A NATURAL RESOURCE MANAGEMENT DIVISION AT CIAT: SOME OPTIONS

This paper explores some of the options for a possible natural resource management division at CIAT. It proposes a possible goal for the division; it discusses some of the approaches the division might adopt to reach this goal, together with the rationale for these approaches; it summarizes the overall strategies of the new division; it discusses possible units within the division, and their functions, activities and outputs; it presents a selection of agro-ecozones on which the division could conduct research, together with the entry points in each; and lastly, it outlines the resource requirements and organizational structure that would be required for the division, were it to adopt a program of the kind presented.

It should be stressed at the outset that this paper's proposals are tentative. The paper presents only one scenario out of several alternatives for a resource management division at CIAT. It is not, therefore, a blueprint for CIAT's future, but a first draft intended for discussion by the Management Committee, after which it will probably need to be substantially revised. However, most of the ideas contained in the paper have been discussed in detail by the working group set up by the Director General to explore the options for a resource management division at CIAT.

Goal

The goal of the new division would be:

To participate in the generation of resource management technologies and land use strategies that will contribute to the sustainable development of agriculture in Latin America and the Caribbean, such that gains in productivity will be compatible with the long-term preservation of the resource base and with greater equity in its use.

Approaches

Four approaches or principles may be considered cardinal in the development of the division's work program.

The first of these concerns the context in which research on sustainability is conducted. Much of the research on this subject in the developed world is concerned primarily with conservation, and especially with reducing the environmental costs of the excessive use of inputs. A low-input approach is being pursued to improve the quality of food, protect soil and water resources, and enhance the landscape. Developed countries, with their food surpluses, can afford such an approach, even if it leads - as it almost certainly will - to a decline in yields. However, in developing countries, sustainability objectives must be combined with those of growth and equity. Increases in production, lower food prices, and more equitable distribution of income and other resources are targets which must be pursued at the same time as the conservation of natural resources.

Resource degradation in developing countries is often caused by the underuse of inputs, rather than by their excessive use. Declining soil fertility is widespread in many developing countries, largely because farmers cannot afford commercial fertilizers, and do not have the surplus labor (or the incentive) to develop and apply organic fertilizers. The judicious use of commercial fertilizers must increase in developing countries. Needed will be technologies which allow their most efficient use, keeping both investment and environmental costs low.

Two contrasting models of technology generation are apparent from the recent history of agricultural research. On the one hand is the 'industrial' model, whereby productivity is increased through the generation and dissemination of high-yielding varieties requiring relatively high inputs of commercial fertilizer and other chemicals, entailing the consumption of large amounts of fossil fuel energy. This model requires the adjustment of the environment to suit the needs of the crop, and so can only be applied in homogeneous production systems where the environment is relatively easily controlled. It often requires considerable investment and infrastructural development. One of the major disadvantages of this model, which is usually associated with monocropping systems, is that nutrient cycling is 'open', allowing inputs to escape through leaks. The system therefore uses energy inefficiently.

The second model is the 'ecological' one. In this model productivity levels are comparatively low, but are maintained through biologically efficient, low-input technologies based on the recycling of energy and nutrients. Crops are protected not by chemicals but by naturally occurring control mechanisms, and - as far as possible - they are fertilized by the residual nitrogen fixed by legumes. The criteria for assessing the performance of such systems include the stability of output, the efficiency of energy use and the conservation of the natural resource base, in addition to productivity. Improved intercropping or rotational systems are the natural outcome of this model.

The first model leads to substantial productivity gains in the short term, but also to problems of pollution and resource conservation in the longer term. The second model conserves resources and avoids pollution, but fails to deliver the substantial production gains needed to satisfy growth objectives in developing countries. CIAT's approach in the past has emphasized the productivity objectives and monocropping systems typical of the first model, while adopting the low-input philosophy of the second model. Because yield gains rather than expansion of the area under cultivation must increasingly become the source of growth in output, CIAT's approach in future must be 'eco-productive'; that is, it must emphasize yield increases, and the inputs needed to achieve these, while simultaneously ensuring the efficient use, and hence the conservation, of increasingly scarce natural resources. The aim will be to ensure 'tight' systems in which nutrients and other resources are retained and wastage is reduced to a minimum.

The second approach or principle on which the program could be built concerns the relationships between the private and social benefits and costs of land use. These relationships are complex, involving considerations of time as well as place. Some of the costs and benefits of agriculture, for example increased income from cereal crop yields, are felt more or less immediately, at the farm level by individual owners and their families; others, such as erosion, make their effects felt over time, and/or may be experienced chiefly beyond the farm, for example polluted water courses, increased siltation, and so on. The short-term benefits experienced by one generation may incur costs for the next.

These considerations imply that resource management research must operate at at least two levels, the macro or ecosystems level, where the social costs and benefits are largely felt, and the micro or farm level, where the private costs and benefits are felt. In addition, because the environmental effects of technology may take many years to accrue, resource management research will be long-term in nature.

Research at the farm level will be oriented toward the generation and testing of ecoproductive technology; research at the macro level will be oriented towards the development of land use strategies, which in turn impinge upon the technology options selected for research and development, and upon the policy environment fostered by governments. The values attached to different resources and products critically affect the willingness of farmers to adopt resource-conserving practices and technologies. Hence the policy environment will be an important element of research at the macro level.

The third approach concerns the way in which resource management research is planned and implemented. Such research is often more location-specific than commodity research. Horizontal networking, to cover a wide range of locations and extrapolate a regional picture, will be needed. In addition, resource management research unites the micro and macro levels, being critically concerned with the relationships between government policy, technical options and farmer behavior. This means that a wide range of protagonists, from farmers through to policy makers, must participate in the research process. The complexity of resource management research implies that a wide range of specialized expertise will be needed, with the result that more than one international research institute will often have to be involved, together with regional and specialized institutes as necessary.

