DATA ANALYSIS FOR DECISION MAKING IN NATURAL RESOURCE MANAGEMENT FOR SUSTAINABLE AGRICULTURE

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DATA ANALYSIS FOR DECISION MAKING IN NATURAL RESOURCE MANAGEMENT FOR SUSTAINABLE AGRICULTURE

PHASE 1.

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INTRODUCTION

The literature abounds with supposed definitions of sustainable agriculture. Many of these tend to confuse the topic. Added to this confusion is the fact that CIAT operates in a wide range of environments, both physical and social. It is felt that Natural Resource management research is more site specific than germplasm improvement. It was therefore necessary to have a clear idea of the environments of possible areas of intervention.

The Agroecological Studies Unit (AEU) has been given the responsibility of providing, mapping and analysing data on the environments, demography and infrastructure of Latin America to assist the CIAT management in deciding on possible agroecological regions in which to mount Natural Resource Management (NRM) projects.

This effort was originally planned for a time frame of about 2 years, however, exigencies of strategic planning have considerably shortened this process. The work was replanned into 2 phases. The first of these has now come to fruition with this report. The rationale behind this division into phase I and II was to provide sufficient information for careful selection of a few Agroecological regions for further study in depth in phase II. Phase I divided Latin America and the Caribbean into broad environmental classes and characterised these with the available information to assist in the decision process. It has lasted only some 2 months with various times out for heated discussion with some of the principals in the process and with some others not in the process at all! It drew on certain data from the CIAT databases, a considerable amount of other data obtained with the foresight that this process might occur and finally with some very hard work by all the staff of AEU to make up the difference.

METHOD

DATA SOURCES

The land system database of CIAT contains much detailed information on the lowland tropics of South America. Our brief in this phase was to include a cross section of all the environments and social conditions in Latin America where CIAT might have a role. We therefore opted for a Phase 1 tabulation based on more general data to be consistent across the continent. We decided to use the Metgrid files developed in CIAT by the AEU. These files give the equivalent of a point quadrant picture of the continent at a resolution of 18.5 km. This resolution is consistent with the rural population and level of infrastructure data available in the very short time of Phase 1. As with any point quadrat study the standard errors of the areas estimated are highly dependent on the number of hits of the quadrat point. This technique should, however, give a sufficient idea of the areas involved to allow the CIAT management to proceed to a selection of (hopefully) less than 6 agroecological zones for further study in depth.

a- Metgrid Files

The Metgrid files are an interpolation from the CIAT climate database using as a grid basis the 10 minute grid of the NOAA digital Terrain model and the central pixel from the UNEP/GEMS/GRID raster version of the FAO Soil Map of the World. Hence the reference to a Point Quadrat mentioned above.

Interpolation of climate data was done by weighted inverse squared distance from the nearest 4 stations in the database, corrected for altitude to the NOAA elevation using the standard tropical atmosphere lapse rate model commonly used by AEU. The spatial spread of climate stations is highly variable but tends to be more dense in areas where there is a high variation in altitude and slope and where the majority of the population are often found.

b- **Legally Restricted Areas**

Since January 1989 we have been gathering and digitizing the areas in each country that are legally restricted from normal agricultural development. These for the most part are national parks, forest reserves, indian reservations, ecological preserves or protected catchment areas. Some countries report no such areas and in others the protection is only on paper. However these areas represent a significant proportion of our target area and therefore we excluded them from our calculation of potential agricultural area of an environmental class.

c- **Population**

Both rural and urban population are extremely unequally distributed in Latin America. We include this information because we feel it is fundamental to know the size of the rural population in each environmental class and where the concentration is. Most problems and opportunities in agriculture are affected by population density.

As a first approximation we digitized a population map that was transposed from the Time Atlas population map. The actual population represented by this map was calculated by computer and a new map was computer drawn to represent 1986 rural population. The map underestimated urban population so a correction factor was applied by country and Brazilian state so as to represent 1986 urban population on a separate map.

This information was overlayed on the map of environmental classes thus providing an estimate of rural and urban population by environmental class.

d- Access

Our brief was to produce a realistic set of environmental classes from which to choose. As the relative area of a class might be a criteria for choosing between classes we feel the figure that should be used is that area that is accessible with current infrastructure. Our calculation was to include all area within each class that is within 30 km of either side of an all weather road, navigable river or sea coast. Since January 1989 the Unit have been digitizing all-surface roads in each country. For Brazil this meant digitizing the entire 1989 road Atlas. The 60 km corredor along each road is a generous estimate for the increase in access that provides might occur over the next few years. This analysis can be extended to future development of infrastructure in more detailed studies.

For most of the 51 chosen classes this exercise did not reduce effective area much. However for the humid forest classes it excluded areas such as the Darien Straits, upper Rio Negro and mid Xingú which are truly inaccessible.

e- **Rural Income per capita**

As equity is one of the criteria for choosing research activities, we included this variable at the country and Brazilia state levels. This is admittedly crude, but even within Brazil the rural income per capita by state varied from around 150 $ (Maranhao and Piani) to over 2000 $ (Mato Grosso do Sul).

The data used was 1987 World Banks figures at the country level. Within Brazil we used figures in the 1980 census for gross agricultural product per capita by state, the resulting differentials were applied to the 1987 World Bank figure for all of Brazil.

ENVIRONMENTAL CLASSIFICATION

The scope of Phase 1 of this project was vast. It included all of Latin America in which CIAT could support a reasonable role in NRM. This forced us to certain assumptions and/or criteria.

a- The environmental classification must be simple enough to be mappable and not require unavailable data.

b- It must be consistent with the data from which it is drawn.

c- It should reflect the environmental requirements of actual or potential commodity crops for a Centre of Tropical Agriculture.

d- Environmental criteria should reflect the experience of scientist working in the centre.

e- To reduce strain on the mind and on computing machinery, ridiculous combinations should be rejected as soon as possible.

Five environmental criteria were decided upon based on many years of consultation with CIAT commodity scientists.

1- **Season Length**

This was calculated as the number of wet months where rainfall exceeds 60% of potential evapotranspiration, calculated by the method of Linacre (1978).

The classes were:

1 over 9 months wet

2 9 to 1 months wet

3 6 to 3 months wet

4 2 or less - REJECTED

NOTE:

Some bean areas are excluded by this rule, but no other CIAT crop can manage the aridity of class 4.

2. **Temperature during the growing season.**

Growing season was defined as that season with wet months (See 1 above).

The classes were:

1. Lowland tropics, temperatures greater than 23.5 ^{o}C.
2. Mid highlands 18 ^{o}C to 23.5 ^{o}C.
3. High highlands 13 ^{o}C to 18 ^{o}C.
4. Cold or Paramo less than 13 ^{o}C - REJECTED

NOTES:

1. 23.5 ^{o}C. This has long been the declared temperature cutoff in the classification of the pastures program. It effectively divides the Llanos at Carimagua from the Cerrados at CPAC. CIAT Palmira is marginal in this, with a mean temp. of 23.4 ^{o}C. Above this temperature in certain moist regions beans can exhibit a completely different regime of disease and pest attack.

2. 18 °C. This is just above the temperature of Popayan. Cassava and Beans exhibit an environment genotype interaction at about this point.

3. 13 °C. This is the temperature limit for cassava as calculated by J.Cock and ourselves. At about this temperature a major change occurs in the bean varieties grown in the Andes. This is not far from the temperature of Pasto.

Class 4. This class is unsuitable for all CIAT commodities apart from very few high altitude beans.

3. **Soil Acidity**

Although the Pastures Program is aiming at producing varieties that will tolerate soil pH lower than the limit we propose, we think it is valid and conservative to set it to pH 5.5.

1. Acid Soils. pH less than 5.5.
2. Less acid and neutral soils pH above 5.5.

NOTE:

1. Many of the soils marked in this study as having pH higher than 5.5 are very poorly drained. This is consequence of having to use the FAO database as a first approximation.

4. **Diurnal Temperature Range**

Many people we have spoken to during this analysis have been surprised at the inclusion of this variable. Many fungal diseases are highly sensitive to dew. J. Lennè and C. Lozano have both solicited studies by AEU on this topic and Dr. Lenné was convinced that this might have been a contributory factor to the lack of adaptation of the CIAT legumes to CPAC, whereas they did well in the forest regions.

In our classification we have designated these Maritime - less than 10 ^{o}C diurnal difference, and Continental for those areas with a diurnal difference greater than 10 ^{o}C. The terms Maritime and Continental occur

frequently in climatological discourse. They have been measured in many different ways. We are proposing to use the terms in a way to clarify a recognized plant pathological concept and not to redefine the terms climatologicaly. We have to have simple names for our classes.

Classes:

1. Maritime - Less than 10 °C mean diurnal temperature range
2. Continental - Greater than 10 °C mean diurnal temperature range

5. **Annual Temperature Range**

We set the annual temperature range at 10 °C. Previously the AEU had used 5 °C as the range for cassava. The larger annual range allowed us to immediately eliminate 12 possible climate classes as having winters too cold for the majority of the crops we would be considering.

Classes:

1. Tropical - Less than 10°C annual temp. range
2. Subtropical - More than 10°C annual temp. range

RESULTS

In determining criteria for selection of activities in NRM the economist group has produced a list in three categories, Economic Impact, Equity and Environmental Impact. The data were analysed using the IDRISI image processing package to extract data from the environment class images in conjunction with the demographic and income data to allow indices to be constructed as measures under these categories.

Economic Impact

Areas of legally protected areas were masked out from the environmental classes and values for the area of each class were extracted. Areas with poor access were then masked out and the resultant areas were extracted. A subjective productivity index was constructed for the environment classes. This took values from 1 to 7 and was contructed as follows:

DRY SEASON

		LT2	3 - 6	7 - 9
Temperature	Lowland	3	4	2
	Med	4	4	2
	Highland	4	3	1

2 points were added for non-acid soils and 1 point for subtropical areas. To form an index of potential economic impact this index was multiplied by the accessible area of each class. Table 1 shows the 47 classes ordered by this index.

Equity

To achieve a crude assessment of an equity index the mean rural income was extracted for each class. We wished to rank this taking into account the rural populations of the classes. The importance for the equity issue increases with number of people but it decreases as rural income rises. We therefore divided total population by rural income to obtain an index increasing with importance for equity. Table 2 shows the classes ordered by this index.

Environmental Impact

Problems of environmental impact are not easy to estimate directly from these data without further detailed knowledge of the region. This will be done in more detail on selected regions in Phase II.

Areas of high risk to problems of an abusive nature such as excess pesticide use will be in the areas with access to markets and hence inputs. They will be the higher population areas within each class. Table 3.1 shows the area in each class with rural population greater than 20 per km2.

Nevertheless some attempt can be made. Areas with relatively untouched native vegetation, be it forest, savanna or other type are likely to be those with low rural populations. Table 3.2 shows the top ten classes ordered by the areas of each class with population less than 2 per km2. this can be read as either the areas available for expansion of agriculture, or as native vegetation for protection.

Problems of depletion and erosion through insufficient inputs are less easy to estimates. We have made an approximation that they will occur more frequently in settled areas, away from markets with less incentive to use inputs. An index of the area of each class with populations from 2 to 20 people per km2 divided by rural income. Table 3.3 shows the classes ordered by this index.

A further consideration is our probability of success. Table 4 shows the areas by class under three of the CIAT crops, unfortunately we do not have a complete or recent distribution of pastures or cattle. Also shown are the areas in square kilometers of each class with a climate similarity index less than 3 when compared to the major CIAT stations.

Table 5 lists all of the classes that have appeared in the top 5 of any of the ordered tables.

TABLE 1. Environment classes ordered by production potential index.

