriate. These network include for example AFNETA (IITA/ICRAF/ILCA), AFRENAS (ICRAF), IFDCs in West Africa and, TSBFs worldwide; RISTROP, CATIE and PROCTROPICOS in Latin America; F/FRED, the Asian Rice Farming Systems Network, the International Network for Sustainable Rice Farming, and IBSRAM in Asia and Africa. Such networks cover most of the tropical deforesting countries: The strengthening and expansion of regional and interregional networks will greatly facilitate training, data exchange and synthesis, standardisation, development and comparison of research methods, and in the discussion of research extension experiences; suitable networks already exist; in part, NGOs, academic and commodity areas.

5.7 Linkage with Related Institutions

Collaboration is anticipated with appropriate developed country institutions with expertise in alternatives to slash and burn. This would be primarily on-campus and through graduate student research at strategic sites. Examples include Reading University and ITE for Africa, North Carolina State University for Latin America and

Madagascar, CSIRO for Southeast Asia and Edinburgh Centre for Tropical Forests for Africa and Asia.

Collaboration is also envisioned with national, developed-country research bodies like CIRAD, and with other CGIAR centers; IFPRI on policy, IPBGR on germplasm conservation and the emerging forest research institute on forestry research. Collaboration is also envisioned with FAO's land resource evaluation, and the tropical forestry action plan. The non CGIAR international organization IBSRAM, will collaborate with IFDC as needed.

5.8. Linkages with the Private Sector

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

5.9 Linkage to Global Environmental Programs

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 varied 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 (biodiveristy-related research, soil degradation and greenhouse gas emissions). In addition, collaboration with GCTE will link this project to GCTE's developing expertise on understanding the dynamics of "complex" (multi-species) agricultural systems, and the global change impacts upon them; it will also contribute research results of direct relevance to GCTE's international programme. The Alternatives to Slash and Burn project will interact with GCTE at three levels:

Level 1

Direct Contributions to GCTE: work characterising and evaluating the environmental soundness of alternative agricultural and agroforestry systems in the humid tropics will contribute directly to GCTE's international programme:

- biogeochemical (nutrient) cycling
- mitigation of soil erosion
- weed dynamics and management
- interactions between components: multi-species systems

In addition to these specific areas of mutual interest, the thorough and standardised site characterisation 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 the project description.

Level II

Additional Collaboration. There is an opportunity for additional research that will benefit both this project and GCTE. In particular, research on the hydrological pathways of nutrient loss from present and alternative production systems would be useful. In these cases, a joint GCTE/Alternatives to Slash and Burn proposal would be submitted to relevant agencies for additional funding.

Level III

Framework for GCTE Research. One of the objectives of the Alternatives to Slash and Burn project is to determine the contribution of slash and burn and associated land-use practices to global environmental problems. The global change research itself is beyond the scope of this project. However, Alternatives to Slash and Burn will provide an excellent framework, through well-characterised sites, extant agroecological research, and support facilities, where appropriate, for GCTE to undertake the research. 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, e.g., impact of elevated Co_2 on soil organic matter dynamics and crop-weed competitive interactions, and erosion risk under changed rainfall.

Although this third level of work will be undertaken in close collaboration with Alternatives to slash and Burn, GCTE is ultimately responsible for organising, securing funding for, and conducting the research.

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

International Global Atmospheric Chemistry (IGAC).

Measurement of greenhouse gas emission 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). The emphasis on the global change impacts on regional hydrology of changes in land use, will link BAHC and this project.

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 analysis, interpretation, modelling and training in addition to collecting

data. Initial emphasis is on three regions: Latin america, Africa south of the Sahara, and Southeast Asia. There are obvious advantages for the benchmark sites of the Alternatives to Slash and Burn project to be linked to the START network.

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

6. EXPECTED OUTPUTS

The first five years of this project will put in place a concerted worldwide effort on mitigating tropical deforestation by alternatives to slash and burn. Strategic research at the benchmark sites will be well under way and initial results from the technological innovations, training, institutional strengthening and policy research will begin to be validated or adapted by networks composed of most tropical deforesting countries. Valuable ground truth data will be exchanged with the global environmental community, which in turn may help sharpen the focus of this project. Major impact on tropical deforestation would be expected after several years once technologies are fully developed and validated and various governments put into practice the appropriate policies.

The ultimate beneficiaries of this project are farmers and consumers in developing countries. The farmers will benefit through the adoption of technologies that provide sustainable crop yields and sufficient firewood, fodder and fiber, plus increased income and improved living standards. Consumers will benefit through greater availability of produce at lower prices.

On the national and global levels, the benefits derived through decreases in deforestation and soil degradation will be a major contribution to the environment. Society in general will be the main beneficiary of the long-term benefits of the project because of the conservation of natural resources, the preservation of biodiversity and reduction of greenhouse gasses.

7. RESOURCES IMPLICATIONS

The collaborative nature of this project builds upon already available resources of the international research centers, the NARS, existing networks and advanced developed country institutions. No new "bricks and mortar" institutions are envisioned. Resource needs, therefore are basically incremental funding needs to existing institutions.

It is envisioned that the NARS that accept the responsibility to host the benchmark strategic research sites receive incremental funds directly from the donors to support such international initiatives. International centers, likewise, would receive incremental funds for their input to the sites and network coordination, training and linkages with the environmental community. Bilateral funding agreements could provide complementary funds for advanced developed country institutes. A small budget for informal program coordination will also be included.

Initial funding estimates for the first five years is in the order of US$5 million per annum per continent (Southeast Asia, Latin America and Asia) respectively . A five-year total of US $75 million, without major capital and administrative costs will result in a definitive step in reducing slash and burn and the destruction of the remaining tropical rainforests of the world.

ANNEX 1

SUSTAINABLE LAND USE ALTERNATIVES TO SLASH AND BURN IN LATIN AMERICA

A Regional Project Proposal

as part of a

Global Strategy on

Alternatives to Slash and Burn

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PROJECT IMPLEMENTATION FRAMEWORK

Date: 25 May 1992

Title: Sustainable Land Use Alternatives to Slash and Burn in Latin America

Implementing Organization:

- Centro Internacional de Agricultura Tropical (CIAT)
- International Centre for Research in Agroforestry (ICRAF)
- International Fertilizer Development Center (IFDC)
- Tropical Soil Biology and Fertility Program - TSBF
- Empresa Brasilera de Pesquisa Agropecuaria -EMBRAPA
- Instituto Nacional de Investigacion Agropecuaria y Agroindustrial - INIAA
- Instituto Nacional de Investigacion Forestal y Agropecuaria - INIFAP
- Cooperativa de Agricultores y Ganaderos de Chiapas - COPEACH
- Corporacion Nacional de Investigacion Forestal - CONIF,
- Institutoamericano de Cooperacion para la Agricultura - IICA, (especialmente el programa PROCITROPICOS)
- Centro Agronomico Tropical de Investigacion y Ensenanza - CATIE
- Centro de Investigacion Regional del Sureste - SARH - INIFAP
- Centro Tropical de Capacitation Agropecuaria y Forestal - CETROCAF

Estimation Duration: Five Years (First Plan)

Donor Contribution: US $ 13,500,000

SUSTAINABLE LAND USE ALTERNATIVES TO SLASH AND BURN IN LATIN AMERICA

A. Regional Issues

Several aspects distinguish deforestation in Latin America from that in Africa and Asia. Population density is lower, deforestation per capita is higher, and cattle ranching is far more prevalent. Slash and burn agriculture in this region not only involves resource-poor farmers, but large-scale ranchers and even large corporations. Furthermore, seasonal labor shortages often preclude optimum management of the ecosystems, discouraging more intensive use of the land. Occupation and land use practices at the forest margin are often related to unequal land tenure locally or in higher population areas. Land speculation has also contributed to unsustainable land use practices. Considerable indigenous knowledge exists in Latin America, but most of the land holders are not indigenous, and therefore unfamiliar with the ecosystem.

While these issues are common throughout most of Latin America, patterns of deforestation and land use vary in three broad regions:

1. Central America and Mexico, with higher populations and the region's highest relative rate of deforestation.
2. The Andean Piedmont, with migration from Andean highlands in Colombia, Ecuador, Peru and Bolivia.
3. The Brazilian Amazon, with migration from the heavier populated northeast and the southeast of Brasil.

The Amazon as a whole constitutes the largest deforesting area in the world and is rapidly being penetrated by roads, not only from the Brazilian side, but also across the Andes in the neighbouring countries. As Brazil accounts for over 50% of the regional deforestation, initial efforts in Latin America will concentrate there. However, the Latin American regional strategy below calls for sites representing the other two situations allowing for research in the different contexts.

Site 1 (Representing Brazilian Amazon)

The states of Rondonia/Acre have been selected by the various partners to represent this area, due to the relative and absolute levels of recent deforestation. The major penetration road of the 1980's, BR 364, linked Brazil's major economic center to a perceived population vacuum in Rondonia and Acre. By 1988, however, 24% of Rondonia's area and 5% of Acre's land area was deforested. The main forms of land use are cattle ranching and food production under extensive and intensive shifting cultivation systems, which lead to land abandonment primarily in the form of degraded pastures or degraded bush fallow.

Since the mid-1980s, policies have changed considerably, for instance fewer roads are being built and government subsidies have been reduced. The

governments and other decision makers have been calling for sustainable development. However deforestation and unsustainable forms of slash and burn continue and have taken a momentum of their own, independent of government subsidies and financed by the private sector. There is need to improve understanding of this momentum at the level of farmer decision making.

Site 2 (Representing the Amazonian Piedmont)

Though Ecuador, Peru and Bolivia each have less land in the Amazon than Brazil, the Amazon represents a larger proportion of their respective national economies. Since the 1950's these Andean countries have made concerted efforts to resettle some of the population from the highlands to these areas. This has partially affected land imbalance within countries, but it has resulted in large populations of migrants that are relatively unfamiliar with the ecosystem. As in Brazil, there have been changes in policy, and colonization recently has not been encouraged to the same degree. However, deforestation continues, and these areas have the added complication of narcotics processing and trafficking. In addition, the Peruvian Piedmont has been suffering serious security problems related to guerrillas.

Initially, the area that has been proposed to represent the Amazonian Piedmont is the Bajo Huallaga; INIAA's Yurimaguas Research Station would be the main experimental center, with IVITA's Research Station in the Pucallpa zone as a support site. INIAA and NCSU have been conducting a sustained strategic research effort on alternatives to slash and burn on acid tropical soils at Yurimaguas since 1972. Pucallpa, on the other hand, is an area where major colonization movements are taking place along the Pucallpa-Federico Basadre highway, and at the Km 59 station IVITA/INIAA and CIAT have been conducting on-station and on-farm research for more than 20 years. Although research continues at both sites, Peru is currently experiencing economic, political and security problems and alternative sites in Ecuador and Bolivia have to be considered.

Site 3 (Representing Central America and Mexico)

This third region is experiencing the most extreme relative migration pressure and rates of deforestation with the resulting loss of biodiversity. A potential site that has been proposed is the area of Lacandona in Chiapas, Mexico. Arrangements between institutions in this area are in an earlier stage that in the other two cases. Alternative sites could be considered in Nicaragua, Panama, or Honduras, in collaboration with CATIE.

B. Objectives, activities and outputs

The objectives listed below are based on those that have been identified at a global level, but are arranged in regional order of priority and according to a regional time frame.

Objective 1: Develop a comprehensive understanding of land use dynamics at the farm and regional levels, and factors that influence them.

Activity 1. Characterize the biophysical environment of the target areas. This will include the collection, collation and digitizing of existing information on climate, soils, and actual vegetation cover.

Activity 2. Characterize the actual land use in the target areas. In all study areas, existing socio-economic information will be collected and collated on the principle land use systems associated with slash and burn agriculture. It will also imply analysis of satellite images to spatially distinguish old deforested areas from recently cleared land, pastures, fallow or forest land. This will form the spatial basis for the survey below.

Activity 3. Conduct systematic agroecological surveys. At this stage initial information will be gathered for issues pertaining to farmers' aspirations, perceptions, constraints and opportunities. This will be done by interviewing community groups, farmers' associations, local extension agents, local decision makers and NGOs to understand better the various perspectives involved.

Activity 4. Identification and inventory of local or indigenous practices and adaptations. This includes actual use of fallows in different stages. Analysis of the advantages and disadvantages of these practices and use of well adopted practices in technology development.

Activity 5. Development of a regional GIS so that the base line information and land use changes can be permanently linked to on-farm and on station experiments.

Objective 2: Assessment and diagnosis of the policy environment and other socioeconomic and cultural factors that affect decision making associated with slash and burn and other related land use.

Activity 1. Analyse actual and past land use in relation to policies in each area.
Activity 2. Evaluation and design of policy alternatives to reduce the unsustainable forms of slash and burn and to encourage suitable alternatives.

Activity 3. Development of methodologies and tools for policy decision making and strategic planning, such as interinstitutional policy dialogue, or participatory methods of identifying priority policy changes.

Activity 4. Assessment of the policy decision-making processes and identification of critical intervention points and means to promote implementation of policy alternatives.