The multiple objectives pursued through resource management research also imply a wider range of partners. CIAT's traditional partners, the national agricultural research institutes, are usually oriented mainly toward yield-increasing research, or in other words, growth. Equity and sustainability, on the other hand, are often the principal objectives of non-governmental organizations. Their experience in the pursuit of these objectives will increasingly make a valuable contribution to the research process.

The fourth approach is concerned with how to achieve impact. CIAT cannot conduct adaptive, location-specific research to generate technology for all locations. Instead, a case study approach will be used, whereby adaptive research in a few locations will serve to develop approaches and methods for use by others. This will be complemented by strategic research to increase our understanding of the principles of resource management for sustainable agriculture. These will be more universally applicable. Each case study will develop the necessary links between policy makers at the land use level and scientists and farmers engaged in technology development at the farm level.

Overall Strategies

The overall strategies of the new division could be summarized as follows:

To plan and conduct, jointly with other institutions, strategic research to optimize the social returns to agriculture through a better understanding of the relationships between:

- agricultural growth and resource conservation, in order to develop land use strategies and corresponding policies, as well as institutional initiatives, conducive to the adoption of technical interventions that bring lasting reductions in the social costs of agriculture

- the objectives of the production system and the technological approaches used, in order to design components and management options that bring sustainable increases in the private benefits of agriculture

To promote inter-institutional collaboration in resource management research, so that issues at the agro-ecosystem and at the farm level are simultaneously addressed

Components

The division would consist of three major components or teams: Land Use, Production Systems, and Institutional Development. Here we summarize the work of each team. Annex 1 gives details of the function, strategies, activities and outputs of each team as formulated by the working group.

Land Use

The function of the land use analysis team would be to contribute to the development of alternative land use strategies and the policies and institutional arrangements that would promote them, with the aim of integrating production systems in such a way as to reduce the social costs of using the resource base for agricultural purposes.

The activities of the team would consist of analysis of current land use, identification of sustainable and economically viable future land use, and the evaluation of technologies and policies that could contribute to this. The team would seek to characterize existing land use systems in terms not only of their natural resources but also of the economic and social forces affecting the use of these resources. This information would be used as a basis for forecasting future developments with and without technical or policy interventions. The 12-step procedure to be followed by the team in conducting its activities is given in Annex 2. The team would focus its efforts on understanding resource management in a few selected watersheds only. These case studies would be used for methodology development and training, and for the design of improved models for collaborative research. The team would also contribute to inter-institutional activities aimed at understanding the implications of different development paths for the natural resource base.

The outputs of this unit would consist of improved ecosystem information systems (EIS), guidelines for the formulation of land use policies at the ecosystem level, and information, criteria and methods useful for setting research priorities for the generation of new technology.

Production Systems

The function of the production systems team would be to contribute to the design of more productive and sustainable farming systems that combine the efficient use of improved varieties and organic and chemical inputs while protecting and enhancing the natural resource base.

The activities of the team would include the development of criteria for identifying relevant production systems, the characterization of resource management problems and opportunities, the analysis of farmers' current strategies and perceptions regarding possible innovations, research on soil-plant-animal relationships, the definition of desirable features for new technological components suitable for multi-species systems, and the study of nutrient flows and erosion rates. The team would seek to develop technologies primarily for multi-species systems. Increasing species diversity in farming systems would be a major objective. Besides strategic research, the team would conduct on-farm participatory adaptive research. The team would also act as a catalyst to forge new types of collaboration between international centers, national institutions and non-governmental organizations. Contributing to the joint planning and implementation of research between scientists from different institutions, farmers and national policy-makers would be an important activity.

The outputs of the team would be the diagnosis of existing production systems, ideotypes to guide crop improvement research, prototype production systems, models for estimating productivity and sustainability trends under different management systems, and feedback to land use specialists on the policy and environmental implications of new technologies at the ecosystems level. Major contributions can be expected to scientific knowledge on the principles that govern the development of sustainable production system, and to the development of scientific methods.

Institutional Development

The function of the institutional development team would be to support CIAT's efforts to integrate regional capacities for research on natural resources, including germplasm enhancement.

The activities of the team would consist mainly of research to develop institutional mechanisms that allow the integration of multiple research partners in the joint planning and conduct of land use research for sustainable development. The unit would develop and guide the application of institutional processes and methods for collaborative research on issues of regional importance. The identification and assessment of potential institutional partners, joint planning, inter-institutional liaison, and the development of enabling mechanisms would be important activities. In particular, the unit would seek to involve non-governmental organizations in national research systems.

The outputs of the team would include an information system on regional networks, research proposals resulting from the joint planning of research, institutional mechanisms facilitating the collaborative implementation of research, and organizational models to enhance integrated approaches to rural research and development.

Selection of Agro-ecosystems

CIAT's Agro-ecological Studies Unit has conducted research in two phases to identify the agro-ecosystems on which CIAT could focus a future resource management program. In the first phase, important environmental classes were identified and selected. In the second phase, land use patterns were determined, and plotted across classes. An agro-ecosystem is defined as the geographical area in which a single land use pattern and a single environmental class overlap.

Only the most widespread land use patterns were selected for evaluation. These were:

1. Areas of intensive agriculture, particularly sugar cane production, found mostly in lowland areas and on non-acid soils.

2. Areas of mechanized crop production, particularly coffee, found exclusively in Brazil. These are essentially highland production systems, but some more intensive lowland variants of them are also found.

3. Lowland and highland areas of extensive grazing and mechanized agriculture on acid soils. This pattern, occupying some 76 million ha, is by far the largest identified. It has a large absolute population, but low population densities.

4. Areas of extensive grazing and manual smallholder cultivation on acid soils. This pattern is also very extensive (45 million ha), with a large human population. It is found mostly in frontier areas.