Class	*	Subjtv. Prod. Index	Sum. Prod. Index	Rural Pop.	Urban Pop.	Rural Pop/km2	Rural PCI mean	Number of countries	Accessibl area Km^2	Acc. are Outside Brazil Km^2	Area Not Protected Km^2
2	T L S M A	4	3242757	7462384	12830741	3	453	24	810689	299383	2431409
5	T L S C A	4	1936433	4496741	8037021	3	675	18	484108	131740	1433703
17	T M S C A	3	1847765	7133114	23632759	8	1032	18	615922	108109	846215
8	T L S M W	6	1819042	5860458	8995565	12	630	23	303174	244770	493803
12	T L D C W	4	1503994	4704845	10728149	7	954	13	375999	171921	708777
9	T L D M W	4	1364902	6264550	11475161	16	523	12	341225	196610	391260
11	T L S C W	6	1085185	4577921	8229079	13	848	17	180864	120358	344035
6	T L D C A	2	1061534	3471035	8324097	4	882	12	530767	73349	784066
1	T L H M A	3	976925	2234896	2798926	2	394	18	325642	142930	1157602
3	T L D M A	2	853181	4122772	7077859	8	541	13	426590	195420	514077
18	T M D C A	2	725071	3379676	8204852	7	826	12	362535	85779	483141
14	T M S M A	3	590522	4810238	13620092	14	734	21	196841	84298	338878
28	T M H C A	4	573443	2432653	5246365	16	1291	10	143361	17298	149420
24	T M D C W	4	549220	2036116	4543727	13	611	9	137305	79138	162507
21	T M D M W	4	521742	2544063	4134194	18	381	10	130436	26846	137627
59	S M S C W	6	462029	447963	1244675	6	1951	4	77005	72818	79458
16	T M H C A	4	457087	1149785	2107770	7	1111	13	114272	43919	153768
23	T M S C W	5	453819	2335137	5189542	22	804	16	90764	35849	105571
20	T M S M W	5	437612	2747640	3802708	29	550	17	87522	49448	93856
60	S M D C W	5	431312	49842	1349743	1	2129	4	86262	86262	89395
13	T M H M A	4	349613	2391089	4393751	21	721	18	87403	39432	111490
7	T L H M W	5	287061	1378344	2015551	14	462	16	57412	48146	101501
52	S M H M A	5	195558	219091	592202	5	1597	3	39112	11030	45568
48	S L D C W	5	195472	103665	553802	2	1683	4	39094	39094	43813
15	T M D M A	2	191606	2053693	3298311	19	450	10	95803	23459	106458
53	S M S M A	4	150799	396976	594447	10	1443	3	37700	23868	39848
25	T M H M A	4	145149	681450	1722393	18	1059	5	36287	13293	38652
54	S M D M A	3	143158	34425	590779	1	2130	3	47719	47719	49619
4	T L H C A	3	141338	272610	392826	1	600	12	47113	26695	269778
19	T M H M W	6	136394	634496	785883	24	415	9	22732	8826	26098
29	T H S C A	2	130279	1397017	3201201	19	724	9	65140	49891	71879
36	T H D C W	3	66512	674154	1410422	24	439	6	22171	22171	27897
30	T H D C A	1	65748	2231058	4621891	28	426	8	65748	66089	79401
44	S L S M W	7	54394	257437	292815	29	736	2	7771	7771	9017
35	T H S C W	4	51424	388800	695010	27	515	6	12856	11909	14516
26	T H S M A	2	47822	715139	1769722	23	950	8	23911	16963	30683
22	T M H C W	6	40546	182390	242253	20	674	7	6758	5571	9108
10	T L H C W	5	39867	312785	421516	22	533	7	7973	7973	14351
32	T H S M W	4	29013	425976	639577	56	701	8	7253	6347	7590
47	S L S C W	7	25941	73926	142339	17	941	2	3706	3706	4321
42	S L D C A	3	24703	44847	81484	4	1020	3	8234	8234	11379
58	S M H C W	7	20811	55395	113045	15	1573	2	2973	0	3586
33	T H D M W	3	16947	194684	298982	30	453	7	5649	5938	6590
27	T H D M A	1	10877	552127	984770	43	560	6	10877	10877	12878
56	S M S M W	6	10723	50802	167056	28	1881	2	1787	305	1787
31	T H H M W	6	8066	50887	70184	38	510	3	1344	1012	1344
34	T H H C W	6	1981	23597	16768	35	373	2	330	330	

* T = Tropical, S= Subtropical, L= Lowland, M= Midaltitude
H = Higher altitude, H= Humid, S= Seasonally wet, D= Seasonally dry

TABLE 2. Environment Classes ordered by Rural Poverty Index.

Class		Rural Pop.	Rural Poverty Index	Urban Pop.	Rural Pop/km2	Rural PCI mean	Rural PCI std.	Number of countries	Acc. are Outside Brazil	Rice x1000ha	Beans x1000ha	Yuca x1000ha
2	T L S M A	7462384	16480	12830741	3	453	298	24	299383	649	74	302
9	T L D M W	6264550	11988	11475161	16	523	492	12	196610	274	136	98
8	T L S M W	5860458	9304	8995565	12	630	487	23	244770	303	51	138.
3	T L D M A	4122772	7619	7077859	8	541	460	13	195420	382	79	113
17	T M S C A	7133114	6912	23632759	8	1032	547	18	108109	925	858	87
21	T M D M W	2544063	6674	4134194	18	381	170	10	26846	20	197	107
5	T L D C A	4496741	6663	8037021	3	675	588	18	131740	844	88	63
14	T M S M A	4810238	6553	13620092	14	734	438	21	84298	174	149	107
1	T L N M A	2234896	5677	2798926	2	394	111	18	142930	83	4	54
11	T L S C W	4577921	5396	8229079	13	848	708	17	120358	225	40	27
30	T M D C A	2231058	5234	4621891	28	426	108	8	66089	0	44	3
20	T M S M W	2747640	4998	3802708	29	550	445	17	49448	38	73	60
12	T L D C W	4704845	4930	10728149	7	954	761	13	171921	435	301	46
15	T M D M A	2053693	4565	3298311	19	450	292	10	23459	12	105	48
18	T M D C A	3379676	4092	8204852	7	826	465	12	85779	390	448	38
6	T L D C A	3471035	3935	8324097	4	882	651	12	73349	831	198	34
24	T M D C W	2036116	3332	4543727	13	611	368	9	79138	34	178	20
13	T M H M A	2391089	3318	4393751	21	721	583	18	39432	58	21	71
7	T L H M W	1378344	2982	2015551	14	462	170	16	48146	60	5	5
23	T M S C W	2335137	2903	5189542	22	804	486	16	35849	93	121	19
29	T M S C A	1397017	1928	3201201	19	724	398	9	49891	20	67	21
28	T M H C A	2432653	1884	5246365	16	1291	379	10	17298	90	248	31
36	T M D C W	674154	1534	1410422	24	439	71	6	22171	0	25	0
19	T M H M W	634496	1527	785883	24	415	269	9	8826	5	8	25
16	T M H C A	1149785	1035	2107770	7	1111	547	13	43919	83	248	75
27	T M D M A	552127	987	984770	43	560	320	6	10877	0	14	0
35	T M S C W	388800	755	695010	27	515	262	6	11909	0	17	0
26	T M S M A	715139	753	1769722	23	950	489	8	16963	5	17	1
25	T M H M A	681450	643	1722393	18	1059	444	5	13295	32	16	20
32	T M S M W	425976	607	639577	56	701	472	8	6347	1	16	5
10	T L H C W	312785	587	421516	22	533	234	7	7973	3	2	0
4	T L H C A	272610	454	392826	1	600	357	12	26695	9	4	8
33	T M D M W	194684	430	298982	30	453	171	7	5938	0	4	0
44	S L S M W	257437	350	292815	29	736	562	2	7771	0	2	9
53	S M S M A	396976	275	594447	10	1443	765	3	23868	27	7	43
22	T M H C W	182390	271	242253	20	674	480	7	5571	13	5	3
59	S M S C W	447963	230	1244675	6	1951	754	4	72818	51	1	23
52	S M H M A	219091	137	592202	5	1597	605	3	11030	13	49	37
31	T M H M W	50887	100	70184	38	510	184	3	1012	0	0	0
47	S L S C W	73926	79	142339	17	941	757	2	3706	1	0	1
34	T M H C W	23597	63	16768	35	373	31	2	330	0	0	0
48	S L D C W	103665	62	553802	2	1683	950	4	39094	1	14	0
42	S L D C A	44847	44	81484	4	1020	910	3	8234	2	16	0
58	S M H C W	55395	35	113045	15	1573	460	2	0	12	0	0
56	S M S M W	50802	27	167056	28	1881	228	2	305	14	0	2
60	S M D C W	49842	23	1349743	1	2129	661	4	86262	33	11	10
54	S M D M A	34425	16	590779	1	2130	680	3	47719	6	0	0

TABLE 3.1 Area of possible degradation from intensification (fertilizer, pesticide and herbicide abuse)

Class		Intensification Degradation	Rural Pop.	Urban Pop.	Rural Pop/km2	Rural PCI mean	Rural PCI std.	Number of countries	Accessible area	Acc. are Outside Brazil	Area Not Protected	Total area
17	T M S C A	98787	7133114	23632759	8	1032	547	18	615922	108109	846215	912817
9	T L D M W	81256	6264550	11475161	16	523	492	12	341225	196610	391260	398355
2	T L S M A	76004	7462384	12830741	3	453	298	24	810689	299383	2431409	2800366
12	T L D C W	67144	4704845	10728149	7	954	761	13	375999	171921	708777	830303
8	T L S M W	62823	5860458	8995565	12	630	487	23	303174	244770	493803	540488
14	T M S M A	59708	4810238	13620092	14	734	438	21	196841	84298	338878	413944
11	T L S C W	49522	4577921	8229079	13	848	708	17	180864	120358	344035	390481
21	T M D M W	39916	2544063	4134194	18	381	170	10	130436	26846	137627	137963
5	T L D C A	39820	4496741	8037021	3	675	588	18	484108	131740	1433703	1576880
3	T L D M A	39179	4122772	7077859	8	541	460	13	426590	195420	514077	557513

TABLE 3.2. Areas in each class that are not legally protected but have had relatively little disturbance

Class		Low Disturban area km2	Rural Pop.	Urban Pop.	Rural Pop/km2	Rural PCI mean	Rural PCI std.	Number of countries	Accessible area	Acc. are Outside Brazil	Area Not Protected	Total area
2	T L S M A	2024818	7462384	12830741	3	453	298	24	810689	299383	2431409	2800366
5	T L D C A	1110909	4496741	8037021	3	675	588	18	484108	131740	1433703	1576880
1	T L H M A	1052434	2234896	2798926	2	394	111	18	325642	142930	1157602	1624899
6	T L D C A	434984	3471035	8324097	4	8872	651	12	530767	73349	784066	879678
12	T L D C W	415829	4704845	10728149	7	954	761	13	375999	171921	708777	830303
17	T M S C A	382568	7133114	23632759	8	1032	547	18	615922	108109	846215	912817
8	T L S M W	304150	5860458	8995565	12	630	487	23	303174	244770	493803	540488
4	T L H C A	250805	272610	392826	1	600	357	12	47113	26695	269778	365079
18	T M D C A	225285	3379676	8204852	7	826	465	12	362535	85779	483141	499928
11	T L S C W	225091	4577921	8229079	13	848	708	17	180864	120358	344035	390481

TABLE 3.3. Area by class with likely degradation by nutrient depletion (erosion or nutrient leaching, weed infestation, etc)

Class		Nutrient Depletion Degradation	Rural Pop.	Urban Pop.	Rural Pop/km2	Rural PCI mean	Rural PCI std.	Number of countries	Accessibl area	Acc. are Outside Brazil	Area Not Protected	Total area
2	T L S M A	792	7462384	12830741	3	453	298	24	810689	299383	2431409	2800366
3	T L D M A	517	4122772	7077859	8	541	460	13	426590	195420	514077	557513
9	T L D M W	473	6264550	11475161	16	523	492	12	341225	196610	391260	398355
5	T L D C A	449	4496741	8037021	3	675	588	18	484108	131740	1433703	1576880
17	T M S C A	427	7133114	23632759	8	1032	547	18	615922	108109	846215	912817
6	T L D C A	386	3471035	8324097	4	882	651	12	530767	73349	784066	879678
21	T M D M W	308	2544063	4134194	18	381	170	10	130436	26846	137627	137963
18	T M D C A	292	3379676	8204852	7	826	465	12	362535	85779	483141	499928
12	T L D C W	283	4704845	10728149	7	954	761	13	375999	171921	708777	830303
1	T L H M A	235	2234896	2798926	2	394	111	18	325642	142930	1157602	1624899

TABLE 4. Environment Classes ordered by present relevance to CIAT crops.