Objective 3: Review, identify, and refine in close collaboration with farmers, sustainable land use methods. These must be economically feasible, socially acceptable, and environmentally sound alternatives to unsuitable slash and burn practices. Key interventions for the improvement of components will be identified, based on the analysis of perceptions and aspirations of farmers and the biophysical and socio-economic factors affecting their decision-making processes (objective 1). The potential of such improvements to enhanced system sustainability and productivity, and the principles governing their function will be evaluated through strategic process orientated on-station research. Such research is essential to provide the basic understanding required to predict performance and impact of improved technology over a wider range of environments. Such studies may include agroforestry and/or agropastoral systems with specific studies on components and processes such as nutrient cycling, soil organic matter management, weed dynamics and management, multi-purpose tree and forage improvement and management, and resource sharing and competition for light, water and nutrients.

Activity I. Conduct strategic interdisciplinary research to evaluate improved technology components and their interactions, to better understand the principles governing their function.

Activity 2. Conduct on-station and on-farm assessment of crop-based, tree-based, and pasture-based systems incorporating improved component technologies.

Strategic research on improved components and their interactionswill generate information which allows the design of improved and/or new production systems. These systems must be evaluated on a long term basis and their productivity, sustainability, environmental soundness and social acceptability will be monitored and assessed. Such research will be undertaken both on-station, where the emphasis will be on biophysical monitoring, and on-farm where the focus will be on assessing the social acceptability, potentials and constraints to adoption.

Activity 3. Further evaluate local or indigenous practices, their ecological principles and their social-economic implications for alternative land use, including alternative fallow use.

Activity 4. Investigate socially and economically viable methods of rehabilitating degraded lands. Degraded lands and existing regenerating mechanism will be identified and classified using the GIS and fieldwork.

Activity 5. Identification, collection and conservation of useful germplasm including forage and multiple purpose tress.
Activity 6. Improve knowledge on use and management of the above germplasm.

Objective 4: To quantify the contribution of slash and burn, and associated land-use systems, to major features of global change, such as loss of biodiversity, emission of

greenhouse gases and soil degradation (to be conducted in collaboration with GCTE).

Activity 1. Provide a framework for the study of the relationship between slash and burn and biodiversity. As detailed in the global document, this project would provide a framework, through support facilities and staff, for GCTE to undertake research on the impact of land-use change, through slash and burn agriculture, on biodiversity, particularly plant genetic diversity.

Activity 2. Provide a framework for quantification of green house gas emissions from slash and burn and associated land-use systems, in collaboration with GCTE and IGAC (Detailed in global document).

Activity 3 - Quantify changes in soil quality in slash and burn and associated land-use systems, including changes in soil organic carbon balances and related nutrient changes. This will help increased our knowledge on the extent and type of soil degradation associated with slash and burn practices the dynamics of soil organic matter and the cycling of nutrients, through the system. Another important aspect of soil degradation that will be studied is the physical loss of soil material through hydrological pathways and by water erosion.

Objective 5: Strengthen and utilize the existing networks to share research information, methodologies and technologies for improved resource management systems and decision making.

Activity 1. In conjunction with NGOs and extension agents, link the farm and participatory research with relevant technology transfer and exchange mechanisms, such as farmers groups, schools, publications and other media.

Objective 6: Training
Activity 1. Hold regional training short courses for researchers on related subjects such as survey methods, participatory research methods, multiple purpose trees or agroecosystem monitoring and evaluation.

Activity 2. Provide a framework for post-graduate degree research.

C. Operational Strategy

The regional subproposal is a joint effort of two International Centers (CIAT and ICRAF), two regional organizations (CATIE and IICA), the national research/extension systems of the three countries and NGOs with a strong presence on the ground. Those institutions should effectively address all the technological, economic, social and policy dimensions involved in sustainable agriculture. Different institutions must then focus on specific themes of agreed research agendas to foster complementarity. Collaboration among national, regional and international research systems will be facilitated through vertical and horizontal linkages.

Vertical linkages will be used to integrate research and development efforts at

ecosystem and farm levels. Integration will take place in specific geographic areas (e.g. a micro-basin), through projects carried out by consortia of institutions operating at levels ranging from regional planning to farm production. The active participation of all consortia members in the identification, planning, implementation and evaluation of R&D activities is key to this strategy.

Horizontal linkages have a double purpose. First, they should systematically capture across the agroecosystem the rich variety of existing indigenous and exotic knowledge through cross-sectional and longitudinal studies, analyzing their agroecological and socioeconomic rationale vis-a vis the development of improved land use alternatives. Second, this type of mechanism will facilitate information sharing and discussion of issues relevant to sustainable research management within the agroecosystem. Development of agroecosystem databases and publication of newsletters will be key media; training and communications will be essential to strengthen institutional capabilities.

While the strategy is similar across countries, the institutional profiles are different as are the stages where they are in the process. This determines that each site should be phased-in separately. The arrangements for Rondonia, Brazil are the furthest along. EMBRAPA, many times in collaboration with CIAT, has been concentrating on components such as evaluation of pasture, rice, beans and cassava germplasm. Furthermore, EMBRAPA recently reorganized its Amazonian stations with the intention of creating six agroforestry stations, one in each state. In 1990 EMBRAPA and North Carolina State University (NCSU) initiated a project titled "Agroforestry Alternatives to Slash and Burn in Western Amazonia" with support from the Rockefeller Foundation for three years. NCSU has stationed a senior scientist (a soil/agroforester) and several graduate students to work in the States of Amazonas and Rondonia on tree selection, soil fertility, socio-economic surveys and greenhouse emissions from potentially sustainable alternatives to slash and burn starting from virgin rainforests and from degraded pastures.

Invited by EMBRAPA, CATIE-CIAT-IICA-ICRAF have recently conducted a joint mission throughout the Brazilian Amazon, to select potential research areas and issues, and to identify their comparative advantages for the development of sustainable land use alternatives. Eastern Para and Rondonia/Acre were selected, and further joint planning efforts were defined. This proposed project can therefore build on existing strengths by adding senior staff from CIAT and ICRAF in the areas of nutrient cycling, weed management, silvoculturists, agroforester, anthropology and silvopastoral systems. Rondonia-Acre has been chosen as the center of activity due to their importance to slash and burn agriculture in Brazil. CPAA (Manaus) headquarters is proposed as a regional training center for Amazonian scientists in collaboration with the PROCITROPICOS program of IICA.

Another feature of Rondonia and Acre is the presence of strong NGOs such as IPHEA in Rondonia and PESACRE in Acre. As in other states, there are also EMATER extension agents in each municipio. Additionally, in the Brazilian Amazon there are five state and two federal Universities, and two ecological research institutes: INPA and the Museo Goeldi. Links will be made with Federal Institutions such as IBAMA and

SUDAM as well as state governments will need links for consideration of policy and land use. The Rondonia state government has shown strong interest in the effort.

The situation is less clear for the site in the Andean Piedmont. The site of Yurimaguas, Peru, has been suggested because of the accumulated relevant research. Current resources at Yurimaguas include a well mapped 135 hectare station, laboratory facilities of analyzing 10,000 soil samples and 2,500 plant samples annually, facilities for monitoring soil moisture, compaction and erosion plus a biological laboratory capable of quantifying root dynamics, mineralization, microbial biomass, soil faunal biomass and other TSBF methodologies. The most important asset is the existence of well-monitored, long-term plots on continuous crop rotations (since 1972), legume-based pastures (since 1979); low input transitional systems with managed follows (since 1980), and agroforestry systems (since 1982) plus a systematic comparison between some of the these systems with shifting cultivation and secondary forest fallows (since 1985). These long-term plots represent an invaluable resource for sustainability studies.

However, in addition to the political uncertainty already mentioned, a disadvantage is that there is no extension service connected to the experiment station. The target area proposed for extension is Pucallpa. FUNDEAGRO and the Camara Nacional Forestal are currently organizing extension in the Pucallpa area and would represent the interface with the farmer. Yurimaguas is also in a national research network, RINAP, with four other research stations in the Peruvian Amazon. There will have to be links with ONERN and the Direccion de la Reforma Agraria for Policy and Land use considerations.

The arrangements for a site in Central America are at a more preliminary stage. Lancandona, in the state Chiapas, Mexico has been proposed. This candidate area in Mexico is different again in that it has no INIFAP Experiment Station scientists that work in the area. On the other hand, there are many NGO's working at the farmer level one of which will be involved as the extension/dissemination agent in this area. The National University and PEMEX, the petroleum company, also have projects with farmers. At the policy level, there will need to be links with the Secretaria de Desarrollo Urbano y Ecologia (SEDUE) and the Instituto Nacional Indeginista - (INI).

Regional Networks

In Amazonia there are several relevant networks: there is PROCITROPICOS, related to IICA and the Tratado de Cooperacion Amazonico - TCA. This has a special commission for science, technology and the environment, and UNAMAZ, the network of Amazonian Universities. More information is needed on specific regional, NGOs and local networks.

D. Coordination

As outlined in the global document there will be a hierarchical structure with global, regional and national steering committees. CIAT is provisionally coordinating the regional efforts, though further details will be worked out at the next global meeting.

It has been suggested that the national or site steering committee be composed of farmer's organizations, NGO's, Agricultural Research Staff, Agricultural Extension Staff, Private Sector and representatives from the regional and international organizations.

The Terms of Reference for the national steering should include:
-Problem Identification
-Project planning, implementation & evaluation
-Financial requirement identification
-Fund raising
-Monitoring & dissemination
-Reporting
-Networking.

E. Budget

Provisional financial needs for the Latin American regional efforts are given below. (5 years)

U$ 1,000

Activities	National inputs	IARC and Reg. Network inputs	Donor inputs	Total
a) Participative Research	5,200	7,650	5,150	18,000
- Personnel	2,550	2,250	1,060	5,860
- Internal	-----	4,250	1,060	5,310
- National	4,550	-----	-----	4,550
- Operat. Costs	650	3,400	3,090	7,140
- Networking				
- Extension, NGO private sector				
b) Training	550	850	4,600	6,000
c) Diffusion	750	-----	5,250	6,000
Total	4,500	6,500	13,500	24,000

LATIN AMERICAN TIME FRAME (% SF TOTAL)

Year	1	2	3	4	5	Total
Research	15	15	10	10	10	60
Training	5	5	4	3	20	
Diffusion	2	3	4	5	6	20
Total	22	23	18	18	19	100

ANNEX 2

SUSTAINABLE LAND USE ALTERNATIVES TO SLASH AND BURN IN AFRICA

A Regional Project Proposal

as part of a

Global Strategy on

Alternatives to Slash and Burn

TABLE OF CONTENTS

PROJECT IMPLEMENTATION FRAMEWORK

Date: 25 May 1992

Title:

Sustainable Land Use Alternatives to Slash and Burn in Africa

Implementing Organizations:

International Institute for Tropical Agriculture - IITA

International Centre for Research in Agroforestry - ICRAF

International Fertilizer Development Center - IFDC

Tropical Soil Biology and Fertility Programme - TSBF

Institut de Recherche Agronomique - IRA

Misanfu Regional Research Station - ZAREP

Estimated Duration: Five years (First Phase)

Donor Contribution: US$ 20,272,500

AFRICAN REGIONAL PROPOSAL

1 REGIONAL ISSUES AND RESEARCH PRIORITIES

1.1 Issues

The humid forest Zone of Africa, its farming systems and the current state of deforestation have been described in the Global Strategy paper on pages 23 - 27.

It should be emphasised that, in Africa, slash and burn agriculture is almost entirely practised by resource-poor farmers living within the forest.

The most critical issue that distinguishes Africa from the other regions is that it faces a continuing decline in per capita food production. The causes of this are complex and must be kept to the forefront as guidelines in determining research priorities for this project. One component of declining food production in the humid forest zone (HFZ) of Africa is the shortening length of the restorative fallow period with consequent effects on soil fertility and pest and weed pressure. The decline in fallow length is commonly attributed to the pressure of increasing population as available land but it is also attributed to a number of other causes including shortage of male labour at critical periods (e.g. at the time of clearing). The declining efficiency in food production and the attendant effects on soil carbon storage, burning frequency and other environmental effects are also influenced by inappropriate national and international policies (e.g. with regard to commodity and input prices) and inadequate infrastructure in many African countries.

Another feature of particular significance to an African regional project is the difficulty experienced by many National Agriculture Research Systems. This is a combination in many instances of the lack of trained manpower and, almost universal, of underfinancing. The main effect is felt at the level of adaptive research and technology transfer where results generated by centres cannot be transferred to the benefit of the farmer.

The zone is varied embracing areas differing significantly in climate, in vegetation and soil resources and embracing population density extremes from SE Nigeria, with the highest in Sub-Sahara Africa, to the Zaire Basin which has among the lowest. Many parts of the region are being rapidly deforested due to timber cutting, intensified fallow use and destruction of plantations; the removal of tree cover leads to increasing environmental degradation; the increased frequency of burning produces a significant contribution to greenhouse gas emission.

Other specific issues in the African HFZ are: 1) environment favours growth of ruderal species in cleared land; 2) weed problems are enhanced by shortened fallows; 3) certain species such as *Chromolaena odorata* become dominant through both fallow

and cropping periods of the cycle; 4) in some parts of the zone *Imperata cylindrica* has become dominant; 5) and provoked fire cycle that maintains land in a permanently uncultivatable condition.

The stable food crop is cassava, with a variety of food preferences including consumption of leaves as well as roots, and of bitter as well as sweet varieties. It also has a spectrum of pest problems; cassava mealy bug, cassava green mite, cassava mosaic virus and cassava bacterial blight.