5. Areas of extensive grazing and manual cultivation by smallholders in the semi-arid lowlands.

6. Highland areas of extensive grazing,shifting cultivation and perennial cropping (notably coffee) on acid soils.

These land use patterns were scored for the potential contribution research in each one could make to CIAT's three goals - growth, sustainability and equity - and for the feasibility of conducting such research. Details of the criteria used for scoring, and of the scoring procedure, are given in Annex 3. The results showed that patterns 6, 4 and 3 were of the greatest relevance to CIAT.

Pattern 6: Well-watered, Mid-altitude Hillsides

Description. Approximately 10 million ha of well-watered, medium-altitude hillsides with acid soils are found throughout Central America, the Caribbean and the Andes. About 18% of the region as a whole is covered by steep land, which accounts for more than half the area in some Andean countries. This land, which presents major difficulties for agriculture, is mainly used by small-scale farmers.

These areas are highly heterogeneous. The natural vegetation consists mostly of seasonally dry forest, with some humid or pre-montane forest. However, only some 10% of this remains. Perennial crops account for up to 30% of the area, even in the better, non-coffee-growing areas. Annual crops, consisting mostly of bean, maize and cassava, are grown on between 5% and 20% of the land. Some 20% to 60% of the land is in pastures. Bush fallow accounts for the remainder, some 10 to 30% depending on the area. Fallowing represents an important traditional means of restoring soil fertility.

The hillsides are relatively densely populated, with population highest in the coffee-growing areas. Land distribution is uniformly skewed, with roughly 80% of farmers holding only 20% of the land. In both Central and South America, rural poverty is an acute problem in hillside areas. Labor productivity in these areas is low.

The accessibility of medium-altitude hillsides is generally good, with areas of poorer soils, in which shifting cultivation is practised, being worse off in this respect. Poor mountain roads lengthen travel time in many areas. About 50% of the area can be classified as rolling, with a further 40 to 50% considered steep. Up to 10% of the area is flat, however.

Problems. Due to their steep slopes, the overriding problems of these areas are soil erosion and water management. In addition, soil fertility is low, exhausted by many years of cropping without sufficient inputs. Another major problem is weed infestation. This is remedied by hand hoeing, which in turn may exacerbate the erosion problem. The pressure on the small remaining areas of forest, for firewood, building materials and additional arable land, is considerable. Clearing these areas will increase erosion risks still further by bringing even steeper land into cultivation.

Problems specific to coffee-growing areas include the excessive use of pesticides and the pollution of watercourses by coffee washing.

Although many hillside areas enjoy reasonable access to markets, economic problems abound. The chief of these is the inherent difficulty of increasing the productivity of labor. There is also a need - perceived more by the relevant authorities than by the growers - to diversify out of coffee, which is in oversupply.

Entry points. Water management and soil conservation are the obvious entry points for technological research. To be acceptable to producers, conservation measures must be self-financing, and show good returns in the early years.

Innovations designed to increase cropping intensity would be an attractive entry point because they would generate additional employment opportunities. Developing more productive fallows represents an obvious opportunity of this kind. Yield-increasing technologies are also needed, to increase the productivity of labor. Multi-species production systems (including trees) may be applicable.

An important entry point for the institutional development team would be to identify the many other organizations (especially non-governmental) working in this environment.

For the land use team, entry points will vary according to the degree of knowledge already acquired, ranging from identifying current land use, to conducting on-farm tests.

Specific activities. CIAT's involvement should begin with the identification of other organizations working in this environment, and the compilation of an information base on previous research activities, their successes and failures. This desk research should be complemented with field surveys to determine current land use and tenure patterns, and to describe the prevalent production systems in greater detail.

This preliminary phase should be followed by detailed investigation of possible management practices and technologies to assist in water control and the prevention of erosion. These include barrier strips of forage species (for feeding in a cut-and-carry system), conour-aligned hedgerow intercropping, live mulch, multi-purpose or fruit trees, and woodlots. Special attention must be paid to the short-term profitability of these interventions. Legume-based ley farming, to support a diary enterprise, combined with horticulture may show considerable promise on less steep land, where urban markets are easily accessible.

As these interventions are tested, a major task will be to select the right combinations of annual and perennial crops and forages for these systems.

Pattern 4: Semi-evergreen Forest Margins

Description. Large areas of extensive grazing are found in conjunction with manual cropping by small-scale farmers at the forest margin. These areas are found mainly in Brazil, but also in Colombia, Peru and Bolivia, and also in Central America and the Caribbean. This is a huge frontier area, totalling some 45 million ha. It has varying degrees of accessibility, but is generally moderately distant or remote from markets.

The natural vegetation is semi-evergreen forest. In some cases this has completely disappeared, but overall about 40% of the original forest remains. This is usually located on steep or otherwise inaccessible land. In relative terms deforestation has been greatest in Central America and Mexico, which have lost 31 and 22% of their forest and woodland areas respectively, compared to 7% in Brazil and 19% in the Andean region. The rates at which the Central American forests are being cleared (up to 3.6-3.9% a year) and the little forest that remains in this subregion (118.000 Km^2 in 1983) suggest that its forest is under much heavier pressure than that in the Amazon.

Of the cleared land, about 4% is under perennial crops, 11% under annual crops and 30% under extensive grazing. In some areas up to 30% of the land has reverted to bush fallow. Land and income distribution are highly skewed. Some 50% of the farmers have less than 10 ha and together control less than 10% of the land. The population density is low to medium, with a few areas of high population in coastal Brazil and the Caribbean.

Problems. The most controversial problem of these areas is their initial deforestation. Shortage of cropland drives small-scale farmers to clear new land, the degraded cropping areas they leave behind them being taken over by larger-scale cattle farmers. Degradation in other ecosystems, notably the Andean hillsides, causes a steady influx of new settlers, accelerating the rate of deforestation still further. Production gains from slash-and-burn clearance are ephemeral - and increasingly so as more and more fragile land is cleared.