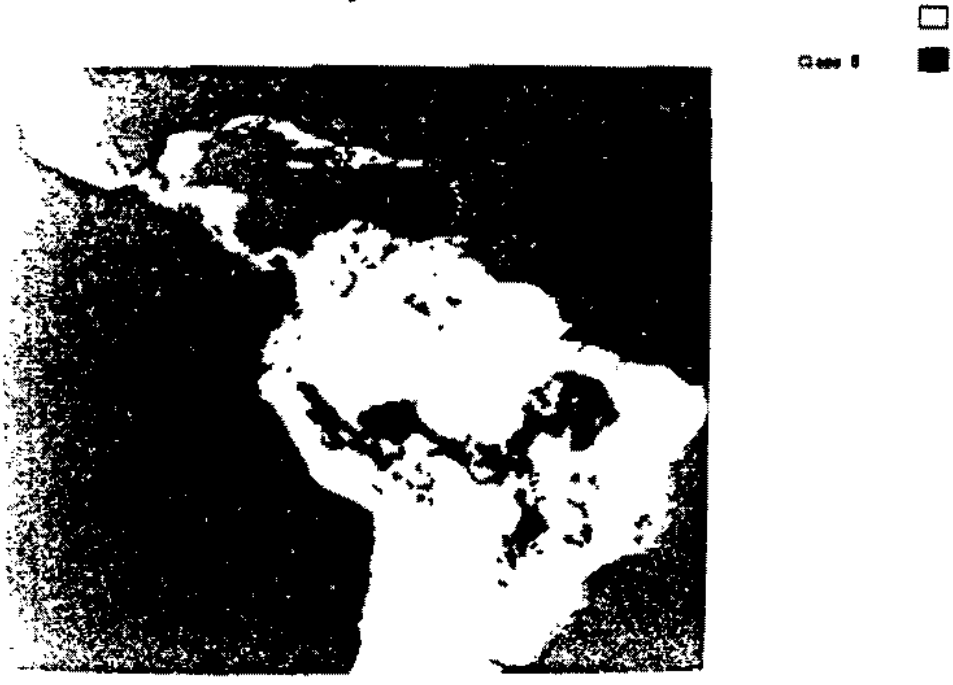
Class		Rice x1000ha	Beans x1000ha	Yuca x1000ha	Summed crop area	Carimagua	Palmira	Quilichao	Popayán	La Libertad
17	T M S C A	925	858	87	1870	0	2039	3062	342	0
6	T L D C A	831	198	34	1063	336	7096	1000	0	0
2	T L S M A	649	74	302	1025	848783	3347	12567	0	32546
5	T L D C A	844	88	63	995	111508	7127	16582	0	5444
18	T M D C A	390	448	38	876	0	341	0	0	0
12	T L D C W	435	301	46	782	1341	4058	1693	0	0
3	T L D M A	382	79	113	574	0	5735	0	0	0
9	T L D M W	274	136	98	508	0	6410	337	0	0
8	T L S M W	303	51	138	492	113871	2699	7756	0	6302
14	T M S M A	174	149	107	430	0	0	2040	0	0
16	T M M C A	83	248	75	406	0	0	681	0	0
28	T M M C A	90	248	31	369	0	0	0	0	0
21	T M D M W	20	197	107	324	0	3051	341	0	0
11	T L S C W	225	40	27	292	26665	2707	5362	0	678
23	T M S C W	93	121	19	233	0	340	340	0	0
24	T M D C W	34	178	20	232	0	681	1008	341	0
20	T M S M W	38	73	60	171	0	0	1360	0	0
15	T M D M A	12	105	48	165	0	335	0	0	0
13	T M M M A	58	21	71	150	0	0	0	0	0
1	T L M M A	83	4	54	141	82397	0	8117	0	2377
29	T M S C A	20	67	21	108	0	0	0	2385	0
52	S M M M A	13	49	37	99	0	0	0	0	0
53	S M S M A	27	7	43	77	0	0	0	0	0
59	S M S C W	51	1	23	75	0	0	0	0	0
7	T L M M W	60	5	5	70	0	0	324	0	0
25	T M M M A	32	16	20	68	0	0	0	0	0
60	S M D C W	33	11	10	54	0	0	0	0	0
30	T M D C A	0	44	3	47	0	0	0	2386	0
19	T M M M W	5	8	25	38	0	0	341	0	0
36	T M D C W	0	25	0	25	0	0	0	342	0
26	T M S M A	5	17	1	23	0	0	0	1363	0
32	T M S M W	1	16	5	22	0	0	0	0	0
4	T L M C A	9	4	8	21	341	0	6138	0	341
22	T M M C W	13	5	3	21	0	0	323	0	0
42	S L D C A	2	16	0	18	0	0	0	0	0
35	T M S C W	0	17	0	17	0	0	0	0	0
56	S M S M W	14	0	2	16	0	0	0	0	0
48	S L D C W	1	14	0	15	0	0	0	0	0
27	T M D M A	0	14	0	14	0	0	0	682	0
58	S M M C W	12	0	0	12	0	0	0	0	0
44	S L S M W	0	2	9	11	0	0	0	0	0
54	S M D M A	6	0	0	6	0	0	0	0	0
10	T L M C W	3	2	0	5	0	0	323	0	0
33	T M D M W	0	4	0	4	0	0	0	0	0
47	S L S C W	1	0	1	2	0	0	0	0	0
31	T M M M W	0	0	0	0	0	0	0	0	0
34	T M M C W	0	0	0	0	0	0	0	0	0
57	S M D M W	0	0	0	0	0	0	0	0	0

TABLE 5 Occurrences of classes in the first rows of the ordered tables.

Class	1	2	3.1	3.2	3.3	4
1				*		
2	*	*	*	*	*	*
3		*			*	
5	*			*	*	*
6				*		*
8	*	*	*			
9		*	*		*	
12	*		*	*		
17	*	*	*		*	*
18						*

Class 2 Acid lowland tropic seasonal maritime

class 5 acid lowland tropics seasonal continental



Class 17 Acid med altitude tropic seasonal continental

class 8 lowland tropics good soil seasonal maritime

Good soil lowland tropics dry maritime

Class 12 good soil lowland tropics dry continental

class 11 good soil lowland tropics seasonal continental

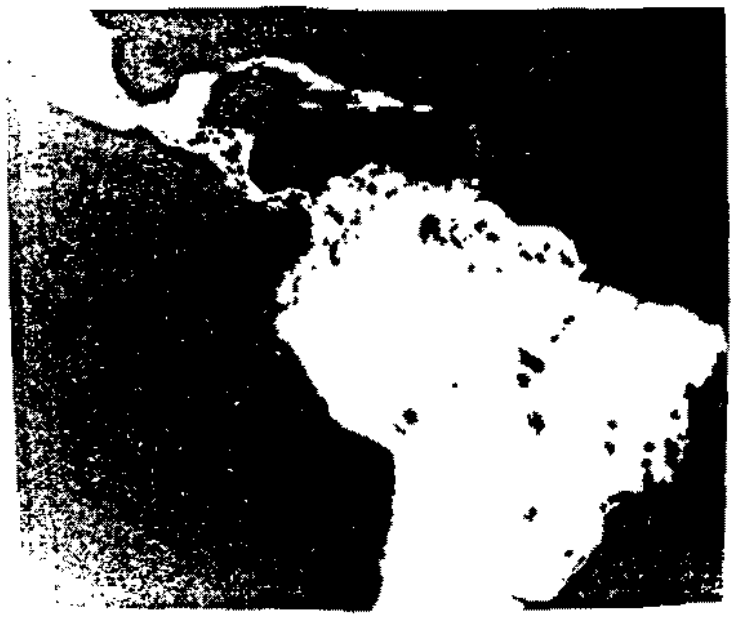
Class 6 Acid lowland tropic dry continental

Class 1 Acid lowland tropic humid maritime

class 3 acid lowland tropic dry maritime

Class 15 Acid mid altitude tropic dry continental

class 14 acid mid altitude tropics seasonal maritime



Drs. Luis Sanint, W. Janssen. May 15, 1990.

Methodology for ranking LAC environmental classes.

From the various categories identified by P. Jones and D. Robinson (J&R) to rank environmental classes, a single ranking index was developed. The three basic criteria (growth, equity, sustainability) have been broken into the following categories:

A. Growth category. It has two components: (i) the production potential component, as defined by J&R (accessible area times a subjective productivity index) and (ii) the growth potential index, which expands the former concept to account for population density, i.e., the more densily populated a class is, the higher the multiplier effects of infrastructure, labor, resource availability, etc. The idea is that currently populated areas have more growth potential than those in the outside frontiers.

B. Rural Poverty Category. Table 2 in J&R divides rural population by the square of the rural Per Capita Income. Here, it was redefined to exclude the rural population size in each class and, in turn, include the density of population divide by PCI. It is argued that area size was already sufficiently incorporated in the growth potential category and total population is highly correlated with area size.

C. Environmental Category. Tables 3.1, 3.2 and 3.3 in J&R were included but the areas in 3.1 and 3.3 were multiplied by the subjective productivity index. This gives more value to more productive hectares at risk, relative to the less productive ones.

In addition to those three criteria, the list was extended to ponderate factors like (i) number of countries in each agroecological class, (ii) percentage of the area in that class currently occupied by the three CIAT crops (beans, cassava and rice) and (iii) the accessible area in each class outside Brazil.

The single ranking index has two basic characteristics:

1.- All the scores in the various categories were standardized (substracted from the category mean and divided by the standard deviation). This yields a unitless index that allows intercategory comparisons.

2.- Subjective weights were applied to those standardized indexes, maintaining a balance among the major criteria already identified by Jones and Robison: growth, equity and sustainability. Each group received weights amounting to 10 points. A sensitivity analysis of those weights reveals that the optimal set is quite stable to changes in the various weights.

Environment Classes ordered by weighted coefficients

Class		Weighted Scoring Coefficient	Hierarchy		Scenario 1
8	T L S M W	67.77	1	Weights	
2	T L S M A	65.86	2	4	Prod. Potential
9	T L D M W	57.54	3	6	Growth Potentia
17	T M S C A	39.25	4		
20	T M S M W	31.41	5	10	Rural Equity
11	T L S C W	31.07	6		
12	T L D C W	27.92	7		Environment
21	T M D M W	24.94	8	5	3.1
5	T L D C A	23.81	9	1	3.2
14	T M S M A	15.62	10	4	3.3
23	T M S C W	14.78	11		
32	T H S M W	10.04	12	3	Number Countr.
13	T M H M A	8.49	13		
3	T L D M A	7.04	14	5	% CIAT Commodit
24	T M D C W	3.01	15		
19	T M H M W	2.30	16	5	Area Out Brazil
28	T H H C A	1.69	17		
15	T M D M A	-0.62	18		
56	S M S M W	-0.72	19		
7	T L H M W	-1.00	20		
1	T L H M A	-1.29	21		
27	T H D M A	-1.45	22		
34	T H H C W	-2.03	23		
6	T L O C A	-2.44	24		
30	T H D C A	-2.44	25		
18	T M D C A	-2.70	26		
16	T M H C A	-5.61	27		
36	T H D C W	-6.84	28		
33	T H D M W	-7.41	29		
35	T H S C W	-7.95	30		
31	T H H M W	-8.95	31		
29	T H S C A	-11.25	32		
22	T M H C W	-12.23	33		
44	S L S M W	-15.34	34		
10	T L H C W	-15.92	35		
25	T H H M A	-17.16	36		
59	S M S C W	-18.91	37		
26	T H S M A	-20.29	38		
53	S M S M A	-23.37	39		
52	S M H M A	-25.25	40		
60	S M D C W	-26.70	41		
4	T L H C A	-29.02	42		
47	S L S C W	-29.37	43		
42	S L D C A	-29.38	44		
48	S L D C W	-31.82	45		
54	S M D M A	-35.57	46		
57	S M D M W	-39.50	47		

nvironment Classes ordered by weighted coefficients

lass						Weighted Scoring Coefficient
9	T	L	D	M	W	47.99
2	T	L	S	M	A	44.48
8	T	L	S	M	W	41.16
17	T	M	S	C	A	28.71
20	T	M	S	M	W	26.54
21	T	M	D	M	W	23.89
11	T	L	S	C	W	19.66
12	T	L	D	C	W	17.37
5	T	L	D	C	A	13.50
34	T	H	H	C	W	11.56
32	T	H	S	M	W	9.33
23	T	M	S	C	W	9.29
14	T	M	S	M	A	7.84
19	T	M	H	M	W	5.57
13	T	M	H	M	A	5.45
27	T	H	D	M	A	5.38
30	T	H	D	C	A	4.56
31	T	H	H	M	W	4.09
3	T	L	D	M	A	3.98
15	T	M	D	M	A	2.08
24	T	M	D	C	W	1.91
28	T	H	H	C	A	0.94
33	T	H	D	M	W	0.90
36	T	H	D	C	W	-0.35
35	T	H	S	C	W	-1.85
7	T	L	H	M	W	-2.62
6	T	L	D	C	A	-3.38
1	T	L	H	M	A	-4.14
18	T	M	D	C	A	-5.54
10	T	L	H	C	W	-7.68
44	S	L	S	M	W	-7.72
29	T	H	S	C	A	-8.70
25	T	H	H	M	A	-12.65
22	T	M	H	C	W	-12.84
16	T	M	H	C	A	-13.12
26	T	H	S	M	A	-13.65
59	S	M	S	C	W	-16.93
47	S	L	S	C	W	-18.11
53	S	M	S	M	A	-19.18
56	S	M	S	M	W	-19.47
52	S	M	H	M	A	-22.16
4	T	L	H	C	A	-23.25
60	S	M	D	C	W	-23.37
48	S	L	D	C	W	-23.77
42	S	L	D	C	A	-24.55
54	S	M	D	M	A	-25.24
57	S	M	D	M	W	-25.93

Hierarchy		Scenario 2
1	Weights	
2	4	Prod. Potential
3	6	Growth Potential
4		
5	10	Rural Equity
6		
7		Environment
8	5	3.1
9	1	3.2
10	4	3.3
11		
12	0	Number Countr.
13		
14	0	% CIAT Commoditie
15		
16	0	Area Out Brazil
17		
18		
19		
20		
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Environment Classes ordered by weighted coefficients