1.2 Priorities

On this basis the priorities for the African Regional Project may be categorised under three headings which highlight particular aspects of the Global Research Agenda as being of particular importance in Africa.

a) Development of sustainable alternatives to current slash and burn practises adopted by the small-scale farmer within the forests and woodlands of sub-Saharan Africa (Objective 3a, b and c)

b) Development of a methodology for achieving successful transfer of this technology to the small scale farmer (Objective 3d)

c) Comparative assessment of the environmental impact of the current and replacement practices (Objective 4)

The characterisation activities identified under Global Objectives 1 and 2 are recognised as essential to the success of the project. They are given lower priority here for two reasons: -

(i) at the local level considerable work has been done, and is on-going in the region;

(ii) some aspects of this work will be done at the global level.

2. RESEARCH OBJECTIVES

2.1. To achieve a significantly better understanding of the agroecological, socioeconomic and policy determinants of major slash and burn agricultural systems currently practised in the forest and wooded zones with particular reference to sub-Sahara Africa.

2.2. To understand the potential contribution of major slash and burn systems to environmental degradation in the forest and woodland zones.

2.3. To identify and develop, in collaboration with NARS and farmers, agricultural production systems that are economically feasible, socially acceptable, and environmentally safe alternatives to current slash and burn systems.

2.4. To develop, in collaboration with NARS, appropriate methods, procedures, and policies for the successful promotion of alternative agricultural systems and their adoption by farmers currently practising slash and burn.

3. RESEARCH ACTIVITIES

The major research activities under each research objective are as follows. Research will be carried out by interdisciplinary teams USARs (Units for Sustainable Agriculture Research) based in the two Regional Research Sites (see Section 4, Project Strategy).

Objective 1

To achieve a significantly better understanding of the agroecological, socioeconomic and policy determinants of major slash and burn systems.

Success criteria: Availability of databases to national and international organisations on (i) vegetation and landuse characteristics of the forest and woodland zones of sub-Saharan Africa; (ii) resource utilisation profiles at the farm and village levels in current slash and burn and associated landuse systems; (iii) information on policy issues affecting current and prospective technologies.

Activity 1.1 - Characterize the current patterns of vegetation and land use in the forest and woodland zones of sub-Sahara Africa.

Major climatic, edaphic, and economic zones will be defined by use of geographic information system (GIS). Within these zones satellite remote sensing imagery from the Systeme Probatoire d'Observation de la Terre (SPOT) facility will be employed to map the distribution of different land- use systems including those occupied by forest, woodland, and fallow vegetation types. Ground truthing will include measurement of the composition and biomass of different vegetation types.

Output - Reliable data base on land-use systems, vegetation characteristics, and their distribution within the forest and woodland zones of sub-Sahara Africa.

Activity 1.2 - Characterize and classify resource-management systems practised by farmers in the forest and woodland zones of sub-Sahara Africa.

A village-level questionnaire survey with confirmatory vegetation and soil characterization will be used to determine cropping patterns, fallow management systems, soil, pest, and labour constraints, market access and demand, and other factors determining the availability and patterns of use of resources by small-scale farmers.

Output - Classification of resource-management systems and their distribution in different agroecological regions of the forest and woodland zones of sub-Sahara Africa.

Activity 1.3 - Determine the policy factors influencing the agricultural practices of small-scale farmers in the forest and woodland zone of sub-Sahara Africa.

Secondary data sources and survey investigations at country level (including the result of Activity 2.) will be used to define current policies and determine their effects on agricultural practices, including those due to input and output price subsides, population policies (including migration and resettlement), land tenure, and other economic indicators.

Outputs - Characterization of the policy determinants influencing agricultural choices made by small-scale farmers.

Objective 2

To understand the potential contribution of major slash and burn systems to environmental degradation in the forest and woodland zones.

Success criteria - Quantified information on processes causing environmental degradation associated with traditional agricultural practices, and clearly stated priorities and strategies for field research and evaluation:

Activity 2.1 - Determine the changes in biological (SOM), physical and chemical properties of soil under differing conditions of agricultural practices. The quantity of SOM and its quality (determined by fractionation into different components including microbial biomass) will be measured annually for 3-5 years from the initiation of the cropping cycle within a variety of agricultural systems. However, it is recognized that these measurements must be done over a much longer period to be truly meaningful. For systems with long cycles, comparative studies of different stages of the cropping System will be substituted for time series. Changes in associated soil chemical characteristics (such as total N and S and ECEC) will also be monitored, together with other soil fertility indicators such as acidity. Soil physical attributes, such as compaction and pore size distribution, will also be determined.

Output - Detailed characterization of the soil fertility constraints under different types of agricultural practices in relation to soil type and environment, with particular respect to SOM dynamics, and (by use of appropriate models) potential erosivity.

Activity 2.2 - Estimate emissions of CO_2 from biomass burning and SOM oxidation in the forest and woodland zones of sub-Sahara Africa.

The information on vegetation biomass and frequency of clearing gained in Activity 1.1 will be utilized with the GIS and appropriate models to estimate C emission from biomass destruction in slash and burn and other agricultural practices. The

experimental information from Activity 2.1 will be used in soil dynamics models, such as Century (TSBF) and SCUAF (ICRAF), to predict loss and storage of C in the soil.

Output 1) Estimate of potential contribution of slash and burn and other agricultural practices in the forest and woodland zones of sub-Sahara Africa to global emission of CO2; 2) Product Maps of SOM liability and other soil fertility change indices for the region.

Objective 3

To identify and develop, in collaboration with NARS and farmers, agricultural production systems that are economically feasible, socially acceptable, and environmentally sound alternatives to current slash and burn systems.

Success Criteria - A series of cropping systems which can act as viable alternatives to slash and burn will have been identified and developed.

Activity 3.1 - Selection of germplasm and design of alternative production systems to slash and burn agriculture.

Improved and local varieties of crops (cassava, yam, plantain, maize, etc.) will be selected from the collections. Cropping systems that will be assembled for comparative study include: (1) cropping systems involving grain legumes (e.g. intercropping, relay cropping, and sequential systems), (2) cropping systems incorporating green manure/legume cover crops, and (3) agroforestry systems, particularly alley cropping, improved rotational fallows, and multistrata/home garden systems.

b) Output - Selected components (plants species, management, spatial and temporal arrangement, etc.) for prototype systems that could be considered as alternatives to slash and burn agriculture.

Activity 3.2 - Develop integrated soil and nutrient management practices.

Such practices aim at efficient utilization of soil water and nutrients and will be incorporated in the design of alternate production systems to slash and burn. The major emphasis will be on exploiting interactions between inorganic nutrients (fertilizers and agrominerals), mineral ameliorants (such as lime or gypsum), organic residues (crop and tree residues, manure, etc.) and SOM to overcome specific soil constraints, such as nutrient deficiencies and soil acidity.

Output - Component technologies on soil, water, and nutrient management that can be incorporated in the design of potential prototype systems.

Activity 3.3 - Assess comparative sustainability of alternative production systems. Aspects to be studied include:

- Nutrient cycling particularly the dynamics of N, P, and S.
- Quantification of biological nitrogen fixation.
- Mycorrhizal association and P nutrition (especially use of phosphate rock).
- Organic matter turnover.
- Monitoring pests, particularly shifts in weed flora and density.
- Potential positive and negative effects of fertilizers and overall nutrient management.
- Economic benefits, including labour use, of prospective technologies.

Output- 1)Information on external inputs and management practices required for the design of sustainable production systems; 2) Selected prototype systems for further development and 3) Input for the development of models to undertake Activity 4.

Activity 3.4 - Model development and application. Computer simulation models are tools to assist in planning research, extrapolation of results, and assessment of the impact of technology adoption at local, regional, and global levels.

As a first stage, models will be developed to predict soil changes under different production systems. The construction of such models will highlight gaps in the knowledge base of particular biological processes, and 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 used to estimate biological productivity and economic returns of different production systems. Existing crop and farm models will be adapted and linked to farm systems models.

Finally, the resulting systems models will be used to evaluate risk factors associated with different management systems and agricultural practices. This will enable the isolation of climate, environmental, and economic variables to allow a thorough assessment of risk for the various alternative production systems.

Output - Models that evaluate environmental degradation, the productivity and sustainability of alternative agricultural practices in relation to both technical and socioeconomic criteria and those that facilitate adaptation and extension of results.

Objective 4

To develop, in collaboration with NARS, appropriate methods, procedures and policies for the successful promotion of alternative agricultural systems and their adoption by farmers currently practising slash and burn.

The strategy proposed for attainment of Objective 4 is one involving integral participation of farmers and NARS collaborators (both research and extension)

throughout the research and development programme. The activities and outputs listed under this objective should not be seen as distinct from those of the previous objectives but rather as extensions of those objectives and activities.

The first component of the strategy involves institution building of NARS. The intention is to achieve, by the end of project period, a capacity among three of the NARS collaborators to conduct research for sustainable food production. The second component is a deliberate strategy for participation of farmers and extension workers throughout the research project. Both groups will be involved in the activities of constraint characterization, technology identification and adaptation, as well as on-farm evaluation of recommended technology. The third component deals with the involvement of policy makers through the Policy Analysis Unit (PAU) for the creation of a conducive policy environment to promote a speedy and successful adoption of alternative systems. It is thus hoped that by the end of its term the project will have achieved adoption of new technology in the pilot areas by a small group of farmers who will act as a nucleus for further diffusion, assisted by National Agricultural Research and Extension scientists with whom they are used to working.

Success Criteria - By the end of the project, a comprehensive and well-tested mechanism will have been established which is capable of transferring the research results to the farming community at regional and local levels.

Activity 4.1 - Establishment of interdisciplinary research and development of Units for Sustainable Agricultural Research (USARs) within the NARS of three countries.

A project scientist will coordinate development activities and training programmes in three selected countries to establish interdisciplinary teams (USARs) capable of conducting integral research for sustainable agriculture, such as resource characterization, diagnosis of constraints, technology identification, development, testing and transfer. Initially, USAR will be established in the benchmark site countries (Cameroun and Zambia). A third country will be selected early in the project with the intention of initiating USAR activities by year 2. In developing the USAR, particular concern will be given to research on gender issues. A social scientist will work with the USAR scientist in the impact countries to define gender issues at both farm and policy levels.

Output - Three established USARs capable of conducting sustainable interdisciplinary research and extension beyond the life of the project. Identification of particular problems associated with the role of women in agriculture and recommendations for policies to improve women's status.

Activity 4.2 - Establishment of the mechanisms for the participation of farmers and extension officers with the scientists conducting characterization and monitoring of the major constraints to the development of alternatives to slash and burn agriculture.

The output of Objective 1 will produce a classification of farmers and farming systems in terms of both resource availability and resource management practices. This classification will be used to select groups of farmers for further detailed participatory

research. The first stage of this will be joint investigation and characterization of the constraints to productivity and sustainability on farms, described in Activity 2.1.

Output - Farmer and USAR input to data base of constraints to production and sustainability.

Activity 4.3 - Establishment of the PAU in the participating countries.

These units will help in creating a conducive policy environment for the adoption of alternative technologies and systems. In particular, they will bridge the existing gulf between the researchers and policy makers so that the new technologies and systems can receive the necessary policy support for their successful and sustainable adoption.

Output - sustainable PAU in the participating countries and guidelines for policy analysis and implementation.

Activity 4.4 - In pilot areas achieve the participation of farmers, extension workers and research scientists in surveys and trials to identify and adapt potential technical and policy solutions to overcoming defined constraints to the development of alternatives to slash and burn agriculture.

Intensive and long-term, on-farm surveys will be conducted with the farmer groups established in Activity 1, to exchange views and information on resource and management alternatives for overcoming identified constraints. The same farmers and extension workers will also be involved in planning, interpreting, and modifying on-station adaptive research on technological options.

Output - Farmer and USAR input to technology development.

Activity 4.5 - Farmer-managed on-farm evaluation of selected technological alternatives to slash and burn agriculture.

The same farmers will collaboratively establish on-farm testing sites in the pilot areas for the most promising technology developed as a result of the intensive studies and modelling activities listed under Objective 3. Farmer's choice and management of the technology will provide feedback information to the adaptive research program for incorporation into the extrapolation models and to guide further research.

Outputs - 1) A set of tested and adopted technological alternatives to slash and burn; 2) Recommendation models for alternative practices to slash and burn in relation to environment, resource constraints, farmers perceptions, and potential adaptability and 3) Handbook for extension officers of guidelines for successful promotion of alternative practices to slash and burn.

4 RESEARCH STRATEGY

4.1. Regional Research Centres

The four project objectives constitute a comprehensive strategy for seeking alternatives to current slash and burn practices in the forest and woodland zones of Africa. The strategy begins with a focus on characterization of the state of the environment and of current farming practice for representative areas of the whole mandate zone. This potentially covers a survey of more than a dozen countries of East, Central, and Southern Africa.

The second component focuses on defining more precisely the environmental changes which occur during the shift from long-term, fallow-based agriculture to permanent or semi-permanent cultivation. The third component, that of technology design and development, requires intensive study. These studies will be carried out in two countries which have been selected as representative of the areas where slash and burn agriculture is the traditional practice - the humid rainforest zone of Cameroun and the dystrophic miombo of Zambia.