Declining soil fertility is the main agent of degradation. Low fertilizer use leads these soils, which are difficult to manage, to deteriorate rapidly. Commonly, land reverts to pasture after only 2 or 3 years cropping; after a further 5 years in pasture, productivity falls so low that the land must be abandoned completely.

Weeds are a common problem during the cropping phase, but the most severe problem is bush encroachment on degrading pastures.
Weed infestation combines with soil compaction and nutrient depletion to depress productivity, leading to continued poverty and so to further frontier expansion. Erosion frequently results from land degradation.

The main socio-economic constraint, besides poverty-induced migration, is insecure tenure for small-scale farmers. Skewed agricultural policies have encouraged the expansion of extensive, relatively unproductive cattle ranching. Conflicts over land frequently arise. Poor market access inhibits diversification into higher value perennial crops, further encouraging the the cultivation of ill adapted food crops and the expansion of ranching.

Entry points. Different entry points are appropriate for Central America and for the Amazon region. In the latter research should probably begin with land use studies to define the major issues, so as to develop possible land use scenarios. In Central America, where scenarios appear to be better understood, it is necessary to develop and test new agricultural technologies adapted to the agro-ecological system and the socio-economic condition of the small-scale farmer (low labour productivity, capital constraints, poor market access, etc.).

A pressing issue for both subregions, however, is how to divert pressures away from the forest zone, to prevent the development of new forest areas, many of which are, or should be, legally protected.

Specific activities. The evaluation of components for legume-based pasture-crop systems should continue, hand in hand with policy research to determine where and how this technology should be applied. Agroforestry components should be included.

Pattern 3: Well Watered Savannas

Description. The well watered savannas consist of three distinct groups: lowland savannas with extensive grazing on poor soils and with little or no other agricultural activity; lowland savannas with extensive grazing, mechanized cropping and some manual crops; and cerrados-type pastures, with mechanized cropping. Together, the accessible, non-protected land in these groups currently being used for cultivation or grazing amounts to some 65 million ha. The environment as a whole accounts for some 10% of the land area of Latin America and the Caribbean. Unlike the forest, savannas require little initial investment in land clearing. In some areas, colonization has taken place rapidly in the last decades, but there is still plenty of room for expansion in this environment, where development for agriculture does not incur the high environmental costs associated with the loss of forest. Some savannas are relatively close to markets, and could be used to ease the pressure on forest areas. Development will often take place through mechanization, such that direct impact on employment opportunities may not be substantial. However, the large increases in food supplies possible from this zone would benefit poor urban consumers. In Brazil, Colombia and Venezuela, where this environment is important, there were 11 million poor urban households in the mid-1980s and 6 million rural ones.

The first group - lowland savannas with extensive grazing on poor soils, with little or no other agricultural activity - consists of the altillanura of Colombia, and is also found in Mexico and Venezuela. The accessible area for this group is some 4.41 million ha. Soils are highly acid and the natural vegetation is savanna and gallery forest. The topography is flat, with only 5 to 10% of the area found on slopes, ranging from 8 to 30%. Population is low and average farm size is almost 1000 ha, but this is decreasing as the area fills up. The principal enterprise at present is a cow/calf operation on native pastures. Markets are distant, but isolation is not extreme. There is considerable potential for expanding the cultivation of acid-tolerant crops on the large areas of land where mechanization is feasible.

The second group - lowland savannas with extensive grazing, mechanized cropping and some manual crops - form the major portion of a large agro-ecosystem of over 40 million ha found in Brazil, Colombia, Panama, Mexico and Paraguay. About 30 million ha of this is savanna; the rest is seasonally dry forest. The difference between this group and group 1 is the existence of significant areas of mechanized cropping, sometimes accounting for up to 30% of the land area. This group of savannas has a population of 2.7 million. Access is variable, but over half the area is highly accessible. Isolation from markets is also variable, but mainly moderate, with only a few areas being very remote. Fifty to 90% of the area is still in natural vegetation, but where this is savanna it is grazed. Virtually no perennial crops are grown, but little of the land is left as fallow. The proportion of flat land is relatively low, but can reach about 25%, the rest being classed mostly as rolling. Steep lands take up less than 5% of the area.

Farm size is highly skewed, with up to 50% of farmers using less than 8% of the land. The crops cultivated include upland rice, sorghum and soybean.

The third group of savannas - cerrados-type pastures with mechanized cropping - covers some 31 million ha, almost entirely in Brazil. Accessibility is moderate, and distance to market high to medium, with the human population varying accordingly. At one extreme, no farmer has less than 10 ha; at the other, in southeast Brazil, 50% of farmers fall into this category. Generally, over 50% of this group is still natural vegetation, which varies from campo cerrado, through cerradao to seasonally dry forest. There are virtually no perennial crops or managed forest. On average, 13% of the area is under annual crops, but this proportion rises closer to markets. Only 54% of the area has a slope of less than 8%, and 13% is very steep land.

Problems. Sheet erosion may occur wherever the native savanna has been burned off. Once cultivation has been introduced, this can become a much more serious problem.

Deforestation occurs throughout all three groups, none of which is wholly savanna. Gallery forests or associated semi-evergreen forests are increasingly used for timber and fencing. In addition, forested areas are used for traditional shifting cultivation.

In areas where continuous cropping is attempted, soil compaction becomes a serious problem.

A build-up in the incidence of weeds, pests and diseases occurs when these reas are converted to continuous cropping or to permanent pastures.

Having low natural fertility, these areas are susceptible to marked nutrient depletion when continuous cropping is attempted.

Entry points. With appropriate management and the required level of inputs it should be possible to integrate crops and pastures in viable farming systems, probably involving ley farming - an innovation holding considerable promise for the acid tropical soils of the savannas. This would address all the above problems except the availability of timber.