Class		Weighted Scoring Coefficient	Hierarchy		Scenario 3	
8	T L S M W	91.59	1	Weights		
2	T L S M A	85.12	2	8	Prod. Potentia	
9	T L D M W	83.04	3	12	Growth Potenti	
17	T M S C A	59.01	4			
11	T L S C W	43.17	5	10	Rural Equity	
20	T M S M W	42.31	6			
12	T L D C W	39.07	7		Environment	
21	T M D M W	31.80	8	5		3.1
5	T L D C A	31.29	9	1		3.2
14	T M S M A	20.84	10	4		3.3
23	T M S C W	20.71	11			
13	T M H M A	12.54	12	3	Number Countr.	
3	T L D M A	12.21	13			
28	T H H C A	9.47	14	5	% CIAT Commodi	
24	T M D C W	5.72	15			
32	T H S M W	4.24	16	5	Area Out Brazi	
6	T L D C A	0.84	17			
1	T L H M A	-0.77	18			
19	T M H M W	-1.34	19			
18	T M D C A	-1.36	20			
15	T M D M A	-3.24	21			
7	T L H M W	-3.60	22			
16	T M H C A	-7.03	23			
30	T H D C A	-8.23	24			
56	S M S M W	-8.57	25			
27	T H D M A	-9.18	26			
34	T H H C W	-10.29	27			
36	T H D C W	-13.05	28			
35	T H S C W	-14.17	29			
33	T H D M W	-15.06	30			
29	T H S C A	-15.23	31			
31	T H H M W	-16.81	32			
22	T M H C W	-19.46	33			
25	T H H M A	-20.75	34			
59	S M S C W	-21.12	35			
44	S L S M W	-21.57	36			
10	T L H C W	-23.24	37			
26	T H S M A	-26.72	38			
53	S M S M A	-28.91	39			
52	S M H M A	-31.32	40			
60	S M D C W	-32.10	41			
4	T L H C A	-36.26	42			
47	S L S C W	-37.02	43			
42	S L D C A	-37.46	44			
48	S L D C W	-38.42	45			
54	S M D M A	-42.90	46			
57	S M D M W	-47.79	47			

Vironment Classes ordered by weighted coefficients

ass		Weighted Scoring Coefficient	Hierarchy		
2	T L S M A	50.02	1	Weights	
9	T L D M W	48.42	2	4	Prod. Potential
8	T L S M W	47.50	3	6	Growth Potential
17	T M S C A	37.69	4		
20	T M S M W	31.11	5	10	Rural Equity
21	T M D M W	26.93	6		
11	T L S C W	23.01	7		Environment
12	T L D C W	20.42	8	5	3.1
5	T L D C A	18.93	9	1	3.2
23	T M S C W	15.58	10	4	3.3
14	T M S M A	15.22	11		
32	T H S M W	13.36	12	3	Number Countr.
13	T M H M A	9.65	13		
19	T M H M W	5.17	14	5	% CIAT Commoditie
3	T L D M A	4.38	15		
28	T H H C A	4.30	16	0	Area Out Brazil
56	S M S M W	2.99	17		
15	T M D M A	2.36	18		
27	T H D M A	2.11	19		
34	T H H C W	1.68	20		
24	T M D C W	1.58	21		
30	T H D C A	0.22	22		
6	T L D C A	-1.10	23		
7	T L H M W	-1.20	24		
18	T M D C A	-1.77	25		
33	T H D M W	-3.96	26		
36	T H D C W	-4.19	27		
1	T L H M A	-4.57	28		
16	T M H C A	-4.75	29		
35	T H S C W	-4.99	30		
31	T H H M W	-5.31	31		
22	T M H C W	-9.03	32		
29	T H S C A	-9.15	33		
44	S L S M W	-12.49	34		
10	T L H C W	-12.83	35		
25	T H H M A	-14.29	36		
26	T H S M A	-17.10	37		
53	S M S M A	-21.19	38		
59	S M S C W	-22.31	39		
52	S M H M A	-22.41	40		
42	S L D C A	-26.05	41		
47	S L S C W	-26.05	42		
4	T L H C A	-26.59	43		
50	S M D C W	-30.01	44		
48	S L D C W	-31.28	45		
54	S M D M A	-34.18	46		
57	S M D M W	-35.81	47		

Environment Classes ordered by weighted coefficients

Class		Weighted Scoring Coefficient	Hierarchy		Scenario 5
8	T L S M W	88.04	1	Weights	
2	T L S M A	81.70	2	4	Prod. Potential
9	T L D M W	66.66	3	6	Growth Potential
17	T M S C A	40.81	4		
11	T L S C W	39.14	5	10	Rural Equity
12	T L D C W	35.43	6		
20	T M S M W	31.72	7		Environment
5	T L D C A	28.68	8	5	3.1
21	T M D M W	22.96	9	1	3.2
14	T M S M A	16.01	10	4	3.3
23	T M S C W	13.97	11		
3	T L D M A	9.69	12	3	Number Countr.
13	T M H M A	7.33	13		
32	T H S M W	6.72	14	5	% CIAT Commoditie
24	T M D C W	4.45	15		
1	T L H M A	1.98	16	10	Area Out Brazil
19	T M H M W	-0.58	17		
7	T L H M W	-0.80	18		
28	T H H C A	-0.92	19		
15	T M D M A	-3.59	20		
18	T M D C A	-3.64	21		
6	T L D C A	-3.78	22		
56	S M S M W	-4.43	23		
27	T H D M A	-5.01	24		
30	T H D C A	-5.10	25		
34	T H H C W	-5.74	26		
16	T M H C A	-6.48	27		
36	T H D C W	-9.49	28		
33	T H D M W	-10.86	29		
35	T H S C W	-10.91	30		
31	T H H M W	-12.59	31		
29	T H S C A	-13.36	32		
22	T M H C W	-15.42	33		
59	S M S C W	-15.51	34		
44	S L S M W	-18.19	35		
10	T L H C W	-19.01	36		
25	T H H M A	-20.03	37		
60	S M D C W	-23.38	38		
26	T H S M A	-23.47	39		
53	S M S M A	-25.55	40		
52	S M H M A	-28.09	41		
4	T L H C A	-31.45	42		
48	S L D C W	-32.37	43		
47	S L S C W	-32.68	44		
42	S L D C A	-32.72	45		
54	S M D M A	-36.97	46		
57	S M D M W	-43.19	47		

solute numbers for each category, by class.

ss		Production Potential	Growth Potential	Equity Index	Environmental Tables 3.1	3.2	3.3	Number Countr.	XCIAT Commod.	Prod.Pot. Out Brazi
1	T L H M A	976925	2241160	4.9	84426	1052434	704	18	0.04%	428791
2	T L S M A	3242757	6100548	6.8	304016	2024818	3166	24	0.13%	1197533
3	T L D M A	853181	6355947	14.8	78358	217178	1034	13	0.13%	390840
4	T L H C A	141338	168410	1.7	5019	250805	85	12	0.04%	80086
5	T L D C A	1936433	3130616	4.6	159280	1110909	1797	18	0.21%	526960
6	T L D C A	1061534	3949002	5.0	68814	434984	773	12	0.20%	146698
7	T L H M W	287061	3036263	29.4	73255	54830	404	16	0.12%	240750
8	T L S M W	1819042	16126036	18.8	376938	304150	1335	23	0.16%	1468621
9	T L D M W	1364902	19506121	30.6	325024	106298	1890	12	0.15%	786440
0	T L H C W	39867	573597	40.9	19990	6030	56	7	0.06%	39867
1	T L S C W	1085185	10564626	15.7	297132	225091	649	17	0.16%	722148
2	T L D C W	1503994	7915689	7.0	268576	415829	1131	13	0.21%	687686
3	T M H M A	349613	7818968	29.8	107920	31595	343	18	0.17%	157729
4	T M S M A	590522	7605732	19.3	179124	159827	586	21	0.22%	252895
5	T M D M A	191606	3456101	42.9	67830	14015	352	10	0.17%	46918
6	T M H C A	457087	3154257	6.7	47700	92625	180	13	0.36%	175674
7	T M S C A	1847765	12905429	8.2	296361	382568	1281	18	0.30%	324328
8	T M D C A	725071	4026617	8.5	71970	225285	583	12	0.24%	171557
9	T M H M W	136394	2937470	58.5	43182	2992	267	9	0.17%	52956
0	T M S M W	437612	12638770	53.2	178255	13844	558	17	0.20%	247240
1	T M D M W	521742	9165456	48.5	159664	7838	1230	10	0.25%	107385
2	T M H C W	40546	640699	29.7	5796	2662	49	7	0.31%	33424
3	T M S C W	453819	8775853	27.5	148790	16837	483	16	0.26%	179246
4	T M D C W	549220	5877331	20.5	90016	40900	720	9	0.17%	316552
5	T H H M A	145149	2930247	16.6	35076	5761	105	5	0.19%	53170
6	T H S M A	47822	1216193	24.5	17344	9412	31	8	0.10%	33925
7	T H D M A	10877	393816	76.6	7893	1651	11	6	0.13%	10877
8	T H H C A	573443	9632710	12.6	80268	26009	349	10	0.26%	69191
9	T H S C A	130279	2709303	26.8	35932	17917	130	9	0.17%	99783
0	T H D C A	65748	1617955	65.9	29159	26107	80	8	0.07%	66089
1	T H H M W	8066	305322	74.3	4008	0	8	3	0.00%	6069
2	T H S M W	29013	1780256	80.0	21056	1009	13	8	0.30%	25390
3	T H D M W	16947	429205	65.3	8100	2594	11	7	0.07%	17814
4	T H H C W	1981	34255	94.2	1980	341	0	2	0.00%	1981
5	T H S C W	51424	1362297	52.0	22192	1672	79	6	0.13%	47636
6	T H D C W	66512	1300072	55.0	25395	8633	100	6	0.11%	66512
2	S L D C A	24703	70455	3.9	960	4093	11	3	0.22%	24703
4	S L S M W	54394	1338184	38.8	15155	310	53	2	0.14%	54394
7	S L S C W	25941	380640	18.2	6468	1238	11	2	0.05%	25942
8	S L D C W	195472	412684	1.4	6335	10682	13	4	0.04%	195470
2	S M H M A	195558	807017	3.0	6025	10715	85	3	0.25%	55150
3	S M S M A	150799	1421333	6.9	26704	4605	66	3	0.20%	95472
4	S M D M A	143158	95518	0.3	1920	5383	2	3	0.01%	143157
6	S M S M W	10723	304812	15.1	8880	0	5	2	0.90%	1830
7	S M D M W	3104	2452	0.6	4545	0	13	2	0.00%	3104
9	S M S C W	462029	2524412	2.9	39930	4845	47	4	0.10%	436909
0	S M D C W	431312	232047	0.3	0	7518	12	4	0.06%	431312
	Means	499099	4041955	27	82186	156273	444	10	0.17%	228685

Standardized Scoring Coefficients Matrix

Class		Production Potential	Growth Potential	Equity Index	Environmental Tables 3.1	3.2	3.3	Number Countr. in Class	% Area in CIAT Comm.	Prod.Pot. Outside Brazil
1	T L H N A	0.72	-0.39	-0.89	0.02	2.48	0.41	1.37	-0.91	0.65
2	T L S N A	4.14	0.45	-0.81	2.20	5.16	4.30	2.35	-0.31	3.17
3	T L D N A	0.53	0.51	-0.49	-0.04	0.17	0.93	0.55	-0.25	0.53
4	T L H C A	-0.54	-0.85	-1.02	-0.76	0.26	-0.57	0.38	-0.90	-0.49
5	T L D C A	2.17	-0.20	-0.90	0.76	2.64	2.14	1.37	0.27	0.98
6	T L D C A	0.85	-0.02	-0.88	-0.13	0.77	0.52	0.38	0.23	-0.27
7	T L H N W	-0.32	-0.22	0.10	-0.09	-0.28	-0.06	1.04	-0.34	0.04
8	T L S N W	1.99	2.64	-0.33	2.92	0.41	1.41	2.19	-0.05	4.05
9	T L D N W	1.31	3.38	0.15	2.40	-0.14	2.29	0.38	-0.14	1.82
10	T L H C W	-0.69	-0.76	0.56	-0.62	-0.41	-0.61	-0.44	-0.77	-0.62
11	T L S C W	0.88	1.43	-0.45	2.13	0.19	0.32	1.20	-0.05	1.61
12	T L D C W	1.52	0.85	-0.81	1.84	0.72	1.08	0.55	0.28	1.50
13	T M H N A	-0.23	0.83	0.11	0.25	-0.34	-0.16	1.37	0.02	-0.23
14	T M S N A	0.14	0.78	-0.31	0.96	0.01	0.22	1.86	0.36	0.08
15	T M D N A	-0.46	-0.13	0.64	-0.14	-0.39	-0.15	0.05	0.02	-0.59
16	T M H C A	-0.06	-0.19	-0.81	-0.34	-0.18	-0.42	0.55	1.35	-0.17
17	T M S C A	2.04	1.94	-0.76	2.12	0.63	1.32	1.37	0.97	0.31
18	T M D C A	0.34	0.00	-0.74	-0.10	0.19	0.22	0.38	0.53	-0.19
19	T M H N W	-0.55	-0.24	1.27	-0.39	-0.42	-0.28	-0.11	-0.01	-0.57
20	T M S N W	-0.09	1.88	1.06	0.95	-0.39	0.18	1.20	0.19	0.06
21	T M D N W	0.03	1.12	0.86	0.77	-0.41	1.24	0.05	0.58	-0.40
22	T M H C W	-0.69	-0.74	0.11	-0.76	-0.42	-0.63	-0.44	1.03	-0.64
23	T M S C W	-0.07	1.03	0.02	0.66	-0.39	0.06	1.04	0.64	-0.16
24	T M D C W	0.08	0.40	-0.26	0.08	-0.32	0.44	-0.11	0.00	0.29
25	T H H N A	-0.53	-0.24	-0.42	-0.47	-0.42	-0.54	-0.77	0.13	-0.57
26	T H S N A	-0.68	-0.62	-0.10	-0.64	-0.41	-0.65	-0.28	-0.52	-0.64
27	T H D N A	-0.74	-0.80	2.00	-0.74	-0.43	-0.69	-0.61	-0.29	-0.71
28	T H H C A	0.11	1.22	-0.58	-0.02	-0.36	-0.15	0.05	0.64	-0.52
29	T H S C A	-0.56	-0.29	-0.01	-0.46	-0.38	-0.50	-0.11	-0.02	-0.42
30	T H D C A	-0.65	-0.53	1.56	-0.52	-0.36	-0.58	-0.28	-0.70	-0.53
31	T H H N W	-0.74	-0.82	1.90	-0.77	-0.43	-0.69	-1.10	-1.22	-0.75
32	T H S N W	-0.71	-0.49	2.13	-0.60	-0.43	-0.68	-0.28	0.97	-0.66
33	T H D N W	-0.73	-0.79	1.54	-0.73	-0.42	-0.69	-0.44	-0.71	-0.69
34	T H H C W	-0.75	-0.88	2.70	-0.79	-0.43	-0.70	-1.26	-1.22	-0.74
35	T H S C W	-0.68	-0.59	1.01	-0.59	-0.43	-0.58	-0.61	-0.26	-0.59
36	T H D C W	-0.65	-0.60	1.13	-0.56	-0.41	-0.54	-0.61	-0.40	-0.53
42	S L D C A	-0.72	-0.87	-0.93	-0.80	-0.42	-0.69	-1.10	0.36	-0.67
44	S L S N W	-0.67	-0.59	0.47	-0.66	-0.43	-0.62	-1.26	-0.20	-0.57
47	S L S C W	-0.71	-0.80	-0.35	-0.75	-0.43	-0.68	-1.26	-0.83	-0.66
48	S L D C W	-0.46	-0.79	-1.03	-0.75	-0.40	-0.68	-0.93	-0.94	-0.11
52	S M H N A	-0.46	-0.71	-0.96	-0.75	-0.40	-0.57	-1.10	0.61	-0.57
53	S M S N A	-0.53	-0.57	-0.81	-0.55	-0.42	-0.60	-1.10	0.26	-0.44
54	S M D N A	-0.54	-0.86	-1.07	-0.79	-0.42	-0.70	-1.10	-1.13	-0.28
56	S M S N W	-0.74	-0.82	-0.48	-0.73	-0.43	-0.70	-1.26	5.25	-0.74
57	S M D N W	-0.75	-0.88	-1.06	-0.77	-0.43	-0.68	-1.26	-1.22	-0.74
59	S M S C W	-0.06	-0.33	-0.97	-0.42	-0.42	-0.63	-0.93	-0.52	0.68
60	S M D C W	-0.10	-0.83	-1.07	-0.81	-0.41	-0.68	-0.93	-0.77	0.66