The remaining tropical rain forests of Africa are concentrated in Central Africa, starting in eastern Nigeria and covering most of southern Cameroon, southern Republique Centrafricaine, and most of Gabon, northern Congo, and northern Zaire. There is also a significant remnant, generally under greater pressure, in far West Africa, i.e., Ghana, Cote d'Ivoire, Liberia, Sierra Leone, and Guinee.

This region includes the densest populated areas of Africa where food production is largely dependent on shifting agriculture with shortening fallow periods. Considering the severe logistical 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 would be a good location for a long-term, strategic soils research initiative looking for alternatives to slash and burn.

The Humid Forest (HF) Station at M'Balmayo has been selected by IITA as representative of these areas for a major new effort for research in the humid forest - acid soil zone of Africa. The HF field site lies 40 km south of Yaounde comprising 1,000 ha of secondary rain forest on Ultisols. The soil problems characteristic of this zone are high acidity and aluminum toxicity, together with relatively low nitrogen reserves and extremely low phosphorus availability. Analytical laboratories and offices have been built adjacent to those of the Institut de Recherche Agronomique (IRA) at Nkolbisson just outside Yaounde.

The dystrophic miombo woodland of Central and southern Africa is a large contiguous area covering about 100 million ha to the south and east of the Congo rainforest. It is a woodland savanna with typical broadleaf vegetation dominated by species of Brachystegia located on red, acid soils classified as Ultisols and Oxisols. Rainfall during the wet season is reliable, temperatures are cool due to the 1,000 m elevation and much of the topography is favourable to agriculture. Traditional agriculture in this area is dominated by the "chitemene" form of slash and burn.

The base for research in this zone will be at the Misamfu Regional Research Station of Zambia's Agricultural Research and Extension Programm (ZAREP) of its Ministry of Agriculture, located in Kasama, Northern Province. The present staff and capabilities of this centre are considerable, having an adequate infrastructure supported by the Norwegian Agency for International Development (NORAD). With NORAD's cooperation, the station recently doubled its land area and has improved its laboratory and computer facilities. The Soil Productivity Research Programme includes teams working on soil survey, soil fertility, soil microbiology, and agroforestry. In addition, the Adaptive Research Planning Team, with smallholder farmers throughout the northern Province, includes agronomists, socioanthropologists and economists. The goal of the station research is to find alternatives to the present and highly complex local shifting cultivation systems, chitemene and fundikila. Scientists employed by the project will be based at both sites.

Many of the scientists employed on the project will be based at one or other of these sites.

The final component of the project addresses the difficult issue of technology transfer. A number of different elements have been included to promote this goal. They are participatory research with farmers, institution building, policy analysis, and interactive interaction between the characterization, technology development, and on-farm evaluation phases.

4.2. Research Approach and Organisation

The research will be carried out by two interdisciplinary research teams, each based at one of the regional research centres. The teams will be comprised of scientists from National Research Systems and International Centres working together with extension agents, members of NGO's and farmers. The teams will be known as Units for Sustainable Agriculture Research (USAR's). As the name implies the intention is to develop an interdisciplinary and systems-orientated approach to research on the development and adaption of sustainable land-use systems. Research will be conducted on-farm and on-station.

The teams will be comprised of scientists designated by the partnership institutions plus a few project-funded posts.

a. Cameroon

Table 1a lists the scientists designated by IITA, ICRAF and IRA to work in the Project USAR in Cameroon. Three essential additional posts were identified: an Extension Specialist to lead the on-farm adoption research (Objective IV); a Policy Specialist to lead the research on policy issues in Objectives I and IV; and a Project site Coordinator.

b. Zambia

Table 2a lists the current staff allocation to the project from a variety of international agencies together with those from the Department of Agriculture of Zambia. Additional expertise required through the project are a Weed Scientist, a Soil organic matter Specialist and Site Coordinator.

This interdisciplinary and partnership approach to research is emphasised as an innovative and important aspect of this proposal.

TABLE 1 Proposed staffing for USAR, Cameroon

STAFF	INSTITUTIONS	NUMBER
1a Current (1994) Allocations		
Soil chemist	IITA	1
Soil Phycist	IITA	1
Weed Scientist	IITA	1
Cropping systems	IITA	1
Agronomist (on farm/on station)	IITA	1
Farm Manager	IITA	1
Multipurpose tree specialist	ICRAF	1
Agroforester	ICRAF	1
Agroforestry Network Coordinator	ICRAF	1
LOCAL		
Agroforesters	IRA	2
Soil Scientist (Fertility)	IRA	1
Soil Scientist (Chemistry)	IRA	1
Anthropologist	IRA	1
Agroeconomist	IRA	1
Plant Geneticist (groundnut)	IRA	1
1b Proposed Project Post		
		1
Site Coordinator		1
Extension Specialist		1
Policy Specialist		

TABLE 2 Proposed staffing for USAR, ZAMBIA

STAFF	INSTITUTIONS	NUMBER
1a Current (1993) Allocations		
Soil Scientists	NORAD	1
Plant Breeder	ICRISTAT	1
Agroforesters	ICRAF	2
Soil fertility	IFDC	1
Cropping Systems Agronomist	DOA	1
Anthropologist	DOA	1
Agroforesters	DOA	2
Agroeconomist	DOA	1
Soil Scientist	DOA	3
Microbiologist	DOA	1
Farm Manager	DOA	1
2b Proposed Project Posts		
Weed Scientist		1
Soil Microbiologist		1
Site Coordinator		1

5. EXPECTED OUTPUT

5.1 Carbon Balance

1.1. Preproject Status - the tropical rain forests and woodlands of Africa make a significant contribution to the accumulation of greenhouse gases because of a net emission of carbon as CO2 from biomass burning and SOM oxidation. Traditional slash and burn agriculture with long fallow periods and 1 to 2 years of cultivation maintained a balance between carbon emission and storage by photosynthesis and SOM formation. Shortening of fallow periods with increased frequency of burning and continuous cultivation without appropriate soil conservation has resulted in a change to net carbon loss. This net loss has been accelerating over time, and no promising technologies to change this trend are on the horizon. The total forested area is declining rapidly, the deforestation rate having almost doubled during the last decade from 7.0 million ha/year in 1979 to 13.9 million ha/year in 1989 (25).

1.2. Postproject Status - Land-use systems which restore the equilibrium of carbon exchange in favour of net storage in vegetation and SOM will be available. Agricultural production systems will have been tested which enable permanent or semipermanent cultivation of land. These systems, which will favour soil conservation and the build up of SOM will remove the need for burning of fallow vegetation, will reduce loss and promote storage of carbon. Increased efficiency of agricultural production per unit area of land wil also enable greater areas of forest and woodland to be conserved.

2. Food Sufficiency and Soil Fertility

5.2.1. Preproject Status - There is a major shortfall in per capita food production (food insecurity) for the small-scale farmer of the forest and woodland zones of Africa which is being continuously exacerbated by population growth in the region. The lack of appropriate methods which would permit sustained cultivation results in suboptimal levels of production which rapidly decline further as soil fertility degrades and pest and weed problems increase. Under circumstances where fallow periods are becoming shorter, the opportunity to reverse these effects is lost.

5.2.2. Postproject Status - The project will generate a series of tested cropping systems capable of producing sufficient food to meet needs of the small-scale farmer and generate income. Continuous cultivation will be promoted by the incorporation of soil-management practices which utilize both organic and inorganic supplies of nutrients and ameliorate such problems as soil acidity.

5.3. Impact and Adoption of Research Findings

5.3.1. Preproject Status - Several decades of research by International Agricultural Research Centers (IARC) and NARS in Africa, in addition to similar work in other parts of the tropics, has generated many technological solutions to the problems posed in this project. Nevertheless, the rate of adoption by small-scale farmers in Africa is very low. To date the research has had a low impact in many regions.

5.3.2. Postproject Status - The project will produce guidelines for participatory research with farmers to assist in the identification, development, and adoption of technology by small-scale farmers of the forested woodland zones of Africa. It will have demonstrated the effectiveness of this research on selected pilot areas representative of large sections of the humid tropical forests.

5.4. Institutional Capabilities

5.4.1 Preproject Status - Research on sustainable agriculture in Africa is of high-quality but suffers from lack of resources, fragmentation, and focus of effort. Lack of interdisciplinary activities, poor communication, and barriers to interaction within and between the institutions concerned with research and extension all contribute to a low efficiency as measured by successful impact. Staff in NARS may be trained in one or more areas of specialization but often lack the interdisciplinary and holistic perspective to focus on sustainable agriculture demands.

5.4.2 Postproject Status - Intensive training to broaden perspective and technical expertise for research in sustainable agriculture will have reached a large number of scientists from national programs by the end of the project. In addition, 12 postgraduate students will have completed their training. The project will also have established a Unit for Sustainable Agricultural Research (USAR) and Policy Analysis Units (PAU) in three countries. The units will have the capacity for interdisciplinary research into all areas relevant to sustainable agriculture and will have established mechanisms for effective collaboration with extension services and policy, makers in their own countries and with IARCs in the region.

5.5 Policies

5.5.1. Preproject Status - Policies for productive development of the forest zone of Africa in the past have effectively promoted tree-based plantation products, such as oil palm, cocoa and timber. Policies which would facilitate the emergence of a self-sufficient and market-oriented food-production sector in this zone have been less well developed. Nevertheless, the zone support's some of the highest (as well as some of the lowest) population densities, in sub-Sahara Africa. The economy produced on plantations is in decline due to changing world prices while the demand for food is increasing.

5.5.2. Postproject Status - The project will produce an evaluation of the policy determinants for sustainable food crop production in the forest and woodland zones and the relationship of this sector with others within the agricultural economy. In particular, policy determinants will be in place that will allow cost-effective and environmentally safe systems, incorporating where relevant, agroforestry, continuous monocropping, and/or rotations.

6. BUDGET

6.1. The project is costed or requiring US$ 14.5 million over a five year period. This is matched by counterpart contributions from the partnership institutions of more than

US$ 16 million. This total is based simply on a five year multiple of the 1993 budgets as listed below.

6.2. The Budget for Cameroon for 1993 is summarised in Table 3 and for Zambia in Table 4. Annual contributions from participating institutions amount to US$ 2.13 million in Cameroun, and US$1.14 million in Zambia. These are minimum estimates as they take no account of the costs to IITA, IRA or DOA of maintaining buildings and farm facilities. ack-up resources from ICRAF, IITA, IFDC and TSBF for training, modelling and scientific expertise other than that listed is also not included.

6.3 The personnel entries are costed on the basis of current national and/or international packages, and associated operational and equipment costs are also given. The entries are based on the staff numbers given in Tables 1 and 2.

6.4 The required project costs are for:

a) Three posts per site (as designated in Section 4.2) costed as international scientist positions, plus operational and equipment packages.

b) Operational and equipment costs intended to enable national scientists to function within the USARs.

c) Training cost to cover PhD and MSc programmes and group training courses.

TABLE 3 PROVISIONAL 1993/4 FOR CAMEROON PROJECT
($ 1000s)

CONTRIBUTIONS	IITA	ICRAF	IRA	PROJECT	TOTALS
PERSONNEL	500	300	100	300	1200
OPERATIONS	500	300	30	650	1480
EQUIPMENT	250	150	-	220	620
TRAINING	-	-	-	200	200
TOTALS	1250	750	130	1370	2500

TABLE 4: PROVISIONAL 1993/4 BUDGET FOR ZAMBIA PROJECT
(US $ 1,000Ss)

	CONTRIBUTIONS								
	NORAD	TSBF	IBSRAM	ICRAF	IFDC	ICRISAT	DOA	PROJECT	TOTALS
PERSONNEL	100	-	-	200	100	25	300	300	737
OPERATIONS	100	50	10	200	100	25	800	800	1295
EQUIPMENT	50	-	-	100	50	12.5	220	220	432.5
TRAINING	-	-	-	-	-	-	200	200	200
TOTAL									2664.5

ANNEX 3

SUSTAINABLE LAND USE ALTERNATIVES TO SLASH AND BURN IN ASIA

A Regional Project Proposal

as part of a

Global Strategy on

Alternatives to Slash and Burn

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PROJECT IMPLEMENTATION FRAMEWORK

Date: 25 May 1992

Title:

Sustainable Land Use Alternatives to Slash and Burn in Asia

Implementing Organizations:

International Rice Research Institute - IRRI

International Centre for Research in Agroforestry - ICRAF

International Fertilizer Development Center - IFDC

Philippine Departments of Agriculture and Natural Resources and Universities

Indonesian Ministries of Agriculture and Forestry, and Universities

Thailand Department of Agriculture and Universities

Asian Coalition of Non-governmental Organizations in Agrarian Reform and Rural Development

Estimated Duration: Five years (First Phase)

Donor Contribution: US$ 13,665,000

This component of the global project was initially developed during a consultative workshop at IRRI on 12-13 February, 1992, with the participation of representatives of the agriculture and forestry departments/ministries of the implementing countries, a representative of the Asian NGO Coalition for Agrarian Reform and Rural Development, and the international research centers. It was further refined and finalized during the global workshop on Slash and Burn held from 17-21 February, 1992.