The testing of suitable forage and food crop varieties is well in hand for most areas. However, some areas, especially the lowland areas of Brazil, need a more complete appraisal. For these areas, suitable crops and forages have yet to be identified.

Entry points for the land use team vary according to the knowledge already acquired of different savanna areas. In some areas, current land use is still being identified; in others, development scenarios can be formulated and ex-ante analysis is being conducted.

Specific activities. CIAT should continue to conduct rapid rural appraisals of selected savanna areas, to identify appropriate crops and forages, and to design and test alternative production systems. The latter should include the use opf crops for pasture renovation, the use of a pasture fallow to restore soils in continuous cropping areas, and the integration of pastures and crops in ley farming systems.

Close monitoring of environmental and soil problems while investigating options for tillage and the incorporation of residues, crop and pasture management, and integrated pest management. As new systems will interact with the remnants of native savanna and improved permanent pastures, the effects on these will also need monitoring.

As research progresses, more data will become available for system modelling. This will allow the productivity and sustainability effects of different managment regimes to be assessed. Results from models will be used for ex-ante economic analysis.

Resource Requirements and Organizational Structure

A preliminary attempt has been made to assess the disciplines required to implement the program outlined above, and the number of staff required in each discipline. An optimum level of staff was envisaged, to be built up over the 5-year time-frame normally required by TAC for planning and budgeting purposes. In addition, the minimum critical mass required to launch an effective program was also estimated. This amounts to some 60% of the optimum staff level. Both levels are shown in Table 1, which summarizes the professional staff requirements for the division. Table 2 shows a breakdown by agro-ecosystem.

At the optimum staff level, 27% of the division's staff would be devoted to land use analysis, 61% to production systems research, 8.5% to institutional development, and 3.5% to the leadership of the division. Some 13% of staff would be specialists in the field of resource monitoring, 21% would be socio-economists, 39% would be systems research specialists, 18% would be involved in research on plant-soil relationships, and 9% in institutional development.

The structure of the department is shown in Figure 1. There would be two main programs - land use and production systems - and five teams, three of which would be regional, and two thematic.

Table 1. Human Resources Requirements.

Research Areas	Optimal	M.C.M.
Land Use		
"Monitoring"		
Climate	1	1
Soils	1	2
Vegetation	1	2
Land Use	1	3
Information Management	1	1
"Analysis"		
Geography	1	3
Economics	1	6
Social Science	1	4
Policy	1	5
Crop Production	1	7
Livestock Production	1	7
Environmental Impact	1	8
"Synthesis"		
Strategy Development/Evaluation	1	5
Decision making process	1	4
Forecasting modelling	1	9
Production Systems		
"Soils-Plant"		
Ecophysiology	1	1
Soil Chemistry	1	-
Plant Nutrition/Fertility	2	1
Soil microbiology	1	1
Soils conservation/management	4	3
Modeller	1	1
"Systems"		
Crop/Pasture Agronomy	7	3
Forest/Range management	2	-
IPM	2	1
Production Systems	5	3
Farm Economics	3	2
Social Science		
Institutional Development		
Integrating mechanisms	1	1
Project planning/monitoring	1	1
Institutional coordination	3	2
TOTAL	49	29

Table 2. Staff allocations per agro-ecosystems

LAND USE

PRODUCTION SYSTEMS

Expertise	Total		HQ		Agroecosystems: Savanna S_1		Savanna S_2		Forest F_1		Forest F_2		Hillsides H_1		Hillsides H_2	
	O	MC	O	MC	O	MC	O	MC	O	MC	O	MC	O	MC	O	MC
Resource monitoring																
Climate	1	1	1	1												
Soils	1	1	1	1												
Vegetation	1		1													
Land use	1	1	1	1												
Geography	1		1													
Environmental impact	1	1	1	1												
Information management	1	–	1	–												
Socio-economics																
Policy	1	1	1	1												
Strategy development	1		1													
Economics	2	1	2	1												
Social Science	3	2	1	1	–	–	–	–	–	–	1	1	1	–	–	–
Decision marking	1		1													
Farm economics	3	2	–	–	1	1	–	–	–	–	1	–	1	1	–	–
Forecasting/modelling	1	1	1	1												
Systems																
Production systems	5	3	–	–	1	1	1	–	–	–	1	1	1	–	1	1
Crop production	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
Livestock production	1		1		–	–	–	–	–	–	–	–	–	–	–	–
Crop/pasture agronomy	7	3	–	–	2	–	1	–	–	–	1	1	2	2	1	–
Forest/range management	2	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–
IPM	2	1	–	–	1	–	–	–	–	–	–	–	1	1	–	–
Environment ecology	4	3	–	–	–	–	1	–	1	1	1	1	1	1		
Soils-Plant Relationship																
Soil conservation/mgment.	4	3	–	–	1	.5	–	–	–	–	1	1	1	.5	1	1
Plant nutrition/fertility	2	1	1	1	–	–	–	–	–	–	–	–	–	–	1	–
Soil chemistry	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Soil microbiology	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
Ecophysiology	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
Modeller	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
Institutional Development																
Integrating mechanisms	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
Project planning/monitoring	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
Coordination	3	2	–	–	1	1	–	–	–	–	1	–	1	1	–	–
Leadership																
<u>Full-time</u>																
Land use	1	1	1	1												
Production systems	1	1	1	1												
<u>Working</u>																
Soils-plant	1	1	1	1												
Savannas						(1)										
Forest											(1)					
Hillsides															(1)	
Institutional Development	1	1	1	1												
					8	3.5	3		1	1	8	5	9	6.5	4	2