hted Standardized Scoring Coefficients Matrix

ective Weight (Scenario 1)		4	6	10	5	1	4	3	5	5	
s		Production Potential	Growth Potential	Equity Index	Environmental Tables 3.1	3.2	3.3	Number Countr.	%CIAT Comm.	Outside Brazil	TOTAL SCORE
T L H M A		2.88	-2.36	-8.88	0.11	2.48	1.64	4.10	-4.53	3.27	-1.29
T L S M A		16.56	2.70	-8.13	10.98	5.16	17.21	7.06	-1.53	15.84	65.86
T L D M A		2.14	3.03	-4.90	-0.19	0.17	3.73	1.64	-1.24	2.65	7.04
T L H C A		-2.16	-5.08	-10.18	-3.82	0.26	-2.28	1.14	-4.49	-2.43	-29.02
T L D C A		8.68	-1.20	-8.99	3.81	2.64	8.55	4.10	1.33	4.88	23.81
T L D C A		3.40	-0.12	-8.84	-0.66	0.77	2.08	1.14	1.14	-1.34	-2.44
T L H M W		-1.28	-1.32	0.96	-0.44	-0.28	-0.26	3.12	-1.69	0.20	-1.00
T L S M W		7.97	15.85	-3.28	14.58	0.41	5.63	6.57	-0.24	20.27	67.77
T L D M W		5.23	20.28	1.46	12.02	-0.14	9.14	1.14	-0.72	9.12	57.54
T L H C W		-2.77	-4.55	5.59	-3.08	-0.41	-2.46	-1.32	-3.83	-3.09	-15.92
T L S C W		3.54	8.55	-4.55	10.64	0.19	1.29	3.61	-0.27	8.07	31.07
T L D C W		6.07	5.08	-8.06	9.22	0.72	4.34	1.64	1.42	7.50	27.92
T M H M A		-0.90	4.95	1.11	1.27	-0.34	-0.64	4.10	0.10	-1.16	8.49
T M S M A		0.55	4.67	-3.08	4.80	0.01	0.89	5.58	1.79	0.40	15.62
T M D M A		-1.86	-0.77	6.39	-0.71	-0.39	-0.58	0.16	0.12	-2.97	-0.62
T M H C A		-0.25	-1.16	-8.15	-1.71	-0.18	-1.67	1.64	6.74	-0.87	-5.61
T M S C A		8.14	11.62	-7.57	10.60	0.63	5.29	4.10	4.87	1.56	39.25
T M D C A		1.36	-0.02	-7.45	-0.51	0.19	0.88	1.14	2.63	-0.93	-2.70
T M H M W		-2.19	-1.45	12.68	-1.93	-0.42	-1.12	-0.34	-0.06	-2.87	2.30
T M S M W		-0.37	11.27	10.55	4.75	-0.39	0.72	3.61	0.96	0.30	31.41
T M D M W		0.14	6.72	8.64	3.83	-0.41	4.97	0.16	2.88	-1.98	24.94
T M H C W		-2.77	-4.46	1.10	-3.78	-0.42	-2.50	-1.32	5.13	-3.19	-12.23
T M S C W		-0.27	6.21	0.20	3.30	-0.39	0.24	3.12	3.18	-0.81	14.78
T M D C W		0.30	2.41	-2.61	0.39	-0.32	1.74	-0.34	0.01	1.44	3.01
T H H M A		-2.14	-1.46	-4.16	-2.33	-0.42	-2.15	-2.31	0.67	-2.87	-17.16
T H S M A		-2.72	-3.71	-0.99	-3.21	-0.41	-2.61	-0.83	-2.62	-3.18	-20.29
T H D M A		-2.95	-4.78	19.95	-3.68	-0.43	-2.74	-1.82	-1.45	-3.56	-1.45
T H H C A		0.45	7.33	-5.79	-0.09	-0.36	-0.60	0.16	3.20	-2.61	1.69
T H S C A		-2.23	-1.75	-0.07	-2.29	-0.38	-1.99	-0.34	-0.11	-2.11	-11.25
T H D C A		-2.62	-3.18	15.65	-2.62	-0.36	-2.30	-0.83	-3.52	-2.66	-2.44
T H H M W		-2.96	-4.90	19.01	-3.87	-0.43	-2.76	-3.30	-6.10	-3.64	-8.95
T H S M W		-2.84	-2.97	21.32	-3.02	-0.43	-2.73	-0.83	4.86	-3.32	10.04
T H D M W		-2.91	-4.74	15.38	-3.67	-0.42	-2.74	-1.32	-3.54	-3.45	-7.41
T H H C W		-3.00	-5.26	27.03	-3.97	-0.43	-2.81	-3.79	-6.10	-3.71	-2.03
T H S C W		-2.70	-3.31	10.07	-2.97	-0.43	-2.31	-1.82	-1.32	-2.96	-7.95
T H D C W		-2.61	-3.60	11.26	-2.81	-0.41	-2.18	-1.82	-2.02	-2.65	-6.84
S L D C A		-2.86	-5.21	-9.30	-4.02	-0.42	-2.74	-3.30	1.80	-3.33	-29.38
S L S M W		-2.68	-3.55	4.73	-3.32	-0.43	-2.47	-3.79	-0.98	-2.85	-15.34
S L S C W		-2.86	-4.80	-3.54	-3.75	-0.43	-2.74	-3.79	-4.15	-3.31	-29.37
S L D C W		-1.83	-4.76	-10.29	-3.75	-0.40	-2.73	-2.80	-4.71	-0.54	-31.82
S M H M A		-1.83	-4.24	-9.64	-3.77	-0.40	-2.27	-3.30	3.05	-2.84	-25.25
S M S M A		-2.10	-3.44	-8.08	-2.75	-0.42	-2.39	-3.30	1.28	-2.18	-23.37
S M D M A		-2.15	-5.18	-10.72	-3.97	-0.42	-2.80	-3.30	-5.64	-1.40	-35.57
S M S M W		-2.95	-4.90	-4.78	-3.63	-0.43	-2.78	-3.79	26.25	-3.71	-0.72
S M D M W		-2.99	-5.30	-10.63	-3.84	-0.43	-2.73	-3.79	-6.10	-3.69	-39.50
S M S C W		-0.22	-1.99	-9.69	-2.09	-0.42	-2.52	-2.80	-2.58	3.40	-18.91
S M D C W		-0.41	-5.00	-10.75	-4.07	-0.41	-2.74	-2.80	-3.84	3.31	-26.70

Ranking of each class by categories.

Class	Product. Potential	Growth Potential	Rural Equity	3.1	3.2	3.3	# Countr.	%CIAT Comm.	Area Outside Brazil
1 T L H M A	6	25	44	14	3	11	5	42	9
2 T L S M A	1	13	35	3	1	1	1	31	2
3 T L D M A	10	12	29	16	11	8	14	28	10
4 T L H C A	26	43	54	41	8	27	16	41	26
5 T L D C A	7	19	47	10	2	3	6	14	6
6 T L D C A	8	16	42	19	4	9	18	16	21
7 T L H M W	22	20	18	17	15	17	10	32	15
8 T L S M W	3	2	24	1	7	4	2	24	1
9 T L D M W	4	1	15	2	13	2	17	26	3
10 T L H C W	39	35	13	31	30	31	29	38	36
11 T L S C W	9	5	27	4	10	12	8	25	4
12 T L D C W	5	9	33	6	5	7	12	13	5
13 T M H M A	21	10	16	12	17	20	7	20	20
14 T M S M A	13	11	23	7	12	13	3	12	13
15 T M D M A	23	17	12	20	22	18	19	19	35
16 T M H C A	18	18	36	21	14	22	13	2	18
17 T M S C A	2	3	32	5	6	5	4	4	11
18 T M D C A	12	15	31	18	9	14	15	10	19
19 T M H M W	31	21	7	22	36	21	24	22	33
20 T M S M W	17	4	9	8	23	15	9	17	14
21 T M D M W	14	7	11	9	28	6	21	9	23
22 T M H C W	37	34	17	40	37	33	30	3	38
23 T M S C W	20	8	19	11	21	16	11	7	17
24 T M D C W	15	14	22	13	16	10	22	21	12
25 T H H M A	27	22	26	25	31	24	34	18	32
26 T H S M A	34	32	21	32	26	35	25	35	37
27 T H D M A	44	38	3	36	40	41	33	30	43
28 T H H C A	11	6	30	15	19	19	20	6	27
29 T H S C A	29	23	20	24	20	23	23	23	24
30 T H D C A	32	27	5	26	18	28	26	36	29
31 T H H M W	45	40	4	43	47	44	40	47	44
32 T H S M W	38	26	2	30	42	37	27	5	40
33 T H D M W	42	36	6	35	38	43	28	37	42
34 T H H C W	47	46	1	44	43	47	47	46	46
35 T H S C W	35	29	10	29	39	29	31	29	34
36 T H D C W	33	31	8	28	27	25	32	33	28
42 S L D C A	41	45	48	46	35	42	42	11	41
44 S L S M W	36	30	14	33	44	32	46	27	31
47 S L S C W	40	39	25	37	41	40	44	40	39
48 S L D C W	24	37	56	38	25	36	35	43	16
52 S M H M A	25	33	52	39	24	26	41	8	30
53 S M S M A	28	28	34	27	34	30	38	15	25
54 S M D M A	30	44	59	45	32	46	39	44	22
56 S M S M W	43	41	28	34	46	45	43	1	47
57 S M D M W	46	47	57	42	45	38	45	45	45
59 S M S C W	16	24	53	23	33	34	36	34	7
60 S M D C W	19	42	60	47	29	39	37	39	8

DATA ANALYSIS FOR DECISION MAKING IN NATURAL RESOURCE MANAGEMENT FOR SUSTAINABLE AGRICULTURE

June 1990

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DESCRIPTIONS OF ENVIRONMENTAL REGIONS CHOSEN FOR FURTHER STUDY.

CLASS 2.
ACID LOWLAND TROPICS SEASONAL MARITIME.

This class is heterogeneous. It includes highly populated areas of coastal Brasil under sugar cane and cacao, some similar areas in the Caribbean and Central America. Large areas of semi-evergreen seasonal forest in Brasil, Peru, Colombia, Bolivia and Central American countries. It also includes the savannas of the Colombian Llanos and in Venezuela, and areas of the northern Cerrados.

CLASS 5.
ACID LOWLAND TROPICS SEASONAL CONTINENTAL

This class is the continental counterpart of class 2. Much of the area is seasonal forest although some areas are lowland savannas. Large extents are inaccessible and lightly populated.