SUSTAINABLE LAND USE ALTERNATIVES TO SLASH AND BURN IN ASIA

A. Regional Issues

The clearing of tropical rainforests is a phenomenon of deep ecological and economic concern in Southeast Asia. Deforestation in developing countries doubled during the last decade, from 7.6 million hectares per year in 1979 to 13.9 million hectares in 1989 (25). Six of the twelve countries accounting for the greatest aggregate deforestation globally are located in Asia: Indonesia, Myanmar, Thailand, Malaysia, India, and Vietnam (in rank order of annual forest cover loss). Together they account for an annual loss in forest cover of 3.83 million hectares. Nearly all of the primary forest cover of some of these countries will be gone by the year 2000 (44). Thirty-seven percent of the net carbon emissions from deforestation in 1980 (24) is estimated to have occurred in Tropical Asia.

The environmental degradation arising from deforestation also directly affects the sustainability of production and subsistence systems in both rural upland and urban lowland areas. The accelerated erosion, flooding, streamflow depletion, and massive siltation of hydroelectric and irrigation reservoirs, is having drastic economic effects, both upstream and downstream, decreasing food availability, income, and employment (54).

But the upland forests serve as major food and fuel sources for poor indigenous and inmigrant communities. Seventy percent of the recent disappearance of closed forests in Asia can be attributed to conversion to agricultural uses (51). The forest resources that remain in Southeast Asia are located in the sloping uplands, which cover 60-90 percent of the land area of the respective nations (Figure 1). The rapid increase in small-scale farms with insecure land tenure, whose primary imperative is the production of the family food supply, has resulted in widespread unsustainable cereal-based farming systems on the acidic, infertile soils of these lands (30). Upland rice is the basic food crop on most slash and burn farms, with lesser areas in maize and root crops. Sustainable alternatives to slash and burn must enable upland populations to produce their rice and other food requirements on less land, reducing or eliminating the need to destroy remaining forest.

The loss of forest cover on the sloping uplands of most countries in Asia is exacerbating serious land degradation through accelerated soil erosion. The river systems of mainland Southeast Asia currently discharge over 3.2 billion tons of sediment annually to the sea (Figure 2), those of the island nations 3.0 billion tons annually, amounts that dwarf those elsewhere in the world (35). Soil loss from deforested sloping lands under intensive food crop cultivation typically exceeds 75 tons per hectare per year (30, 36). The land is typically clean cultivated for a large part of the year. Overgrazed and burned grasslands also account for severe soil erosion, and are estimated to be the most significant source of soil loss in the Philippines (37).

The negative effects of upland soil erosion rates and nutrient removal, due to inappropriate land use practices, are directly felt in the uplands through continuous decline in the productive potential of the land (38). They also produce major negative externalities that affect the lowland and coastal areas downslope. Deforestation in the Philippine uplands has been found to be linked with a reduction in the amount of irrigable riceland (39), due to the silting of irrigation reservoirs. The accelerated elevation of riverbeds by silt deposition worsens the flooding potential of major rivers. Thus, finding pragmatic ways to slow or reverse the loss of tropical rainforest is one of the principal global environmental concerns of our time.

The nations of tropical Asia are strongly cognizant of the seriousness of their upland deforestation and land degradation problems. Major progressive changes in national forestry policy have recently been made in several countries. And important research has been done on the generation of promising technologies that would enable large areas of rainforest to be spared. But unfortunately, the knowledge base is far behind the public and private will to responsibly implement change (34).

Such knowledge, to be useful, must be derived through research that is holistic, people-centered, problem-solving, interdisciplinary, interactive, and responsible to society (52). This calls for a new research paradigm around which to structure the work. The framework must be comprehensive enough to elucidate the natural, agricultural, and human ecological interactions, and identify comprehensive solutions that will apply at both the national and local levels. The framework must bring scientists and development specialists from the agricultural, forestry/environmental sectors together in strongly knit teams, to tackle the policy and technical issues jointly. It must provide strategic locations in key watersheds where these teams will work in direct collaboration with local resource managers, foresters, and farmers. And it must provide for strong backward and forward linkages between a coordinated research structure at the research sites, the national level, and the international level.

This project was conceived to provide such a model. It was developed as part of a comprehensive global effort by the International Agricultural Research Centers to combat the increasing rate of deforestation and upland environmental degradation (43). The project is directed specifically to Asian conditions, but we anticipate that the principles and solutions derived will be applicable to the other regions of the tropics, and will draw important methodology and knowledge from the global component of the project.

The work will be a collaborative effort between a consortium of three key national research systems (Indonesia, Thailand, and the Philippines), international centers (ICRAF, IFDC, and IRRI), and non-governmental organizations. Field research will be based in three strategic research sites in Southeast Asia, one site in each nation selected to represent the unique conditions of the major eco-geographic forest zones of the region: The equatorial tropics, the mid-tropics, and the northern tropics. The work is anticipated to be part of the global program that will also include research at strategic sites in Africa and Latin America (43).

B. Goals, Objectives, and Research Model

The project is proposed as a Southeast Asian regional effort, within the framework of the global program on 'Alternatives to Slash and Burn' (43). The time frame is 15 years, recognizing the long-term nature of the work required, with an initial phase of 5 years.

B.1 Goal

In the Asian context the project goals are:

A reduced rate of deforestation, rehabilitation of the degraded uplands, advanced welfare of Asian populations, and an enhanced global environment.

To achieve these goals a number of strategies must be pursued a the national level. These include land-use and economic policies that induce economic growth, reduced population growth rates, and agricultural production and settlement in less fragile environments. The project will put mechanisms in place to embody the strategic and applied research outputs in technologies and policy recommendations that are implementable at the national and local levels.

B.2 Objectives

1. Develop a comprehensive understanding of the agroecological, farm-level, and macro-level factors influencing the dynamics of major land use systems in the tropical uplands.

2. Document the degree of environmental degradation of the current land use systems, and to what degree alternative systems will alleviate it.

3. Review, identify, and refine, in collaboration with farmers and others, sustainable land use systems that are feasible, acceptable, and environmentally sound alternatives to slash and burn systems.

4. Identify and further develop appropriate institutional structures to facilitate a successful shift to alternative production systems, and their adoption by the upland resource users.

5. Strengthen the networks currently working in different Southeast Asian countries to better evaluate and validate methodologies and technologies for improved resource management systems.

B.3 The Research Model

Systems approach. Interrelatedness and complexity are fundamental conditions of the land use problems of the sloping uplands and recognition of these realities must govern any valid approach to generating solutions (53).

Many of the future research and development challenges of the Asian uplands must be dealt with at the interface between forestry and agriculture.

The upland farm family places primary emphasis on subsistence food crop production. But the land use systems that result from pursuing these needs are the least sustainable alternatives. More secure farming systems can be evolved and deforestation rates alleviated by eliminating the need to abandon cleared land. For the upland farming populations to become effective partners with government in conserving, managing, and replanting forest, a holistic understanding of the constraints and workable solutions, is imperative.

Systems evolution. The issue from the policy, research, and extension perspectives, is how to enable the farm enterprise to move profitably along a trajectory that will continually increase the area of perennials, including trees, and achieve a sustainable farming system. Sustainable food crop systems in the sloping uplands require simple conservation farming practices, improvements in nutrient conservation and cycling, and enterprise diversification toward mixed farming systems. Technology for improvement in a shifting cultivation system will differ from that for permanent field cultivation, due to major differences in labor and land use intensity. Shifting cultivators maximize their returns to labor rather than to land, and resist inappropriate labor-intensive technologies (29).

An upland ecosystem-based approach to international and national research is required (30). The work will employ a sustainable land use systems research methodology (42) that provides foresters and agriculturists a common action framework. The research will be linked with the development-oriented activities of non-governmental organizations, and government agencies involved in extension, and infrastructural support. The research will employ a farmer-participatory approach. Farmer-directed experiments will be emphasized that complement conventional research methodologies and draw upon indigenous technical knowledge (55, 48).

Watershed framework. The watershed is the natural unit upon which to base a systems research effort, due to the interconnected nature of all land-use within a catchment, particularly the interplay between upland and lowland areas. Typically, a watershed is composed of a series of recognizable agroecological zones: The coastal plains, dominated by irrigated wetland rice systems; a zone of permanent upland cropping on flat to gently sloping well-drained soils; the sloping uplands dominated by grasslands, and shifting cultivation, incipient permanent-field farming, and perennial crops such as coconuts; the secondary forest zone; and at the highest elevation, the remnant primary forest zone. Social, political, and economic variables, as well as ecological ones, determine the interplay of land use systems within the catchment area (54).

The body of research on the upland ecosystem, including that conducted by the collaborating agencies, already provides a sound basis for sustainable technologies. An array of agroforestry technologies are under development by the collaborating national and international institutes and research consortia in the region, many of which improve upon the most sustainable systems that farmers have

indigenously evolved. The concept of hedgerow farming systems has now been extensively tested, and experience indicates that there are a wide range of species of choice in hedgerow enterprises that are effective in soil conservation (31, 32). Improved cultivars of upland rice, cassava, cowpea, and other crops are now available, and the value of selected acid tolerant trees in increasing the efficiency of nutrient cycling and maintaining soil organic matter has been demonstrated.

The project will develop collaborative relationships to foster the development of a national network of on-farm 'field laboratories' in a range of selected watersheds, where research and development teams can focus effort in a critical mass. The work at the strategic research watershed will be linked to the applied research and extension nationwide.

Forestry research linkages. The primary function of the forest industry in most countries has been the extraction of high value timber from old growth forests. The project will accelerate research on both technical solutions and management systems to provide sound bases for the new directions in sustainable forest management, including restoration systems for degraded secondary forests, the ecology and management of fire, and technology to develop farm forestry.

Inter-institutional framework. A national coordinating structure to approve, manage, and exploit the research will be created in each participating country. This will be institutionalized to provide a permanent framework to support national efforts. Within the university community the project shall initiate or strengthen joint academic and research programs targeted on the upland ecosystem, drawing from the colleges of agriculture and forestry.

Structured mechanisms for research collaboration between professionals in the government departments of forestry/natural resources and agriculture will be developed. This will be fostered through Upland Working Groups, building on mechanisms as have evolved in the Philippines over the past decade (Gibbs et al., 1990).

Land tenure interactions. Land tenure issues shall be a major focus of project research, particularly the effects of alternative tenurial instruments on upland farm viability and sustainability, acceptance of improved management systems, and sustainable forest management and protection. Process-oriented research is needed to refine methods by which communities, cooperatives, and NGOs can organize to manage common resources, particularly remaining forest areas in their vicinity. Research on the linkages between population, tenure, and technology, is needed to strengthen the database supporting progressive policy change. Since there is significant work in progress on these issues in the Asian region, this project shall include policy research only on those topics that complement on-going work.

New international research model. A focus on the Southeast Asian upland ecosystem does not fall within the mandate of any CGIAR center. Since the complex problems of upland sustainability transend national boundaries, international mechanisms are needed that target the upland ecosystem as a totality, to provide more effective research and development support to the respective nations. The

project proposes a novel approach to provide this support through a consortium of instituions that unite the diverse expertise needed to address an eco-regional problem.

To efficiently share project outputs, and obtain guidance from outside the consortium, the project will be strongly linked with a number of networks active in the Southeast Asian region (26). The network linkages will include the Asian Rice Farming Systems Network (ARFSN), the Southeast Asian Universities Agroecosystems Network (SUAN), and the Multipurpose Tree Species (MPTS) Network, the Asian Soil Conservation Network (ASOCON), among others.

C. Project Activities

C.1 Selection of Research Watersheds

The land use strategies evolved in the project must have relevance to major regions of the Southeast Asian tropics, and indirectly, to analogous zones in tropical America and Africa. The project will begin with a characterization of the state of the environment and of current farming practices for representative areas of the whole mandate zone. This will involve study of the upland areas of three major countries in Southeast Asia.

The second component focuses on defining more precisely the environmental changes which occur during the shift from long-term fallow-based agriculture to permanent or semipermanent cultivation. The third component, technology design and development, requires intensive work at sites in selected watersheds. The studies will be carried out at three strategic watersheds, selected as representative of the three major upland ecoregions of Southeast Asia, the equatorial tropics, the mid-tropics, and the northern tropics. The soils of the uplands of Southeast Asia are predominantly strongly acidic Ultisols and Oxisols, with low phosphorus availability, high aluminum saturation, low cation exchange capacity, and steeply sloping topography. These soil conditions will be represented in the research areas selected.

Proceeding north from the equator the climate generally becomes progressively harsher in the uplands, with longer, more arid dry seasons, cooler winters, and a greater threat of severe tropical storms. Northward along this gradient are also ecological conditions that are associated with slower establishment of vegetation, lower primary productivity, and a greater tendency for upland soils to lack ground cover for substantial portions of the year. The respective ecoregions along the gradient, and the collaborating countries are:

* Equatorial tropics, Indonesia.
* Mid-tropics, Philippines.
* Northern tropics, Thailand.

Within each of the collaborating countries, the selection of the strategic research watershed is based on several key criteria:

1) The watershed contains a significant zone of primary and secondary forest, and is located in a region with a relatively large area of the country's remaining forest cover.

2) The ecological conditions (human, natural, and agricultural) are representative of the broad tropical latitudinal zone, and conducive to the strategic objectives of the project.

3) The existing research infrastructure is suitable to support a major strategic effort.

4) Prospective linkages exist with the International Upland Rice Research Consortium.

The identified research locations are now discussed.

C.1.1 Equatorial Tropics: Central Sumatra, Indonesia

The equatorial rainforests are primarily located in Indonesia and Malaysia. Indonesia has 144 million hectares of forest cover. It is the second largest deforesting country in the world, with a deforestation rate of 1.2 % per year (45). Formation of extensive unproductive grasslands of alang-alang (Imperata cylindrica) has taken place . These now occupy 20 million hectares on the outer islands.