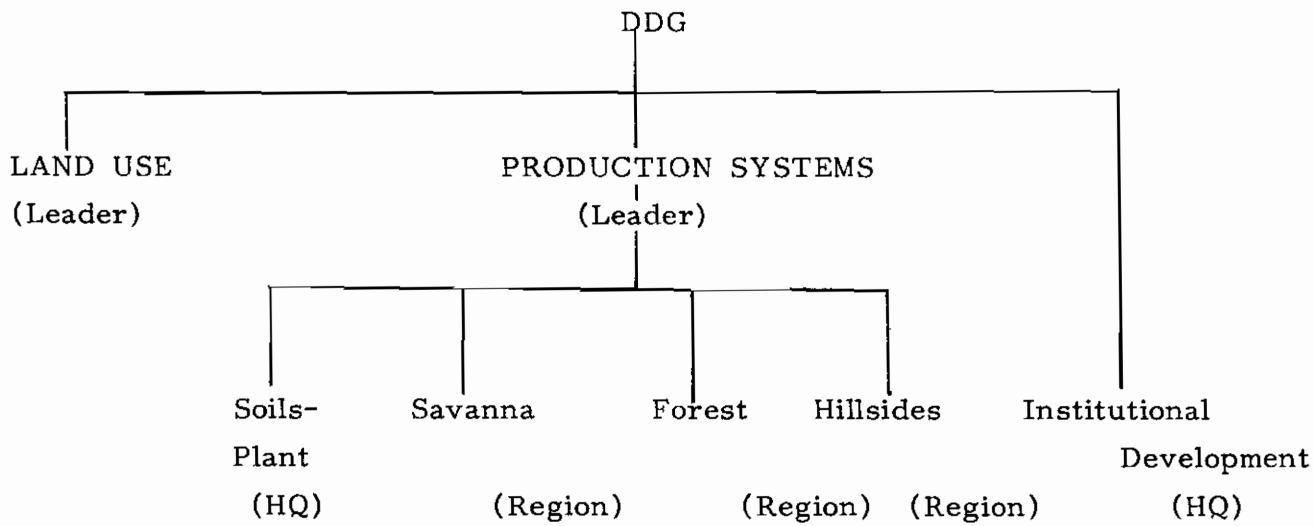
	Total	HQ	Savanna	Forest	Hillsides
Total: Optimal	58	23 (11)	11.0(15.0)	9.0(13.0)	13.0(17.0)
Min.Crit.M.	34	11(5)	4.5(6.5)	7.0(9.0)	9.5(11.5)

HQ: Headquarters
S_1: Llanos
S_2: Cerrados
F_1: South America
F_2: Central America

H_1: Mondomo
H_2: Central America

O: Optimal
MC: Minimum Critical Mass

Figure 1 . Organizational of a Natural Resource Management Division at CIAT



Annex 1. Integrated Resource Management Division

GOAL

The generation of resource management alternatives that contribute to the sustainable development of agriculture in LA/C, making increases in productivity compatible with the long-term preservation of and equity in using the resource base.

OVERALL STRATEGIES

- On the basis of joint inter-institutional planning CIAT will carry out strategic research on the optimization of social returns, through a better understanding of relationships between:

  i) agricultural growth and resource conservation, vis-a-vis the development of land use strategies and corresponding policies and institutional environments encouraging land use alternatives that <u>ameliorate social costs</u>; and

  ii) objectives of the production system and technological approaches, in relation to the design of components and farm management alternatives that <u>increase private benefits</u> on a sustained basis.

- Actively promote inter-institutional collaboration in integrated research on the management of natural resources, addressing issues at the agroecosystem and farm level of intervention.

<u>Land Use Analysis</u>

Function

Contribute to the design of alternative land use strategies and corresponding policy/institutional frameworks, which integrate production systems to ameliorate the social costs of using the resource base for agricultural purposes.

Strategies

- Characterize existing land use systems within selected ecosystems, in terms of available resources and the economic, social and cultural background explaining their present utilization and indicating future trends.

- Understand the implications of development paths and corresponding resource management alternatives on the socio-economic and environmental benefits/costs at the ecosystem level.

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- Focus efforts on integrated resource management in a few selected agroecozones, to be used as case-studies for methodology development, strategic applied research and training, and the design of collaborative mechanisms.

Activities

The land use team will be responsible for three principal functions:

1) The analysis of present land use.

2) The identification of sustainable and economically viable future land use.

3) The evaluation of instruments such as technologies and policies that can contribute to the realization of improved future land use.

The land use team will do so by elaborating a stepwise methodology, testing it in selected agro-ecozones and comparing results of all three functions across zones.

Here a brief description will be given of the proposed methodology, the expected output and the concrete research activities to be undertaken in the selected agro-ecozones.

Before the methodological procedure can be started a zone has to be selected. Initial selection will be based on the importance of the zone in terms of agricultural production, resource problems, representativeness and the presence of institutional collaborators. Nevertheless, since the procedure should be applicable in any agro-ecozone, and since its future use will depend of the demand for it by regional authorities, zone selection is not considered an essential step in the procedure. The stepwise methodology is as follows:

1) Inventory of natural resources and of existing knowledge on resource management. Soil, water, plant and animal resources will be thoroughly characterized. Existing knowledge on their management will be documented, and if this knowledge is not applied, the reasons for it will be researched.

2) The study of the present land use within its socio-economic context. Land use patterns for the dominating production systems will be documented. Land distribution issues will be addressed and productivity indices (yields, variability) will be obtained.

3) The explanation of the present land use. By reviewing the regional history, the regional economy, the national and regional policies, the regional development efforts, the existing infra-structure and the institutional setting, the current land use will be explained.

4) Trend analysis. The current land use will be reviewed in the light of present or expected economic, demographic or social trends. The trend analysis will lead into a projection of future land use without additional intervention.

5) Definition of principal land use issues. By combining the knowledge on the present land use with the outcomes of the trend analysis the principal land use issues will be defined. Four categories have been distinguished" Resource degradation (deforestation, erosion, silting, water pollution, etc.); inequities (access to land, water, infra-structure); inefficiencies (cropping patterns, yield levels) and spill-over from or to other regions (migration trends, water use, erosion, regional agricultural interdependences).