CLASS 8.
GOOD SOIL LOWLAND TROPICS SEASONAL MARITIME.

Includes heavily populated coastal areas throughout the regions, apart from Peru. An anomaly in this region as mapped is that it includes poorly drained areas in Bolivia, Arauca Colombia and some regions of the Amazon basin.

CLASS 9.

GOOD SOIL LOWLAND TROPICS SEASONALLY DRY MARITIME.

This class includes heavily populated coastal areas of N.E. Brazil, Venezuela, Colombia, Ecuador, Costa Rica and Mexico. It contains lower populated areas of the Yucatan, Honduras and Bolivia. Perhaps most important class for Mexico.

Much of the area is hilly, contains much cotton and various annual crops. Also an important sugar cane region.

CLASS 11.

GOOD SOIL LOWLAND TROPICS SEASONAL CONTINENTAL

The continental counterpart of Class 8. Although some areas are truly good soils, highly productive and well populated, significant areas of this class are remote poorly decimal areas in the continental interior.

CLASS 17.

ACID MEDIUM ALTITUDE TROPICS SEASONAL CONTINENTAL.

Also a highly heterogeneous class but closely allied to the coffee areas. These are the poorer coffee areas throughout Central America and the Andes. Large areas in Brasil include the high cerrados around Brasilia and CPAC but also the more broken terrain of the coffee areas to the south. Apart from the savannas of Roraima and Guyana and the northern extent of the cerrados all these areas are moderately to highly populated.

CLASS 20.

MID ALTITUDE GOOD SOIL SEASONAL TROPICS MARITIME.

Hill slope areas with high population -coffee zones throughout Central America and the Northern Andes. The good soil companion to Class 17. Also good soil areas in coastal Brasil.

DATA ANALYSIS FOR DECISION MAKING IN NATURAL RESOURCE MANAGEMENT FOR SUSTAINABLE AGRICULTURE

CHARACTERIZATION OF LANDUSE WITHIN EACH CLASS

PHASE II

13 August 1990

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Agroecological Studies Unit-CIAT

The selection of environmental classes within which to concentrate does not suffice to characterize and identify researchable problems. Problems with the use of land resources depend as much on the nature of the landuse as on the nature of the resources. The purpose of Phase II, therefore, was to assess the actual landuse in the selected environmental classes to identify and organize the nature of problems resulting from the respective landuses.

The approach used was to consider each contiguous area of a selected environmental class (referred to as a subzone) and determine a number of variables relating to its actual landuse. Figure II.1 is an example of the worksheet that was filled for each subzone over 600 km2. That cutoff size reduced the number of subzones from over 500 to just over 300, yet accounted for over 98% of the area. The actual variables were chosen in conjunction with the economists.

Using maps censuses, atlases and reports, simple variables were noted for soil, topography, climate, natural vegetation, actual use, principal crops, principal farming systems, population density, urban dependence on agriculture, land distribution, % of area readily accessible to transport and relative distance to market. This work absorbed three people working full time for three months.

PAIS: HOJA ONC: SUBZONA:
TITULO: AREA :

DESCRIPCION :

TOPOGRAFIA < 8 : 8 < 30 : > 30 :

SUELOS

PROFUNDIDAD : TEXTURA :
DRENAJE :
PROB. QUIMICA:
PROB. FISICA:

CLIMA

BIMODAL: MESES > 200 mm.:

USO DE LA TIERRA

VEGETACION NAT. : % :
RIEGO % : ANUALES :
PERENNE : PASTURAS % :
BOSQUE MAN. : RASTROJO LARGO :

ANUALES (en orden):

PERENNE (en orden):

SISTEMAS

1.- P1:

2.- P2:

3.- P3:

4.- P4:

DEN. POB.: DEP. URB.:
LANDLESS: IPCR:
% EXP. < 10 Ha.: % AREA < 10 Ha.:
ACCESO: AISLAMIENTO :

FIGURE 1. SURVEY WORKSHEET

TABLE 6. **Patrones de uso de la tierra identificados**

Ganadería Ext., Cultivos Disc., Bosque Natural	GE-CD-BN *
Ganadería Extensiva - Cult. Mec. - Cultivos Discontinuos	GE-CM-CD
Ganadería Extensiva - Cultivos Anuales Mech - Bosque Nat.	GE-CM-BN
Ganadería Extensiva - Bosque Natural	GE-BN
Ganadería Extensiva - Cultivo Discontinuo Tradicional	GE-CD
Ganadería en Pendiente - Café - Frutales, Maíz, Frijol	GP-CA-FR
Ganadería en Pendiente, Café, Cultivos Discontinuos	GP-CA-CD
Frutales - Ganadería Pequeña Escala - Cultivo Disc.	FR-GP-CD
Caña Intensiva - Ganadería Intensiva - Cultivo Mec.	CI-GI-CM
Caña y Cultivo Pequeña Escala	CN-CP
Ganadería Pequeña Escala - Cultivo Disc., Frutales	GP-CD-FR
Cultivos Intensivos con Riego - Ganadería Extensiva	CIR-GE
Cultivos Intensivos con Riego - Cultivos Mixtos Mec.	CIR-CM
Ganadería Extensiva, Cultivos Discontinuos, Colonización	GE-CD-CO
Cultivos Mecanizados Escala Media - Ganadería Med.	CMM-GM
Ganadería Mixta-Arroz Secano Mecanizado-Otros cultivos Mec.	GM-AS-MM
Cultivos Disc., Ganadería en Pequeña escala, colonización	CO-GP
Ganadería Extensiva en Tierra Inundada	GEI
Cultivos Disc. - Bosque Manejado - Ganad. Peq. Escala	CD-BM-GP
Ganadería Pequeña Escala, Cult. Disc., Banano	GP-CD-B
Goma (Caucho) y Castaño extensiva	GO-CA
Cultivo Discontinuo - Ganadería Pequeña Escala	CD-GP
Sistema Fluvial selvática en Tierra Firme	FTF
Sistema Fluvial selvática en Várzea	FV
Pastoreo Extensivo de Caprinos	CP
Ganadería Extensiva - Palma Africana	GE-PA
Café y Cultivos Mecanizada, Ganadería Intensiva	CAM-GI-CM

* El orden de las abreviaciones no siempre representa la predominancia relativa entre los sistemas de un patrón.

Parallel to this process Jenny Gaona and Argemiro Monsalve were conducting interviews with visitors to CIAT from different countries, and obtaining recent, first hand information about as many subzones as possible.

Once these variables had been determined for the 300 subzones, they were used to determine systems, and the combination of these to determine land use patterns. It is important to note that virtually all of the subzones had at least two modal landuses systems, that is, different systems practiced by different people within the same area eg. extensive cattle ranching and shifting cultivation. Table 6. shows all of the landuse patterns described, regardless of environmental class.

Vegetation

Table 7. helps illustrate the limitations of using original vegetation alone to separate ecozones. Approximately the same percentages of areas formerly under forest and savanna are now under cropping or pasture. There is as much managed forest in former savanna areas as in former forest areas. While each environmental class is mainly one vegetation type or the other, we found instances of savanna and forest in each of the 7 classes that we considered.

Each of the environmental classes has an area of steep slopes constituting "ladera". Each class had areas with extensive use and others with intensive use. However in the process of individually describing each area, we quickly came to realize that there are repeating patterns of land use with common problems and potential as well as similar environments. The process below is attempt to organize these repeating patterns into a structure that allows for simplification while retaining the necessary complexity.

TABLE 7. Vegetation in the selected classes

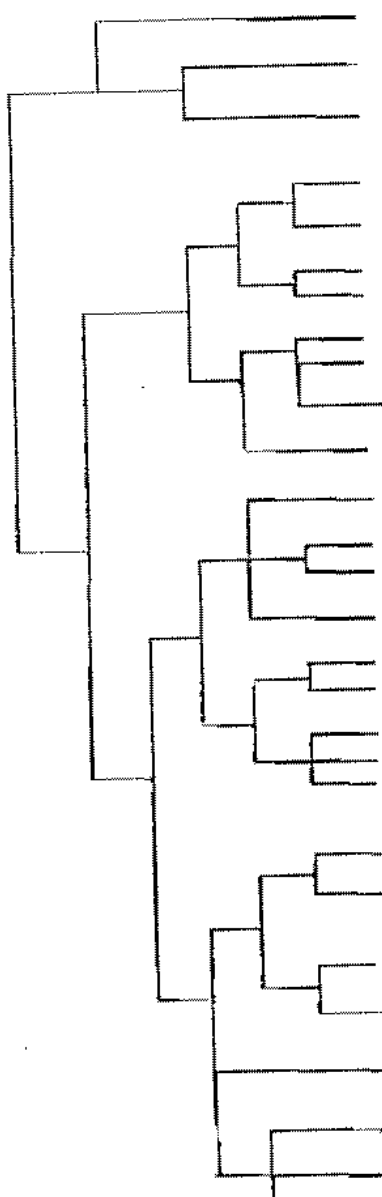
	Original (km2)	Existing nat.veg.	Accessible area	Area under grazing	Annual cropp.	perennial	Mechaniz. area
Forest	1366839	574809.9	915543.5	358376.7	143767.6	84159.48	615720.8
Savanna	804689	415573.7	583551	431644.0	68113.37	10384.96	420967.5
Unclassif.	293663	146790.7	240436	135456.8	26861.36	19310.44	65907.8
Total	2465191	1137174.	1739531.				

LAND USE PATTERN GROUPING

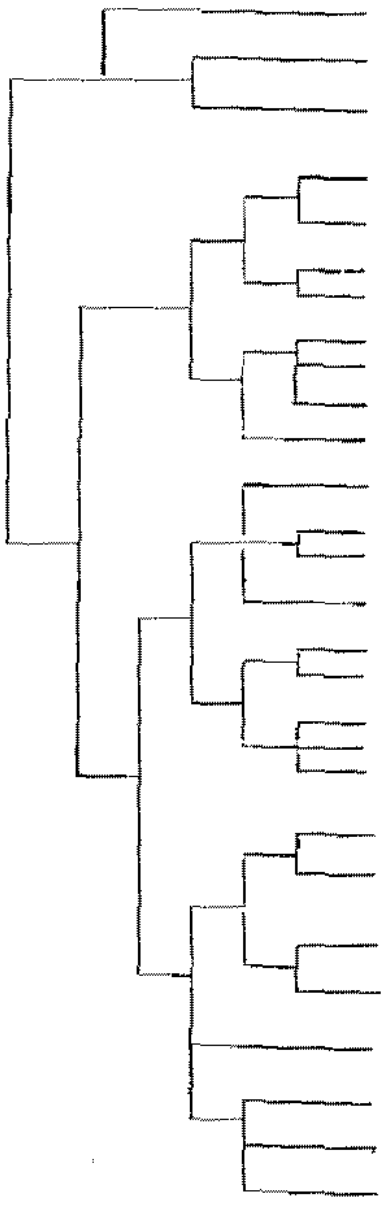
The land use patterns were assigned to each of the 300 subzones along with the environment class. When sorted by predominant patterns a series of groupings appeared which seemed to be logical. These were inspected and clustered according to a consensus of subjective estimates of similarity among those working in the unit. Since much of the information was non numeric and not ordered this was considered more appropriate than a numeric clustering algorithm. Figs. 2 and 3 show the areas and population respectively for these land use pattern groups within the six environmental classes selected in Phase I.

These follows a selection of descriptions of the main clusters.