The government of Indonesia has embarked on various programs to slow deforestation. Most programs are directed to rationalization of shifting cultivation (41). Research on alternatives to slash and burn has been targeted to the transmigration areas in West and South Sumatra, where settlement is accelerating in tall Dipterocarp rainforests and Imperata grasslands. Productive crop rotation schemes have been devised with moderate fertilization (46). The reclamation of Imperata grasslands is being researched with promising results (47).

The project would build upon the research base established by the Sukarami Research Institute for Food Crops (SARIF), the Tropcial Soils Program, the Agency for Forestry Research and DEvelpment, and the Center for Soils and Agroclimate Research (CSAR) at Sitiung and other locations in Indonesia. The work will focus on sustainable land use systems for recently cleared forest lands, and the rehabilitation of degraded grasslands.

C.1.2 Northern Tropical Hill Country of Mainland Southeast Asia: Chiangmai, Thailand.

The second site in Asia will represent the totally contrasting region that includes the vast northern tropics hill country of the interior of mainland southeast Asia. This region encompasses a contiguous belt from Assam, India, through northern and

eastern Myanmar, to northern Thailand, Laos, Vietnam, and southern China. The climate is strongly monsoonal with long dry winters that are slightly cooler. Shifting cultivation is still the prevalent agricultural system. Major land degradation in watershed areas has occurred as a result of agricultural intensification on the steep terrain due to population pressure. Possible sites with infrastructure suitable for intensive research are located in northern Thailand. Potential collaborating institutions are Chiang Mai University, and the Thai Departments of Land Development, Agriculture, and Forestry.

Approximately 90% of the land area in northern Thailand is mountainous, and is classified as critical watershed area. The Ping River catchment near Chiang Mai is a prospective benchmark research area for this ecosystem. It covers an area of 33,900 km2, with a population density of 72 persons/km2. The catchment has 49% forest cover.

C.1.3 Mid-Tropics: Northern Mindanao, Philippines

The third benchmark site in southeast Asia would represent the mid-tropical monsoon latitude belt including the Philippines and southern Thailand, where population densities in the uplands are rapidly increasing, and steep terrain is being clean-cultivated in short grass fallows and incipient permanent annual crop systems.

The northern Mindanao region (Region X) has one of the largest areas of remaining forest cover in the Philippines. Two prospective watersheds are under consideration: The Mati-Matibog watershed encompassing the municipality of Claveria, Misamis Oriental, and the nearby Pulangi River Basin in Bukidnon Province. Both watersheds are characterized by moderate to steep slopes, grading with elevation from permanent and fallow rotation upland agriculture to secondary and primary and forest that is being depleted rapidly. Soils are strongly acid Oxisols and Inceptisols.

The Claveria site is the key upland farming systems research site of IRRI. It is a collaborative activity with the Philippine Department of Agriculture. Major strategic and applied research has produced a range of technical alternatives to sustain food crop farming on sloping lands. Much of this work has been done through farmer-directed research, and transfered to a large number of farmers through farmer-to-farmer extension methods (31, 32, 38, 48). A major program in Community-Based Forest Management is underway in the upper reaches of the watershed, coordinated by the Department of Environment and Natural Resources and an NGO. Also, an Australian-funded project on the development of extension methodology development is active in the northern Mindanao provinces, and will provide linkages in the transfer of the technologies developed through this project.

The Central Mindanao University MUSUAN Program has been conducting research on sustainable sloping upland farming and agroforestry systems at several sites in the Pulangi River Basin. The Pulangi River is scheduled for development of the largest hydro-electric power development scheme in the country, with six dams slated for construction. Resevoir siltation from accelerated erosion is already threatening to

shut down the first of these power-generating systems, which was initiated in 1985. Conservation-oriented farming systems will be essential to ensure that the project is a viable investment. Parts of the upper watershed of the catchment are included in the country's Integrated Protected Areas System (IPAS). Outputs of the project will link directly with the IPAS forest preservation activities.

C.2 Research Activities

Activity 1. Develop a comprehensive understanding of the agroecological, farm-level, and macro-level factors influencing the dynamics of major land use systems in the tropical uplands.

1.1 - Review and interpret the current data on the state of vegetation and land use at the eco-regional level, and complete an intensive characterization of the strategic research watersheds.

A eco-regional analysis of existing datasets and maps will be conducted to define the context of present and emerging land use patterns. Recent studies at the national level by several countries will be used as the base for the this regional assessment of the environmental state of the uplands. The data and maps will be developed and analyzed by means of a geographic information system (GIS). The distribution of different land-use systems, particularly primary and secondary forests and fallow vegetation types, will be interpreted to define research priorities among ecoregions. The eco-regional studies will be the basis for a detailed characterization of the upland ecosystems of the strategic research watersheds. The detailed characterization will guide the development of the research agenda agenda, and the subsequent extrapolation of technologies.

a) **Participation** - A research design workshop will be held to bring together collaborating scientists from the national research systems and international centers to develop and standardize the analytical methods. All current efforts to map and analyse the land and forest resources will be tapped to provide a database for study. After analyses are conducted in each country, a successive workshop will bring the collaborators back together to compare and harmonize the results. The regional-scale analyses will be done in close collaboration with remote sensing agencies and national mapping agencies.

b) **Resources** - Expertise in forest ecology/land use and remote sensing image interpretation will be needed at the regional level. GIS expertise will be integrated with the work coordinate the regional activity, drawing upon the the GIS facilities of the international centers. National level studies will be conducted by scientists of the appropriate institutions in the respective nations, who will meet periodically to develop a common methodology and share results.

c) **Output** - A reliable data base using a common scale and methodology will be made available on the region's land use systems, vegetation characteristics, and their distribution in the humid, subhumid tropics of Southeast Asia.

Published interpretations will be available on upland land use trends, and the factors controlling them.

1.2 - Develop, analyze, and harmonize knowledge on current resource management systems.

Diagnostic studies will be conducted using modern agroecosystems analysis and rapid rural appraisal techniques to develop a comprehensive understanding of the structure of upland agricultural systems, and the determinants of farmer decision-making. The studies will be conducted in the strategic watersheds to provide a detailed characterization of the technical, social, and economic constraints to more sustainable upland farming and forestry systems. Emphasis will be on the solutions that farmers have indigenously developed to cope with the complex circumstances of their environment. The work will provide direction to the technical and policy research phases of the project.

a) **Participation** - Diagnostic methodologies pioneered by the collaborating international and national centers will be employed, building upon the existing base of upland studies. Joint participation in these studies will be explored with the regional networks, particularly the Southeast Asian Universities Agroecosystems network (SUAN), drawing upon the available expertise of the five participating universities in agroecosystems analysis of upland systems. The studies shall also draw upon the work of national groups such as the Research Group on Agroecosystems (KEPAS) in Indonesia.

The studies will be organized and conducted jointly by international and national scientists through each of the respective national research systems. A training workshop will be held at the commencement of the program to refine a common methodology and train the collaborating institutes' personnel. Another workshop will be held at the end of the activity (year 3) to collate and synthesize information across sites.

b) **Resources** - Social scientists from each of the participating national program will be involved. They will be supported by the social science programs of the international research centers in training and synthesis workshops. The national research systems will provide staff resources for the in-country data studies.

c) **Output** - Detailed analyses and classification of the resource-management systems employed by rural upland populations in representative locations in Southeast Asia, and the distribution of these systems across different agroecological regions of the region, will be published. Systems diagnoses will have been published and used in research design and technology extrapolation.

1.3 - Analyze the policies, including legal and land tenure issues, influencing the utilization of upland resources.

In-depth policy studies on specific aspects of the identified problems will be undertaken through a regional upland policy research initiative. Current policies impinging upon land use systems in the uplands will be analyzed, and specific policy options developed and documented. The policy framework will include agricultural and forestry policy interactions, population policies (including migration and resettlement), and land tenure. The work will include an assessment and identification of the policy decisionmaking process, and the means for policy implementation.

Some major portions of this work are being attempted through other related projects in the region. Each country has a natural resource management project which is conducting social forestry and forest policy research. Therefore, this project shall complement and draw from the related work to provide a more regional and global synthesis.

a) **Participation** - Each of the participating international centers will contribute expertise on specific policy aspects: ICRAF on land and tree tenure issues, IFDC on fertilizer policy, IRRI on food policy. Links will be established with the new international forestry institute (CIFOR) for forest policy issues. National institutions of the collaborating countries will participate in the areas of their expertise, for example the Philippine Forest Developent Center. The work will be linked with the resepctive USAID-funded Natural Resource Management Projects in each country.

b) **Resources** - A social scientist will lead the policy effort at the regional level, linking this work with the national-level policy development work engaged in by social scientists of the national centers. National scientists will be involved in developing major studies related to a range of policy issues.

c) **Output** - The policy determinants influencing the choices in production systems made by small-scale resource users will be thoroughly analyzed, and prospective policy options that are conducive to the adoption of sustainable land use systems that alleviate deforestation will be proposed. This work will feed into the strengthened mechanisms for policy generation and implementation that are anticipated as outputs of Activity 4.

Activity 2. Document the degree of environmental degradation of the current land use systems, and to what degree alternative systems will alleviate it.

Environmental degradation of the uplands negatively affects the global environment, inadvertently reduces the quality and value of the resource base in the lowlands, and permanently lowers the stock of productive land resources in the uplands. The quantitative extent of these negative effects is not scientifically documented. The watershed research infrastructure generated through this project will provide a efficient base for research to estimate the emission of carbon dioxide and other greenhouse gases to the global CO2 pool as a result of deforestation,

shifting cultivation, and derived agricultural systems. This requires estimating the volume of emissions of CO2 from vegetative biomass destruction and SOM oxidation due to current practices, and determining the changes in biological, physical and chemical properties of the soil under the alternative systems proposed. This work will be undertaken in collaboration with the International Geosphere-Biosphere Program core projects, particularly the Global Change and Terrestrial Ecosystems (GCTE) and International Global Atmospheric Chemistry (IGAC) Projects.

The information on land use and nature of upland vegetative cover obtained in Activity 1 will be utilized. Appropriate models, including GIS, will be employed to spatially estimate carbon emission loads from biomass destruction in slash and burn and other agricultural practices. The quantity of SOM and its quality (determined by fractionation into different components) will be measured annually for 3-5 years from the initiation of field experiments in a variety of agricultural systems. However, it is recognized that these measurements must be done over a long period to be truly meaningful.

Measurement of the rates of change of the biotic and abiotic determinants of environmental degradation in the major upland agricultural systems will be accomplished. Weed ecology in shifting systems is a major driving force, and the factors governing weed infestation and population shifts will be thoroughly characterized. Emphasis will also be given the underlying ecological processes governing resource stocks and flows in the system, including changes in associated soil chemical and physical properties. For systems with long fallow cycles, comparative studies of different sites at various stages of the crop/fallow cycle will be substituted for time series data collection at a given site. The information will validate dynamic models of soil processes, resulting in a greatly improved capacity to predict the loss and storage of C and nutrient elements in deforested soils managed in different ways.

Human populations and their livelihood are part of the environment. Environmental degradation will also be measured in terms of the degree of negative effects on the social and cultural systems of upland populations.

a) **Participation** - This activity will be carried out through the GCTE and IGAC Projects. Separate funding for the instrumentation and experimentation will be sought through these projects. All the institutes participating in the research consortium will be involved. Collaboration with the modeling groups of TSBF, ICRAF and IFDC is also envisaged. A training workshop on monitoring and modeling soil property changes is planned.

b) **Resources** - The work will involve participation of the project's soil scientists, working at the strategic sites. Further contributions will be made by the soil scientists and agronomists of the international and national research centers, particularly those based at the benchmark sites. Operational resources are anticipated to be provided through the GCTE.

c) **Outputs** - The outputs will include estimates of the potential contribution of slash and burn and other upland agricultural systems in Southeast Asia to global

emission of CO2, and a detailed characterization of the environmental constraints under different production systems, and soil and crop management practices at the strategic watershed, extrapolated to the eco-regional level. This will be complemented by an analysis of the prospective social and economic degradation in the study areas due to agricultural systems under pressure.

Activity 3. Review, identify, and refine, in collaboration with farmers and others, sustainable land use systems that are feasible, acceptable, and environmentally sound alternatives to current slash and burn systems.

3.1 - Review with the intent of building upon past research and development efforts to provide alternatives to environmentally damaging resource use systems.

A large store of knowledge and experience pertinent to slash and burn alternatives has accumulated from numerous previous projects. The project will conduct an in-depth review of the previous work, and distill this into comprehensive analyses that will provide a basis for research design.

3.2 - Further develop alternative and rehabilitative systems that incorporate ecologically-integrated resource management practices.

Research will focus on developing 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-directed and research-directed experimentation, building on farmer technical knowledge as well as researcher expertise. The alternatives explored will include agro-silvicultural, agropastoral, agro-silvo-pastoral, and reforestation systems. The systems evaluated under more densely settled conditions will emphasize conservation-oriented farming systems, including contour hedgerow intercropping, that involve food crops in association with perennial horticultural crops, timber trees, forages, or natural filter strips. The cropping systems given emphasis will involve cereal crops in association with leguminous forage and grain crops in intercropping, relay cropping, and sequential systems; and improved fallow systems involving legume cover crops or trees. The agroforestry systems will also include detailed study of multistrata home garden systems.