6) Definition of causalities and priorities among issues. The causes for the principal land use issues will be identified. An assessment will be made of how these issues could be addressed. The issues will be ranked for their importance to proper land use management strategies.

7) Scenario development and break-through elicitation. A set of desirable future land use scenarios will be developed. Explicit attention will be given to the creative elicitation of presently not recognized opportunities.

8) Identification and ex-ante evaluation of technologies and policies. Policy and technology options that might bring forward the envisaged land use patterns will be identified and analyzed by means of formal models or comparative studies. An expert system (to be developed) might support this process.

9) Elaborating of strategies directed to improved resource management. A set of desired production systems options and their spatial distribution will be developed in collaboration with the relevant institutions. Policy options will be refined.

10) Creation of a land use monitoring system. A monitoring system will be established to obtain information on exogenous developments and how these influence the effectiveness of the proposed strategies; on the occurring regional developments; on the degree of already existing and newly arising land use externalities.

11) Implementation of a pilot project. Together with development organizations or regional planning offices CIAT will participate in the implementation of the proposed strategies on a pilot scale.

12) Ex-post evaluation and comparative studies. By means of the monitoring system the pilot project will be evaluated. Developments in the study region will be compared with other regions that have been submitted to a land use analysis and with regions that have not benefitted from such a plan.

Expected Outputs

- Improved Ecosystem Information Systems (EIS).

- Guidelines for the formulation of land policies/strategies at the ecosystem level.

- Information/criteria/methods useful in setting research priorities/ strategies for the generation of technological components.

Production Systems

Function

Contribute to the design of sustainable farming systems that increase private benefits through the combination of improved varieties and endogenous/exogenous inputs, their efficient utilization, and protecting/enhancing the resource base.

Strategies

- Understand farmers' rationale behind existing "unsustainable"/ "sustainable" production systems within agroecozones.

- Increase species diversity in space or time, so that plant components complement each other in covering the ground and in exploring the space below- and above- it.

- Develop strategic studies on soil-plant-animal relatioships in multispecies systems to understand the principles that govern the development of productive and sustainable farming systems.

- Design more sustainable production systems based on the identification of technological components and available natural resources, and text them through on farm participatory research.

Activities

- Develop set of criteria to identify relevant production systems within selected agroecozones.

- Characterize "sustainability" problems/opportunities in existing production systems.

- Analyze farmers' strategies to cope with agroecological and socio-economic constraints, and their perceptions on possible innovations.

- Define desirable features for technological components to combine in multi-species systems, fitting preferred development options and congruent technological paths.

- Study nutrient flows and erosion rates in multi-component systems, to define principles governing relationships between biomass accumulation, yield output and soil degradation (especially vis-a-vis diversity and its management).

- Develop and test through on-farm research, prototype production systems.

- Evaluate the environmental impact of the new production systems and their components.

- Assess the management skills, and their implications, required to successfully operate these farming systems.

Expected Outputs

- Diagnosis of existing systems.

- Component ideotypes for preferred management options, to guide the improvement of cultivars.

- "Prototype" production systems.

- Models to estimate yield output and soil changes for multi-species systems under alternative management regimes.

- Provision of feedback to the land use specialists, regarding likely implications of new system's development for strategies at the agroecozone level.

- Response functions of biotic and abiotic components, useful in designing production systems.

- Estimates of the environmental impact of prototype systems.

- Principles and methodologies used in designing sustainable systems.

- Training and institutional development, relevant to the design and operation of sustainable farming systems.

Institutional Development

Function

Support CIAT's effort to integrate regional capabilities for research on natural resources, from land use analysis to germplasm enhancement.

Strategy

- Seek a more efficient use of available research capabilities by promoting and/or strengthening the development of regional programs addressing common problems/opportunities through the complementary efforts of international, governmental and non-governmental institutions.

Activities

- Facilitate the identification of institutional partners, their objectives, research/development focus, capabilities and resources.

- Develop and guide the application of institutional processes/ methods for multi-institutional collaborative research programs on common regional issues.

- Project planning and implementation

- Inter-institutional liaison to motivate their participation in joint programs, acquire and maintain commitment to the concerted enterprise, and facilitate the development of enabling mechanisms.

Expected Outputs

- Information System on regional institutions.

- Project proposals resulting from the joint planning of integrated research for development programs.

- Institutional mechanism enabling the collaborative implementation of research programs for generating/validating technologies of regional interest.

- Organizational models to enhance integrated approaches to collaborative research efforts in resource management, fostering the generation of sustainable technologies congruent with policies, and management alternatives.

Annex 2. A Land Use Analysis and Modification Methodology

Before the methodological procedure can be started a zone has to be selected. Initial selection will be based on the importance of the zone in terms of agricultural production, resource problems, representativeness and the presence of institutional collaborators. Nevertheless, since the procedure should be applicable in any agro-ecozone, and since its future use will depend of the demand for it by regional authorities, zone selection is not considered an essential step in the procedure. The stepwise methodology is as follows:

1) Inventory of natural resources and of existing knowledge on resource management. Soil, water, plant and animal resources will be thoroughly characterized. Existing knowledge on their management will be documented, and if this knowledge is not applied, the reasons for it will be researched.

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5) Definition of principal land use issues. By combining the knowledge on the present land use with the outcomes of the trend analysis the principal land use issues will be defined. Four categories have been distinguished" Resource degradation (deforestation, erosion, silting, water pollution, etc.); inequities (access to land, water, infra-structure); inefficiencies (cropping patterns, yield levels) and spill-over from or to other regions (migration trends, water use, erosion, regional agricultural interdependences).