FIG. 2 Corrected Populations Thousands



Environment Class	2	5	8	9	11	17	20
UNUSED FOREST LANDS	0.00						
RUBBER- NUTS	8.75	6.45			4.05		
FLUVIAL & VARSEA SYSTEMS	1.47	0.63	5.56		12.42		0.94
INTENSIVE CANE POOR LANDS	111.08						
INTENSIVE CANE GOOD LANDS	59.13		126.97	159.34	90.25		100.17
INTENSIVE IRRIGATION			46.35		6.34		29.20
BRASIL MECHANIZED COFFEE AREAS	158.19	200.80				138.90	
MECHANIZED MEDIUM SCALE			142.82			4.24	
CERRADOS TYPE PASTURES MECH CROPPING						405.76	
POOR LOWLAND PASTURES MECH CROPPING	81.45	192.47					
LOWLAND EXTENSIVE GRAZING POOR SOILS		3.64					
GOOD LOWLAND PASTURES MECH CROPPING			75.81		39.35		
POORLY DRAINED PASTURES	15.23	5.47	0.64		219.99		
GOOD LOWLAND PASTURES ALONE					12.17		
HIGHLAND PASTURES ALONE						1.65	1.06
LOWLAND EXTENSIVE GRAZING POOR SOILS		3.64					
POOR LOWLAND PASTURES MANUAL CROPPING	273.63	6.90	0.99				
GOOD LOWLAND PASTURES MANUAL CROPPING			160.20		37.68		
DRY LOWLAND PASTURES MAN/MECH CROPS				149.87			
DRY LOWLAND PASTURES MANUAL CROPPING				267.03			
GOAT GRAZING				5.92			
LADERAS CATTLE COFFEE POOR SOIL						113.70	
LADERAS GRAZING SHIFT CULT POOR SOIL					8.45	49.04	
LADERAS CATTLE COFFEE GOOD SOIL							69.91
LADERAS GRAZING SHIFT CULT GOOD SOIL							62.51
LOWLAND CATTLE COFFEE	26.15		14.12	18.71	18.59		
SHIFTING CULTIVATION			4.83	4.57			0.26
SMALL SCALE CANE & MANUAL CULTIVATION			6.16	17.02	8.45		10.67



	2	5	8	9	11	17	20
UNUSED FOREST LANDS	1.68	0.17					
RUBBER- NUTS	2.58	1.88			0.77		
FLUVIAL & VARSEA SYSTEMS	6.11	0.18	1.62		1.77		0.46
INTENSIVE CANE POOR LANDS	7.51						
INTENSIVE CANE GOOD LANDS			15.57	5.34	1.73		
INTENSIVE IRRIGATION			1.27		0.24		0.72
BRASIL MECHANIZED COFFEE AREAS	3.17	4.09			0.23	19.73	
MECHANIZED MEDIUM SCALE			1.24			0.16	
CERRADOS TYPE PASTURES MECH CROPPING						31.07	
POOR LOWLAND PASTURES MECH CROPPING	11.27	29.22					
LOWLAND EXTENSIVE GRAZING POOR SOILS	3.35	1.06					
GOOD LOWLAND PASTURES MECH CROPPING			3.39		2.10		
POORLY DRAINED PASTURES	4.49	1.60	0.11		8.42		
GOOD LOWLAND PASTURES ALONE					0.54		
HIGHLAND PASTURES ALONE						0.35	0.52
LOWLAND EXTENSIVE GRAZING POOR SOILS	3.35	1.06					
POOR LOWLAND PASTURES MANUAL CROPPING	37.42	7.25					
GOOD LOWLAND PASTURES MANUAL CROPPING			4.98		1.73		
DRY LOWLAND PASTURES MAN/MECH CROPS				5.10			
DRY LOWLAND PASTURES MANUAL CROPPING			0.79	13.92			
GOAT GRAZING				4.44			
LADERAS CATTLE COFFEE POOR SOIL						3.02	
LADERAS GRAZING. SHIFT CULT POOR SOIL					0.08	6.78	0.22
LADERAS CATTLE COFFEE GOOD SOIL							3.51
LADERAS GRAZING SHIFT CULT GOOD SOIL							2.89
LOWLAND CATTLE COFFEE	2.05		0.15	1.62	0.17		
SHIFTING CULTIVATION			0.84	0.56			0.13
SMALL SCALE CANE & MANUAL CULTIVATION	0.26		0.05	1.47	0.23	0.42	0.26
LOWLAND GRAZING. SHIFT CULT ON SLOPE	1.11	2.92	0.26	1.62			

CLASS 8 AND 9. INTENSIVE CANE, MECHANIZED CULTIVATION.

These areas are characterised by intensive estate managed sugar cane, large farm grazing of cultivated or induced pastures and mechanized cultivation of sorghom soybean, cotton and often irrigated rice. A small farm sector generally concentrates on fruit and horticultural products. Tobacco in some areas along with beans, maize and some cassava. Often irrigated, the climatic difference between the dry class 9 and seasonally wet class 8 is diminished.

Soils are good and topography flat and easily mechanizable. There is little or no remaining natural vegetation except in places where this was a native grassland suitable for grazing. Fallowing is rarely practiced.

Growth potential is low in terms of area expansion, there being little land unused. Movement to intensified mechanized cultivation may diminish the importance of grazing. The small farm sector may account for up to 80 percent of the rural population but only about 5-10 percent of the land.

Increased profitability of broad scale mechanized crops might lead to "intensification" and absorption of small farmer areas, but this is less likely than in some other areas because the latter sector concentrates on higher value crops for the urban markets.

Small farm sector may provide labour for the estate and larger farms but this is also supplied from nearly urban populations.

Problems

1. Erosion risk is generally low but compaction by heavy machinery may occur in some areas.
2. While these areas are not the typical arid irrigation areas, salt buildup due to poor irrigation practices is a risk in many places.
3. Excessive use of pesticides and herbicides occurs frequently on the commercial cropping lands especially on rice, cotton and soybeans.

Spillover

Shift from grazing to cultivation will push cattle to less easily managed areas.

LOWLAND EXTENSIVE GRAZING POOR SOILS
CLASSES 2 AND 5 (CARIMAGUA)

These areas are found in the altillanura of Colombia, in Mexico and Venezuela and have an accessible area of 4.41 Mha. Soils are highly acid and natural vegetation is savanna and semievergreen forest. Topography is flat with only 5-20% on slopes from 8 to 30 percent.

The land use pattern is differentiated from a further 29.2 million hectares of Class 2 and 5 savannas by having insignificant cultivation either perennial or annual, manual or mechanized.

Population is low and average farm size is almost 1000 ha but decreasing. The principal production system is presently cow/calf operation on natuve pastures. Markets are relatively distant, but isolation is not extreme.

Growth potential is high for acid tolerant crops on mechanizable land.

Problems

1. Erosion is little risk under native pasture but could become severe on even moderate slopes under inappropriate cultivation.
2. Destruction of the gallery forest.

Spillover

Intensification may increase the demand for rural labour or enhance the reduction of farm size.

Technology developed here should be applicable to the Class 2 and 5 poor lowland pastures where mechanized cropping already exists. However it may also be feasible to use in the cleared forest areas where large numbers of small farmers at present using manual methods might be prejudiced, possibly increasing deforestation.

CLASS 2 AND 5. POOR LOWLAND PASTURES, MANUAL CROPPING

This is a very widespread frontier area of 44.7 million hectares. It has varying degrees of access but generally moderate to high distance to markets.

Land and income distribution are highly skewed. An average of 51% of the farmers have less than 10ha but control an average less than 10% of the land.

Natural vegetation is semievergreen forest. In some cases this has completely disappeared, but overall about 40% of the original forest remains. This is usually located on the steep and inaccessible lands.

About 4% of the land is under perennial crops 11% in annual cropping and 30% under extensive grazing. In some areas up to 30% is under bush fallow. Topography is heterogeneous but over half the area is flat and inherently mechanizable. One third is undulating and the remainder mountainous.

Population density is low to medium with a few areas of high population in coastal Brasil and teh Caribbean.

30% to 70% of farmers have between 1 to 10 hectares. Access is moderate to good, with moderate distance to markets.

Problems

Most areas show a marked contrast between small farmers practising shifting cultivation or long fallowing, and extensive graziers.

Competition for land is reducing fallow periods and inducing small farmers to extend the forest clearance.

Soil depletion is a problem where fallow periods are cut due to land shortage.

Insecure tenure for smallholders.

Spillover

It may be that technology developed for the lowland savannas might be applicable by the larger landowness, although they are not generally at present persueing much mechanized cropping. This would increase competition for land, and result is serious disbenefits for smallholders.

WELL WATERED MID ALTITUDE HILLSIDES

Classes 17 and 20

Comprizes:

Laderas Cattle Coffee	Poor Soil	3.02 Mha
Laderas Cattle Coffee	Good Soil	3.52 Mha
High Grazing Shift. Cult.	Poor soil	7.01 Mha
High Grazing Shift. Cult.	Good Soil	2.90 Mha
	Total	15.43

Throughout Central America the Caribbean and the Andes. Also includes areas from Classes 14 and 23 not analysed in this study.

Even at this level of classification these areas are highly heterogeneous. Natural vegetation is mostly seasonal forest although in some cases humid or pre-montane forest. A small proportion, about 10%, of this remains.

Access is generally good but least in the shifting cultivation poor soil areas. Population is highest in the coffee areas and quite low in the non coffee poor soil region. Land distribution is uniformly skewed with approximately 80% of the farmers holding roughly 20% of the land. Isolation is generally low to moderate although poor mountain roads give long travel times in some areas.

Perennial crops account for up to 30% of the area, even in the better non coffee areas. Annual crops, beans maize cassava etc. are grown on 5% to 20% and between 20% to 60% is in pastures. Bush fallow accounts for the remaining lands and may be from 10% to 30% depending on the area.

Approximately 50% of the area can be classed as rolling with up to 40-50% steep nevertheless there is generally about 10% of the area which is flat.

Problems

1. Erosion is a serious problem almost everywhere due to:
   a) Overgrazing on steep pastures
   b) Fire fallow clearance
   c) Poorly managed cultivation
   d) In some cases poorly managed coffee.

2. Pesticide overuse is prevalent in the coffee crop.
3. Although most of the remaining forest is on steep lands, there is still pressure for felling.
4. Coffee washings are a frequent pollutant of streams and rivers.

EXTENSIVE GRAZING AND SMALL-SCALE MANUAL CULTIVATION, IN THE DRY, LOWLAND AREAS OF NON-ACID SOILS

Class 9

This land-use pattern occupies about 14 million hectares, most of which is accessible. The type includes an important portion of the Sertao in N.E. Brazil, the middle Sinú on Colombi's north coast, and the Acapulco and Cancún areas of Mexico. The rural population density is moderate to high, and the total rural population is estimated at 2,700,000.

Between 30 and 50 percent of farms are less than 10 ha. and control less than five percent of the land.

The natural vegetation, scrub, dry forest and wooded savanna, is extant in approximately half on the area.

Agricultural land use is dominated by pastures, about 30% of the total area, adn bush fallow. The latter varies in importance, in some places it reaches 40% of the area. Annual crops occupy about ten percent of land, and perennial crops are generally absent. Exceptions to the latter are found in parts of N.E. Brasil, where cashews and tree cotton can occupy upto 15% of the land.

Topography is predominantly flat (70%) with the remainder mostly rolling.

Problems

Problems associated with the area's climate are important, that is, the unreliability of rainfall and risk of drought. These affect humans, crops and animals.

Adaptation to drought is most difficult for smallholders who rely on annual crops rather than extensive grazing. Declining soil fertility is a significant problem for many of these people, due to overcultivation.

EXTENSIVE PASTURES AND SMALL-SCALE MANUAL CULTIVATION ON NON-ACID SOILS IN THE SEASONAL LOWLANDS

Class 8 and 11

This type occupies about 6.7 million hectares, in northern Colombia, Venezuela, Guatemala, Belize, Mexico, Paraguay and Brazil (the litoral in Ceará). The natural vegetation is seasonal and humid forest, on average half of the area retains this cover. Land holding patterns vary greatly. These areas are not densely populated, although the total rural populationis around two million. Access varies a great deal.

A small percentage of the land, less than five percent, is under perennials, and annual crops cover 5-40%. Pastures cover about 40% of the area; the proportion rises to 70% in some places. Bush fallow is unimportant.

Forty to ninety percent of the area has flat topography, with ten to fifty percent rolling. Steep topography is generally absent, and does not usually exceed 30% of these regions where it is found.

Problems

Forest clearance is an important aspect of the agricultural dynamics of these areas. Frequently land is cleared by colonists and smallholders, only for these to be displaced soon after by ranching. Concentration of land ownership is particularly notable in accessible areas and where the quality of land is particularly good.

As a result of insecure tenure and land concentration, fragmentation and social conflict affect sedentary agriculture in numerous ways. Many farms are too small to permit sustainable systems to be implemented by their owners, and soil degradation is to be expected. The social instability of these areas prevents consensual resource management amongst all land users. This also contributes to inefficient, absentees management of pastures, with the emphasis on area rather than pasture and animal quality.

Like most new or recent frontier areas, social infrastructure (health care, education, roads) is often absent.

CLASS 2 AND 5. POOR LOWLAND PASTURES MECHANIZED CROPPING, SOME MANUAL CROPS

A large are comprising 40.5 million hectares in Brasil, Colombia, Panama, Mexico and Paraguay, 29.2 million hectares of this are lowland savannas environmentally similar to the Altillanuras of Colombia, the rest is seasonal forest. The reason for separate classification from the Carimagua type is the existence of signficant areas of mechanized cropping, sometimes up to 30% of the land area.

The area accounts for a population of 2.7 million. Access is variable but over half the area has 100% accessibility. Isolation from markets is variable but mainly moderate, a few cases being highly isolated.

50% 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 and can reach 25%, the rest is classed as rolling with steep lands less than 5% of the area.

Up to 50% of the farmers use less than 8% of the land.

Crops include upland rice, sorghum and some soybeans.

Problems

1. Erosion. A maximum of a third of the land is suitable for mechanized cropping and small farmer crops are often relegated to slopping lands.
2. Compaction by heavy machinery.
3. Soil depletion - soils are poor and not suitable for continual cropping.

CERRADOS TYPE PASTURES AND MECHANIZED CROPPING

Class 17

The area of 31 million hectares is almost exclusively in Brazil. Access is moderate and distance to market high to medium.

Depending on the distance to population centers the rural population varies from low to medium. At one extreme these are essentially no farmers with less than 10 ha, but in the S.E. up to 50% of farmers do.

Generally over 50% of the area is still natural vegetation which is campo cerrado, cerradao and seasonal forest. Almost no perennial crops or managed forest. On the average 13% the area is under annual cropping but the proportion is higher closer to markets, just under half the area is declared as pasture, as a significant proportion of the area is in some farm of natural forest.

Only 54% of the total area is less than 8% and fully 13% is over 30%, or very steep land.