All these systems will be designed utilizing improved and local stress environmentally stress-tolerant (particularly acidity tolerant) cultivars of crops (rice, maize, mungbean, cowpea, cassava, groundnut) and tree species selected from the on-going national crop improvement programmes and the genetic improvement programs of the consortium members. Fodder production systems will be investigated where the scope for livestock raising exists. The systems will incorporate improved soil, water and nutrient management practices. Special attention will be given to soil conservation on sloping lands through a combination of traditional and agroforestry practices.

Conventional researcher-managed work will be essential, but equal emphasis will be given to farmer-participatory research, including farmer-initiated experimentation. Project research will be carried out predominantly at on-farm laboratories at the key sites, rather than at experiment stations. Farmers' choices and management of the technology will provide feedback information to the adaptive research program for incorporation into the extrapolation models and to guide further research. People's organizations, and NGO and private sector partners, will be directly involved in the research, incuring that the local communities' perspectives are fully articulated.

a) **Participation** - The more strategic and intensive aspects of the work will be undertaken at the strategic watersheds in Indonesia, Philippines and Thailand. In each of these countries this activity will benefit from the on-going crop improvement programmes in the national and international institutes. The project will also benefit from Winrock's F/FRED programme and the ACIAR tree species testing projects. Wider evaluation of improved systems will be encouraged through collaborative research activities at sites of the Asian Rice Farming Systems Network (ARFSN), and the International Network for Sustainable Rice Farming (INSURF). NGOs have a comparative advantage in action research in collaboration with farmers. Much of the farmer-participatory research will be done through joint NGO-research institution collaboration.

b) **Resources** - This activity will require the full-time involvement of an agronomist and an agroforester at each benchmark site, and one full-time social scientist across sites.

c) **Output** - The output will include specific recommendations on appropriate sustainable land use systems that are targeted to the array of upland ecoregions of the humid tropics, including selected components of systems that are viable alternatives to shifting cultivation.

3.3 - Further develop integrated soil and nutrient management practices for the alternative production systems based on a better understanding of biological processes and nutrient cycling.

Efficient use of resources endogenous to the farm is a key element in viable limited-resource upland farming. A thorough understanding of the nutrient cycling processes in shifting cultivation systems will be obtained from field experimentation and modeling studies. The potential for much greater efficiency in exploiting the soil biota and organic matter will be studied, including enhanced biological nitrogen fixation, mycorrhizal association and P nutrition, and organic matter turnover.

Sustainable production systems for the fragile uplands require the efficient use of exogenous as well as endogenous resources. The development of technologies to achieve this requires strategic studies on the relationships between levels of plant residues, fertilizer inputs, and tillage methods that ensure synchrony between nutrient supply and demand, while conserving those nutrients that are not immediately used in the production processes. Major emphasis will be placed on maximization of nutrient use efficiency through exploitation of the interactions between inorganic inputs

and amendments (fertilizers and agrominerals), organic residues (crop residues, tree prunings, manure, etc.) and soil organic matter (SOM).

Specific aspects to be studied include the factors influencing fertilizer use efficiency, losses and balance; biological nitrogen fixation (BNF); P nutrition, especially use of phosphate rock; beneficial and adverse effects associated with the use or lack of use of fertilizers and other nutrient inputs.

Assessment of the comparative sustainability of alternative production systems will include the socioeconomic as well as ecological and agronomic factors which influence the sustainability of crop production and maintenance of the resource base. Specific activities include examination of soil organic matter maintenance; maintenance of soil physical properties including structure and porosity; changes in soil floral and faunal activities and populations; changes in levels of pest infestation, particularly weed flora and density; economic benefits of fertilizer use as well as labor use in prospective technologies.

(a) **Participation** - Scientists of the international and national research institutions will work in collaboration at the benchmark sites in the strategic watersheds.

(b) **Resources** - A team of soil resource specialists in the areas of soil microbiology, fertility, chemistry and physics will provide leadership to research at each of the strategic research sites.

(c) **Outputs** - The work will provide published guidance on the management principles and practices for the endogenous resources of organic matter, as a basis for the design of sustainable production systems. Component technologies on soil, water and nutrient management that can be incorporated into the design of potential prototype systems. Process parameters for incorporation into simulation models which will enable the isolation of climate, environmental and economic variables and thus allow a thorough assessment of risk for the various alternative productive systems.

3.4 - Develop conceptual and deterministic methods to guide the analysis of systems sustainability and the extrapolation of the alternative production systems developed through watershed-based research.

Systems models will be developed, refined and adapted to the alternative cropping systems under evaluation to assist in the assessment of the impact and sustainability of technology alternatives, on production and on the resource base, and to support research prioritization and the extrapolation of results. Model development will be based on existing models to simulate carbon dynamics and associated N, P, and S cycling in soils; crop production models which describe the influence of agroclimatic and soil variables on crop growth and production; and models which evaluate the costs and benefits of alternative production systems and the inputs required to sustain them.

The modeling activity will involve identification of knowledge gaps on particular biological processes; adaptation of existing models to alternative cropping systems; linkage of soil process models, crop production models and econometric models to estimate biological productivity and economic returns of alternative technologies; application of the farming systems models to the evaluation of risk factors associated with different management systems and agricultural practices.

(a) **Resources** - A scientist specializing in modeling soil and crop processes will coordinate this activity, which will involve contributions of the soil scientists, agronomists, agroforesters, and social scientists participating in the site-based research efforts.

(b) **Outputs** - Methods will be released that can be used to evaluate degradation of the soil resource base, and the productivity and sustainability of alternative agricultural practices in relation to both technical and socioeconomic criteria.

3.5 Determine the factors affecting adoption of technology, and develop improved extension methods.

Adoption of improved technologies to prevent further degradation and rehabilitation of degraded land resources are determined by various factors which include policy, support servces, participation of farmers, and appropriateness of the technology. Most research activities relating to these factors has been concentrated on technology generation. Research will also be conducted to determine more effective extension methods for the transfer and adoption of improved technologies.

(a) Participation - The work will be led by agricultural anthropologists and NGO staff working within a team that includes researchers, extension staff, and farmers.

(b) Outputs - Identification of the major factors affecting the adoption of technologies, and improved methods of transferring knowledge about improved farming methods among farmers.

Activity 4. Identify and further develop appropriate institutional structures to facilitate a successful shift to alternative production systems, and their adoption by the upland resource users.

4.1 - Build the institutional capacity to conduct in-depth sustainable land use systems research and development within a strong inter-disciplinary and inter-institutional framework.

(a) **Participation** - The project will emphasize the training of scientists and extensionists through support for numerous post-doctoral fellowships, graduate research assistantships, and short-term training experiences. On-the-ground research in the strategic watersheds will be the focus of much of the training, which will in addition contribute directly and substantially to accomplishing the project research objectives.

(b) **Resources** - A substantial portion of the project budget shall be targeted to training activities at a number of levels.

(c) **Outputs** - A large pool of trained scientific manpower adept at investigating upland sustainability issues with a systems perspective will have been developed in each collaborating country.

4.2 - Strengthen current interdisciplinary and cross-institutional mechanisms for coordinating upland research and development within the collaborating countries.

A major endeavor of the project will be strengthening the coordinating mechanisms for upland research and development at the national level. The strengthening of national level working groups will be an integral part of the strategy for the implementation of activities addressed in the preceding objectives. The working groups will have representation from both the agriculture and forestry sectors, and will involve policy makers, researchers, extensionists, NGOs, farmers' organizations, and members of the private sector.

The policy advisory bodies at the national level identify and research the policy options to technology adoption. More importantly, through their involvement in this activity, and their positions of influence in their respective countries, they help create a policy environment conducive to the adoption of alternative technologies and systems. In particular, they will bridge the gulf between researchers and policymakers so that new technologies and systems can receive the necessary policy support for their successful and sustainable adoption. These committees may be constituted as part of the Upland Working Groups.

(a) **Resources** - Most project scientists will spend a portion of their time in the development of the Upland Working Groups. A project social scientist will play a major coordinating role in the institutional strengthening activity.

Mechanisms will be in place for analyzing policy constraints to the adoption of alternative technologies will be made operational, and functioning working groups within participating countries that are capable of providing guidelines for policy analysis and implementation to their respective governments.

(b) **Output** - Functioning upland working groups in the collaborating countries that are capable of conducting sustainable interdisciplinary research and extension beyond the life of the project.

Activity 5 - Strengthen and utilize the existing networks in the Southeast Asian countries to share research information, methodologies, and technologies for improved resource management systems and decisionmaking.

5.1 Strengthen and utilize the existing networks.

Existing networks of upland farming systems sites will be strengthened in collaboration with the Southeast Asian countries. Key institutions and upland farming systems sites in Myanmar, Laos, Vietnam, Cambodia, and southern China will be linked with the project strategic research sites, and ongoing sites in Indonesia, Philippines, and Thailand. At each site, diagnostic studies will be conducted using methods developed at the strategic research sites, and a research agenda developed to capitalize on the fund of knowledge and methodology of the project. The Asian networking activities will also be linked into the global exchange of knowledge and experience through coordination with the other regions.

(a) **Participation** - The scientists involved in the collaboration on different network activities, and scientists from other related institutions in the region will participate. Collaborators of the Asian Rice Farming Systems Network, and other regional networks, will participate in the collaborative research activities. An interdisciplinary and inter-institution team will be created at each site, with scientists and extensionists from agriculture and forestry. Farmers will participate as members of the research teams.

(b) **Resources** - A scientist will assist in effectively implementing networking activities. Project agronomists, soil scientists, agroforesters, and social scientists will provide part-time technical support to the network activities.

(c) **Outputs** - Proceedings of all workshops will be published for distribution. Progress reports on the collaboration will be produced and disseminated. Important findings will be published in peer-reviewed publications, including international journals. Upland farming systems technology specifically-adapted to the range of subecosystems will be identified, and the research capabilities of the collaborating countries will be strengthened.

5.2 Disseminate knowledge and technology through networks of government and non-governmental institutions.

An annual workshop will be organized in collaboration with the participating institutions to review the progress of the research, identify and share innovative methodologies, clarify research issues for the scientists to focus on, and sensitize administrators and policymakers of the implications of the work. A study tour will be organized each year for collaborating network scientists to visit strategic research sites to gain insight on the emerging methods and results.

D. Preproject and End of Project Status

D.1 Carbon Balance

D.1.1 Preproject Status - The tropical rain forests of Asia contribute in a major way to the global accumulation of greenhouse gases through net emission of CO2 from biomass burning and soil organic matter oxidation. Traditional slash and burn agriculture, with long fallow periods and 1 or 2 years of cultivation, maintained a balance between carbon emission and storage by photosynthesis. The shortening of fallow periods with increased frequency of burning, and continuous cultivation without appropriate methods for soil conservation, has resulted in a shift to massive net carbon loss. This net loss has been accelerating over time, and promising technologies to change this trend are imperative. The total forested area is declining rapidly. The global deforestation rate has almost doubled during the last decade from 7.0 million ha/year in 1979 to 13.9 million ha/year in 1989 (25).

D.1.2 Postproject Status - Land use systems which restore the equilibrium of carbon exchange in favor of net storage in vegetation and soil organic matter (SOM) will be available as a result of the project. Agricultural production systems will have been tested which enable the permanent and productive cultivation of land. These systems favor soil conservation and the maintenance of SOM. They will eliminate the need for burning of fallow vegetation, and reduce the loss of stored carbon. The increased efficiency of agricultural production per unit area of cleared land will also enable greater areas of forest and woodland to be conserved. Many of these systems, particularly those involving farm forestry, will be a major sink that will capture and sequester large and increasing amounts of CO2 during the coming decades.

D.2. Food Sufficiency and Soil Fertility

D.2.1 Preproject Status - There is a major shortfall in per capita food production (food insecurity) and income among small-scale farms of the Asian uplands. This is being continuously exacerbated by population growth. The lack of appropriate methods for sustained cultivation results in suboptional levels of production which rapidly decline further as soil fertility is depleted, and pest and weed problems increase. Under circumstances where fallow periods are becoming shorter, the opportunities to reverse these effects are limited.

D.2.2 Postproject Status - The project will generate a series of practical conservation farming and agroforestry systems that will produce sufficient food to meet the needs of the small-scale farmer and generate increased income. Continuous cultivation will be promoted through agroforestry and annual crop systems employing soil management practices that utilize both organic and inorganic supplies of nutrients.

D.3 Impact and Adoption of Research Findings

D.3.1 Preproject Status - Several decades of research by IARCs and national research systems in Asia, in addition to similar work in other parts of the tropics, has generated many technical solutions to the problems posed in this project. This previous research has had limited impact due to the diversity of human and natural ecological conditions in the target ecosystems, and the lack of research to generate environment-specific technologies that are practical within the circumstances and means of small-scale resource users.

D.3.2 Postproject Status - The project will refine and disseminate recent methods that greatly increase the efficiency of participatory research with farmers. A combination of strategic and applied research will lead to the identification, development, and adoption of land use technology appropriate to small-scale farmers of the Southeast Asian uplands. The work will have demonstrated the effectiveness of this research framework in selected watersheds representative of large sections of the humid tropical uplands.