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7) Scenario development and break-through elicitation. A set of desirable future land use scenarios will be developed. Explicit attention will be given to the creative elicitation of presently not recognized opportunities.

R

8) Identification and ex-ante evaluation of technologies and policies. Policy and technology options that might bring forward the envisaged land use patterns will be identified and analyzed by means of formal models or comparative studies. An expert system (to be developed) might support this process.

9) Elaborating of strategies directed to improved resource management. A set of desired production systems options and their spatial distribution will be developed in collaboration with the relevant institutions. Policy options will be refined.

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11) Implementation of a pilot project. Together with development organizations or regional planning offices CIAT will participate in the implementation of the proposed strategies on a pilot scale.

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Annex 5. Selection Criteria and Procedure for Agroecological Zones

To evaluate the different combinations of land use patterns and environmental classes we devised sets of criteria, as follows:

Set 1. Economic potential

Market demand	:	Demand for agricultural production is significant.
Area or volume of total production	:	Spatial extent, and/or overall importance for agricultural production is high.
Intensification potential	:	Existing production systems could be intensified significantly.
Infrastructure	:	Physical communications and support services are good.

Set 2. Resource potential

Productivity Index	:	Climatic and edaphic conditions are favourable for agriculture.
Expansion of agricultural land	:	There is scope for a real expansion of agriculture.
Natural vegetation	:	A strong value is attached to conserving natural vegetation.
Spillovers	:	Intervention will have a positive impact elsewhere, or non-intervention will have a negative impact elsewhere.

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Set 3. Resource Problems

Ecological fragility:	The area is ecologically fragile for agriculture.
Sustainability of existing agricultural systems :	Existing systems are not sustainable.
Extent of deforestation :	Deforestaton is a concern over a large area.
Soil degradation :	Soil resources are suffering significant degradation and/or erosion.

Set 4. Equity

Rural poverty :	There are a large number of poor rural inhabitants.
Employment opportunities :	Significant employment opportunities can be generated through agriculture.
Food supply for the urban poor :	The area supplies basic foodstuffs to urban areas.
Land distribution :	Uneven land distribution is a major source of inequity.

Set 5. Technological considerations.

Lack of appropriate or exogeneous technology	:	Appropriate technology is not currently employed/available.
Problems can be addressed through technology generation	:	New technology can significantly contribute to finding a solution.
Probability of generation	:	It is likely that new technology can be generated to solve identified problems.
Time frame	:	New technology can be generated quickly.

Set 6. Institutional considerations.

Institutional strength	:	Potential collaborators exist.
CIAT's comparative advantage	:	Previous or current CIAT research can contribute to finding solutions.
Internationality	:	The agroecosystems is found in a number of countries.
Site availability	:	It is feasible to begin research soon at CIAT test sites or other known locations for a given agroecosystem.

Each land use pattern or agroecosystem was then scored, for each criterion, on a three point scale from -1 to +1. Zero implied neutrality or irrelevance. For technical considerations, if there was no real lack of appropriate technology, giving a score of -1, then the remaining criteria were automatically scored as zero, since they became irrelevant.

The scores for each group of criteria were then summed to give an overall score, for the six agroecosystems. The members of the team did this individually, and then compared their scores. An average score was then computed (Table X). Where a strong difference of opinion arose, scores were discussed in detail for each criterion to resolve the disagreement. Most discussion centred upon the extensive grazing and smallholder systems of the forest frontier. Here, intensification potential was considered as high relative to current low levels. The overall resource potential was reduced by a score of one, since the issue of conservation of natural vegetation was covered under the deforestation criterion in the resource problems group. On equity, rural poverty and skewed land distributions were considered important, but employment opportunities and food supply were both given a neutral score. For technical considerations, the time frame was scored as zero, giventhat we could not identify feasible interventions at this stage.

To arrive at a final set of scores with which to compare the six agro-ecosystems, we summed the scores for each group of criteria. We envisaged the need to apply different weights to these scores, in accordance with different views on the relative importance of growth, equity and sustainability as final selection criteria. To this end, we grouped economic and resource potential to give a single indicator of growth. Resource problems indicated the magnitude of sustainability as an issue in each agroecosystem, with equity untouched. As a fourth factor, we combined technological and institutional considerations to indicate feasibility.

The results are given in Table Y, which suggest where resource management will fit best with CIAT's various goals, and where research is most feasible. Giving different weights to the issues of growth, equity, sustainability and feasibility would have little effect on the ordering of agroecosystems in Table Y. Only if we doubted the weights for equity and sustainability, and halved those for growth and feasibility, would the semi-arid pasture and manual cultivation system rank higher than the conglomerate of savanna agroecosystems, for example.

Table X. Agroecosystem average scores for grouped evaluation criteria.

Agroecosystem	Economic Potential	Resource Potent.	Resource Problems	Equity	Technical considerations	Intitutional considerations
1. Intensive cane, etc.	3	-1	-3	1	-1	2
2. Mechanized coffee, etc.	3	-1	-1	2	-1	0
3. Pastures and mechanized cultivation	2	2	0	1	3	3
4. Pastures and manual cultivation (forest margin)	1	2	4	2	2	0
5. Semi-arid pastures and crops	1	-1	2	3	-1	1
6. Hillsides: pastures, coffee, manual cultivation.	2	1	4	2	3	3

Table Y. Agroecosystem scores for growth, equity, sustainability and feasibility.

Agroecosystem	Growth	Equity	Sustainability	Feasibility	Total
1. Intensive cane, etc.	2	1	-3	1	1
2. Mechanized coffee, etc.	2	2	-1	-1	2
3. Pastures and mechanized cultivation	4	1	0	6	11
4. Pastures and manual cultivation (forest margin)	3	2	4	2	11
5. Semi-arid pastures and crops	0	3	2	0	5
6. Hillsides: pastures, coffee, manual cultivation.	3	2	4	6	15