D.4. Institutional Capabilities

D.4.1 Preproject Status - Previous research on sustainable agriculture in Asia has been limited by lack of resources and suitable methodology. Within each country the responsibility for research and extension is usually a complex division of responsibilities among the forestry and agriculture departments. This complicates technology generation, and the delivery of infrastructure and services in these ecosystems. But research and delivery institutions are strengthening, and the prospects of developing successful interdisciplinary activities and reduce barriers to interaction among institutions is now very great. The national systems are now ready to employ somewhat more sophisticated research models for managing team efforts.

D.4.2 Postproject Status - Intensive training and on-the-ground research experience will have broadened the perspective and technical expertise for research in sustainable upland agriculture among the various institutions involved. A large number of scientists from national institutions will have shared these experiences by the end of the project, including approximately 100 scientists, post-doctoral fellows and graduate students. The project will also have established a national working group for upland research and policy in three countries. These units will have the capacity for sustained coordination of interdisciplinary research in all areas relevant to sustainable agriculture and forestry, and will have established mechanisms for effective collaboration with extension services and policymakers in the countries, and with the international research consortium in the region. NGOs and people's organizations will have gained greater capacity to participate directly in research efforts to solve upland problems.

D.5. Policies

D.5.1 Preproject Status - The collaborating countries have recently accelerated major policy reform in forestry and land use management in the uplands based on concepts of sustainability and social forestry. Major initiatives are planned or underway in community-based forestry, contract reforestation under local private or community management, extending more secure land use rights to indigenous communities, and leases to private settlers on public lands. Implementation of many of these efforts will be heavily reliant upon a better knowledge base of the prospective repercussions of the alternatives. Policies and implementation guidelines to facilitate a people-based strategy of upland development and sustainable forestry need comprehensive strengthening.

D.5.2 Postproject Status - The project will produce framework for the evaluation of the policy determinants for sustainable food crop and forest production in the forest and adjacent zones. Policy determinants will be in place that will promote cost-effective and environmentally safe land-use systems generating an more optimal balance of long-term flows of income and environmental benefits.

E. Project Strategy

E.1 Concerned Parties/Target Beneficiaries

E.1.1 Project Initiation

The project is a joint effort of three international centers, the national research systems of three countries, and a regional coalition of NGOs. The experience and expertise of the participating institutions is reviewed below.

Philippine Department of Agriculture and Agricultural Universities - The Department of Agriculture (DA) is the lead agency in agriculture and rural development in the Philippines. It has a network of twenty three institutions involved in research and development, particularly applied and adaptive research coordinated by the Bureau of Agricultural Research. The National Rarming Systems R & D Network is solidly established. The Department of Agriculture has institutionalized the involvement of farming communities, the private sector, and non-governmental organizations.The Central Mindanao University, located at the benchmeark watershed, has been long been engaged in pioneering research on sustainable upland farming and agroforestry systems with support from the Ford Foundation.

Philippine Department of Environment and Natural Resources (DENR) - The department manages a nation-wide upland development and social forestry program, implementing a "people-oriented forestry" perspective. The Forestry Management Bureau and the Ecosystems Research and Development Bureau are the key units in the development of social forestry practices. The Upland Development Working Group provides national leadership and coordination among government, academic, and

NGO institutions. A Rainfed Resources Development Foundation has been formed, and a nationwide Upland Farmers' Federation is now forming to provide grass-roots leadership. Research strength is provided by the Institute of Environmental Science and Management, and the College of Forestry of the University of the Philippines at Los Banos.

Thailand Department of Agriculture (DOA) - The Rice Research Institute (RRI) of the DOA has joined with IRRI in conducting strategic research on land use systems in northern Thailand through the Upland Rice Research Consortium. From a research base at Phrae and Sameong work is focussed on the upland rice crop component that is the basis of slash and burn agriculture in the northern tropics belt of countries.

Thailand Royal Forestry Department (RFD) - The RFD conducts research and development in forestry nationwide in 13 divisions and 21 forestry offices. The Watershed Conservation Division leads in research and development on degraded upland watershed areas in northern Thailand. The 'Thailand Upland Social Forestry Project' at Chiang Mai, funded by the Ford Foundation, and the 'Highland Development' and 'Integrated Watershed Management Projects' funded by UNDP, are major initiatives that will provide a base of expertise and experience for the Slash and Burn initiative. The RFD is also involved in the Asian regional network on 'Agroforestry Systems Research and Development in the Asia and Pacific', and can participate in and facilitate the research through the regional office in Chiang Mai.

Indonesian Agency for Agricultural Research and Development (AARD) - Most ressarch activities in agriculture are carried out by the AARD through research centers in the major agroecological zones. The Sukarami Research Institute for Food Crops (SARIF), through its well-equiped sub-center situated in the slash and burn area of central Sumatra shall provide the infrastructural support to the Slash and Burn Project. SARIF has a full scientific team with experience in a range of relevant research areas. It currently is responsible for acid soil management research in the International Upland Rice Research Consortium.

Indonesian Agency for Forest Research and Development (AFRD) - The AFRD is responsible for improved technology in forestry and agroforestry, with two research centers in major forest areas of the country, with centers planned for five agroecological zones. The Watershed Management Technology Development Center conducts major work on agricultural and forest systems, with emphasis on hydrological, soil erosion, and other impacts of watershed conditions.

ICRAF - The International Council for Research in Agroforestry, headquartered in Nairobi, Kenya, has global responsibilities for mitigating, via sustainable agroforestry systems, deforestation in the humid tropics and massive land degradation in subhumid and semiarid tropics in a way that farmers' needs for food, fiber, 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 Southeast Asia and the Amazon. It has played a key role in developing plans for agroforestry research in some South Asian countries, and will soon be actively involved in field research through outposted scientists in Southeast Asia. The experience and

expertise from its field research through its networks in four major ecological zones in Africa will be very useful in implementing this project.

IFDC - The International Fertilizer Development Center, headquartered in Muscle Shoals, Alabama, U.S.A., with Africa Division offices in Lome, Togo, conducts fertilizer and nutrient dynamics research throughout the tropics, placing special emphasis on the use of indigenous agrominerals and the maximization of fertilizer use efficiency through the modification of fertilizer materials and their management and interpretation with on-farm inputs. With its multidisciplinary structure, it also places a high priority on crop simulation modeling as well as the identification of policy and marketing constraints of fertilizer use and nutrient management in developing countries. All of these activities are geared to increased food production which can be sustained in an environmentally sound manner.

IRRI - The International Rice Research Institute, headquartered in Los Banos, Laguna, Philippines is the world's leading research institution on rice, the prevalent food crop upon which shifting cultivation systems are based in the humid tropics. The Upland Rice Ecosystem Research Consortium is a joint activity among four Southeast Asian countries and IRRI to conduct strategic and applied research at key locations representative of the uplands to develop sustainable upland rice-based production systems, particularly on sloping, strongly acidic soils where most of the remaining forest is located. Where appropriate, the consortium may provide a logistical base for site-based research activities envisioned in the project. IRRI has been working with national programs throughout Asia and the world in research on rice and rice-based farming systems for 30 years. IRRI staff are now stationed in many countries of Southeast and South Asia, and networks coordinated by IRRI on farming systems (ARFSN) and sustainable rice farming (INSURF) link researchers from all the countries of the region.

ANGOC - The Asian NGO Coalition for Agrarian Reform and Rural Development (ANGOC) is an autonomous, non-profit, Asian regional association of development, non-governmental organizations (NGOs) who operate at the regional, national and local levels taking into account the development framework and perspectives discussed at the World Conference on Agrarian Reform and Rural Development (WCARRD). ANGOC's internal dynamism lies in the active participation of its various networks which ensures its continuing relevance. It represents a collective effort of the NGOs in Asia to reach out to the international development scene.

E.1.2 Target Areas and Beneficiaries

The outputs of the project will be targeted to the degraded uplands and tropical forest margins, focusing on their rehabilitation through long-term sustainable land use systems that provide optimal resource and income flows to the farming populations and to the national economy. The target beneficiaries are the upland rural populations, and indirectly the lowland populations and consumers. Upland resource users will benefit through the adoption of technologies that provide sustainable flows of food and cash crops, fodder, firewood, timber, and other forest products, generating increased income and living standards. Consumers will benefit through

greater availability and sustainability of produce and forest products at lower prices, the conservation of natural and agro-ecosystems in the uplands, and ecological services in the form of reduced flooding, and more secure water sources.

Benefits derived through decreases in deforestation and soil degradation will be a major contribution to the national and global level environment. Global society, in general, will be a major beneficiary of the long-term benefits of the project, which include the enhanced conservation of natural resources, preservation of biodiversity, and reduction of greenhouse gases.

E.1.3 Direct Recipients

The direct beneficiaries of the project are the national research systems, who will have stronger institutional capacity, better researhc and development methodology, and more definitive knowledge to combat accelerated deforestation and upland degration processes. The direct recipients of the targeted outputs of the project include:

1. Employees of the national research systems (research scientists, extension personnel, NGO staff), development programs and members of the Upland Working Groups in the impact countries.

2. Employees of national institutions of higher learning in the countries having significant areas of deforesting uplands within Asia.

3. National and international policymakers of these countries.

The ultimate beneficiaries are the rural populations, and the consumers of agricultural, forest, and ecological products in the nations, and globally.

E.2 Special Considerations and Innovative Approaches

Special issues being addressed by the project include:

o The role of women in upland agricultural systems and the impact of alternatives on their responsibilities and opportunities.

In traditional upland agricultural systems, specific roles and tasks are often strongly related to gender, within the cultural framework of the people who practice these types of agriculture. Changes in the traditional system would therefore affect different members of the family differently in terms of workload, responsibilities, and income-earning opportunities. Alternatives to slash and burn systems must address the issues of equitable realignment of responsibility and opportunity such that activities that predominantly involve the female members of the family are integrated into the new systems, in such a way as to improve the quality of their lives and the viability of the households.

o A novel institutional mechanism to cope with the complex agenda of land use systems in the uplands, and integral involvement of national research systems and IARCs in the planning and execution of the project.

The project represents a pioneering effort at global collaboration (43). The highly collaborative nature of the effort will serve as a model for a more effective focus on priority research issues for sustainable development. The project will allow individual donors to pool their efforts in financing a well-focussed, coordinated program.

The regional component of the global program will be managed through an inter-institutional consortium that enables national research systems to contribute strategic research toward the solution of international problems. This mechanism will make full use of the cumulative expertise within the collaborating countries. Project outputs will achieve impact through the formation of national Upland Working Groups. Countries which have a shortage of qualified manpower, and other resources necessary for key site participation, will benefit from the shared experience available through participation in the collaborative research network.

o An emphasis on a farmer participatory approach.

Research in tropical Asia, Africa and Latin America to find productive, profitable and stable land use systems for the uplands has already produced a number of potential options. But their adoption has been meager. It is now realized that this is largely due to their inappropriateness to the realities of slash and burn farming. It is also appreciated that this outcome can only be avoided by meaningful involvement of farmers in the technology generation process itself. Therefore, the research will employ a farmer-participatory approach. Farmer-directed experiments will be emphasized that complement conventional research methodologies and draw upon indigenous technical knowledge (55, 48). The project will also place major emphasis on technology extrapolation and farmer-to-farmer methods of technology transfer, seeking not only to improve the rate of diffusion but to evaluate the factors determining success or failure.

E.3 Complementary and Related Activities

There are a number of institutions and networks active in Southeast Asia that are concerned with components of upland resource management. A regional assessment of the current work relevant to sustainable land use systems has been made (26). Several projects and institutions that will directly collaborate or link with this project have been discussed earlier in the document and will not be repeated here.

A key entity that supports a more comprehensive approach is the Southeast Asian Universities Agroecosystems Network (SUAN), a consortium of universities that is active in developing methods for the analysis of systems sustainability using agroecosystems analysis tools. Other important networks that are more technology-driven are the Asian Rice Farming Systems Network (ARFSN), supported

in large part by IDRC; the International Network for Sustainable Rice Farming (INSURF), supported by the Swiss Government; the IBSRAM Sloping Lands Network, supported in part by ACIAR; the Asian Soil Conservation Network (ASOCON); and the F/FRED Multipurpose Tree Species Network, supported by USAID. Also, many NGOs now play an important role in adapting solutions to specific local conditions (33).

The USAID-funded Collaborative Research Support Program (CRSP) on Sustainable Agriculture and Natural Resources Management (SANREM) will enable US universities to collaborate with institutions in the region on the development of landscape and watershed-based approaches to sustainable agriculture in the uplands. This project will draw strongly upon the methodology development aspects of this prospective program.

An Indochina regional upland farming systems project is currently under review by the UNDP Asian regional program. The Indochina project will strengthen research on developing sustainable upland farming systems in Vietnam, Cambodia, and Laos. The project will provide a means by which the slash and burn project may link strongly with activities in the Indochina region.

F. Budget

Alternative Land Use Systems to Slash and Burn in Asia
Project Budget
Total for 5 years (US $ 1000s)

National Inputs	Total	Donor Inputs	International Center Inputs
A. Research Personnel			
International	5862	2375	3487
National		3170	1960
4000	9130		
Operating costs			1375
500	5400	3525	
Travel		700	451
500	1651		
Equipment		1095	175
300	1570		
B. Training/Networking			
Graduate train		900	150
25	1075		
Short-term		600	100
100	800		
Workshops		500	50
100	650		
Networking		800	50
100	950		
C. Overhead			
TOTAL	3753		
5625	30841	13665	3753

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