Problems

Erosion

Compaction

Water talbe modification under cropping.

Class 9. EXTENSIVE PASTURES, MEDIUM OR LARGE SCALE MECHANIZED AND SMALL SCALE MANUAL CROPPING, ON GOOD SOILS IN THE DRY LOWLANDS

This type covers some 5.1 million hectares, in N.E. Brazil and Mato Grosso, the sabanas de Bolivar on Colombia's north coast, and small areas in Nicaragua and Bolivia. Together they have a moderately dense rural population of about 1.500.000. Between thirty and seventy percent of farms are smaller than 10 ha, and account for no more than five percent of the land.

Natural vegetation, which ranges from wooded savanna and sertao to seasonal forest, covers appproximately one quarter of the total area. Perennial crops are unimportant. Annual crops account for five to ten percent of the area. The proportion of the area under pastures varies from 30 to 70%, and fallow from 10 to 30%. Topography is mostly flat to rolling. Most of the type is accessible, moderately isolated from urban market centres.

Problems

Availability of water for crops and livestock is a significant problem as is unreliability of rainfll for upland cultivation.

Since well-watered land is such a critical resource for agriculture competition is important. Since the land-holding pattern is often extremely skewed, with large landholders dominating well-watered bottomlands, conflict over both land and water is common.

Smallholdings are too small for traditional fallow-based systems to remain effective, shortened fallows have led to soil nutrient depletion.

Soil erosion is common, both for small-scale and mechanized agriculture.

Access to markets is usually most difficult just as smallholder crops are being harveted, at the end of the rainy season. Since there are few opportunities for employment during the ry season, labour migration is high. Labour shortages for land preparation, and a high incidence of female-headed families often result from all male seasonal migration.

GEOGRAPHIC SURVEY OF PROBLEMS IN AGRICULTURE

Parallel to the characterization of environmental classes and land-use clusters, the AESU has been conducting a simple survey about problems and research experience in Agriculture in Latin America. This was done in anticipation that the result of the Agroeco-zones study might imply activities that CIAT has not done in the past. The goals were to find out what organizations in Latin America have been doing research in natural resource aspects of agriculture and for how long. The survey also requested a listing of the five most serious problems in agriculture in the respective areas, and the five most serious obstacles that the organizations themselves encounter. Additional questions relate to the organization's opinion of CIAT's work in the past, and what activity CIAT could emphasize in the future.

Finally, information was requested on the geographical area that they cover in their work. The purpose is to be able to map and analyze the distribution of this information about organizations. Analysis should help, for example, to detect subjects which have received little attention or geographic areas which lack investigation of a certain nature.

INITIAL RESULTS

To date over 450 organizations have been contacted, mainly from two lists of NGO's and CIAT's 13,000 strong mailing list. Preliminary analysis has been conducted on the first 91 responses that were received. 27 are ONG's, 6 international organizations and the rest state research organizations.

Table 1 indicates the research subjects that were specifically mentioned in the survey and the percentage of organizations that have some experience. The subject that most organizations have addressed is the evaluation of alternative crops: 60% of organization have worked with them, and 40% have more than five years of experience. Of the subjects that we specified, the least studied were water rights and land rights. A few organizations have decades of experience. eg. Instituto Agronómico Campinas (IAC) with 25 years of research in erosion control.

Table 2 lists additional research that organizations have reported, and that they consider to be relevant to natural resource use. Some obvious omissions to our original list illustrate one of trade-off with the survey. If we provide a survey which is too exhaustive.

TABLE 2 Additional research subjects reported by the first 91 respondants.

- Agroecologia y monitoramiento ambiental.
- Organización Comunitaria.
- Manejo de Pasturas.
- Manejo de Animales Menores.
- Manejo de Parcelas Familiares / Huertas. Leguminosas Comestibles.
- Fruticultura General.
- Procesos Agricolas (Post-cosecha).
- Sanidad Vegetal.
- Ganado Mayor.
- Mejoramiento de Variedades.
- Sistemas Agricolas de Producción.
- Análisis de políticas agrícolas.

PROBLEMS

Unlike the research subjects, we decided to leave the systems blank, so as to not limit or guide the listing of problems. Appendix I lists the 43 unique problems that have been identified in the 91 surveys to date. Roughly speaking of the 455 possible answers, these have broadly into 43 responses, and most of them into 15 responses.

The organizations have been classified as international, state and now-government (NGO) regardless of organization type the most common response is 1. Degradación de recursos naturales: erosión y perdida de fertilidad. However the next most common problems identified differ considerably. State organizations identify losses to insect and disease, followed by inadecuate commercialization, irrigation and drainage problems and a lack of market for alternative crops. NGO's by contrast cite inadecuate use of technology, land tenure, unequal, distribution of resources, inadecuate commercialization and irrigation / drainage problems.

Aside from land degradation the only overall common top problem to the three organization type is inadecuate commercialization. The responses on one hand shows tendencies related to the technical approach of state research and socially oriented NGO's. With more responses and further analysis it showed be possible to identify more common ground. It is also important to note that while natural resources are identified as the most important problems, relatively little research has been done on some aspects.

OBSTACLES FOR THE ORGANIZATIONS

Two problems are overwhelming favorites: "Falta de recursos" is top for international organization but second in NGO's. First for NGO's is "Falta de politicas y reglamentaciones adecuadas del gobierno". This is 2nd and 4th for the other organization. International and state organizations a concern for "Problemas administrativos" while state and NGO's share "Insuficiente coordinación entre organizaciones". International and NGO's agree on "Formación inadecuada y unilateral de técnicas.

Appendix II lists all of the unique answers on obstacles. these have varying degrees of relevance to natural resource use and varying significance to possible CIAT's activities. However geographic analysis should help to reinforce the most relevant areas of CIAT's current work and possibly suggest news activities.

APPENDIX I. Problems identified among the five most important in each area.

1. Degradación de Recursos Naturales, Erosión y Pérdida de Fertilidad.
2. Minifundio excesivo.
3. Pérdidas ocasionadas por plagas y enfermedades.
4. Uso Indiscriminado de Pesticidas. (Agroquímicos) (Dependencia).
5. Comercialización Inadecuada.
6. Distribucion Inequitativa de Recursos (Tenencia de tierra).
7. Pobreza, Marginalidad y Emigracion a las ciudades. (Baja capacitación de los agricultores).
8. Políticas Gubernamentales Inadecuadas.
9. Carencia de Apoyo Adecuado al Pequeño Agricultor.
10. Uso Inadecuado de la Tierra.
11. Uso Inadecuado de Tecnología.
12. Falta de Organización Campesina. (Organización ineficiente de productos utilizados para servicios y no para producción).
13. Deforestación.
14. Problemas de Riego y Drenaje.
15. Uso de Tierra Marginal.
16. Monocultivo y Falta de Rotación de Cultivos.
17. Desconocimiento del Ecosistema de la Región
18. Cultivo de la Coca.
19. Falta de Mercados para Cultivos antiguos ó alternativos.
20. Quemas.
21. Inseguridad.
22. Alcoholismo.
23. Falta de opciones de Agroindustria para dar valor agregado (Problemas post-cosecha).

24. Cambio y descuido de los sistemas tradicionales.
25. Transferencia de tecnología inadecuada.
26. Deficiente Producción y Uso de Semillas.
27. Falta de Cobertura total de la Investigación Agropecuaria.
28. Deficiente Manejo de Fertilización.
29. Mala calidad de los productos.
30. Agricultura totalmente Exportada (Enfoque de Exporte)
31. Ausencia de una Verdadera Cultura Forestal. (Poca tradicion en agricultura tropical).
32. Falta de Mecanización Adecuada ó falta mano de obra.
33. Falta y/o Deficiencias de conocimientos profesionales y Básicos. Escasa educación de los agricultores.
34. En ganaderia baja productividad tanto por unidad animal como por área.
35. Falta de opciones reales para diversificación.
36. Problemas financieros. Tasas de interés altas contra nivel de rencabilidad casi inexistente, altos costos de producción, escasez de créditos.
37. Infraestructura deficiente.
38. Monopolio de recursos genéticos.
39. Altos precios de insumos.
40. Heterogeneidad geográfica. (Terrenos en ladera con mayor ó menor grado de inclinación).
41. Necesidad del campesino de actuar a corto plazo.
42. Falta de germoplasma adaptada.
43. Animales destructores (Depredadores).

APPENDIX II. List of obstacles identified as among the five most important.

1. Falta de Financiamiento para Programas de Extensión en Agricultura Ecológica.
2. Falta de Apoyo y Apatía a la Investigación de la Agricultura Ecológica.
3. Falta de especialización y metodología en Agricultura Ecológica.
4. Formación Inadecuada y Unilateral de Técnicos.
5. Falta de Integración (Investigación, extensión, crédito).
6. Inhabilidad para Hacer el Seguimiento de los proyectos y las actividades Iniciadas.
7. Falta de Políticas y Reglamentaciones Adecuadas del Gobierno.
8. Carencia de Tecnología que Combine Productividad y Conservación del Medio.
9. Lento proceso de Consolidación y Concietización de Organizaciones campesinas. (Ausencia de concietización adecuada de la problemática alimentaria - nutricional y productiva.
10. Apatía por parte del Gobierno a diferentes Niveles.
11. Insuficiente Coordinación entre instituciones con:
    1. Transferencia de Tecnología.
    2. Sistematización de experiencias.
    3. Otorgaciones de fondo ó credito.
12. Crisis Económicas y Políticas del País.
13. Dependencia en Agroquímicas.
14. Tenencia de la Tierra.
15. Falta de Recursos Económicos y Humanos, Políticas Salariales e Infraestructura Propia. (Disponibilidad de tierra en la Est. Exp.

16. Poca Instrucción o Conocimiento de los Agricultores con Relación a Consecuencias Ecológicas o Económicas.
17. Inestabilidad y otros Problemas de Comercialización.
18. Inseguridad por Problemas de Orden Público.
19. Falta de Personal Técnico y Apoyo a la Investigación.
20. Problemas Administrativos.
21. Falta de Incentivos y Estímulos para Publicar Resultados. (Falta en la Difusión de la Información).
22. Falta de Planificación Estratégica a largo plazo.
23. Centralizacion de la Investigación y Personal Capacitado. Ubicación geográfica de la sede principal - Dispersión geográfica de los investigadores.
24. Dependencia Económica de Ayuda Extranjera.
25. Coca y Narcotráfico.
26. Dificultad de acceso e Infraestructura.
27. Falta de Mercado para Productos Alternativos.
28. Heterogeneidad Geográfica.
29. Perfil socioeconómico de los usuarios atendidos (Demasiada pobreza).
30. Atomización de los usuarios en algunas zonas atendidas. (Dispersión de productores).
31. Alto indice de analfabetismo.
32. Ausencia de una verdadera cultura forestal.
33. Concentración poblacional a las ciudades.
34. Falta de cobertura total de la Investigación Agropecuaria.
35. Dificultad en medir el efecto e impacto de las acciones efectuadas.
36. Uso inadecuado de semillas (poco resistentes a las enfermedades).
37. Minifundio.

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SELECTION OF AGROECOSYSTEMS
DELIBERATIONS OF WORKING GROUP 4
18 August 1990

S.Carter

A. Areas Evaluated

Within the environmental classes selected by the Agroecological Studies Unit and commodity economists, land use was found to be highly patterned. A hierarchy of land use patterns was identified based on the structure and intensity of associated farming systems. The patterns were quite strongly concentrated in certain environmental classes. Henceforth, we refer to a particular combination of land use pattern and environmental class as an agroecosystem.

A considerable database has been compiled as a result of the process of agricultural characterization of environment classes. We were able to calculate the total area of each land use pattern within each class, and to estimate rural population. These two variables gave us an initial indication of the relative importance of the different agroecosystems. A number of land use patterns, some spreading across different agroecosystems, clearly stood out as worthy of further evaluation, whilst others could be rejected as insignificant. We have evaluated the most important land use patterns (and in cases where these were largely confined to a single environmental class, agroecosystem) as potential areas for natural resource management research to focus. These were as follows:

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

2. Areas of mechanized crop production, particularly coffee, and found exclusively in Brazil. These were most extensive in the highlands, but some lowland systems contained a significantly large population.

3. Lowland and highland areas of extensive grazing and mechanized agriculture on acid soils. The Colombian Altillanura was also included in this group, although mechanized crop production is not yet important there. These land use patterns occupy some 76 million ha., and are by far the most areally extensive of all those identified. They also have large absolute populations, despite low overall densities.

4. Areas of extensive grazing and manual small holder cultivation on acid soils. These are also very large (45 m ha.) with large populations. They are mostly frontier areas.

5. Areas of extensive grazing and manual cultivation by smallholders in the dry lowlands.

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

The only other significant land use patterns not evaluated was that dominated by extensive grazing on poorly drained pastures. This has a smaller spatial extent, but possibly a higher total rural population, than the highland cattle-coffee systems.

B. Selection Criteria and Procedure

To evaluate the different land use pattern and environmental class combinations we devised a set of criteria, as follows:

Group 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.

Group 2 Resource potential

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

Group 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.

Group 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 urban poor	:	The area supplies or could supply basic foodstuffs to urban areas.
Land distribution	:	Uneven land distribution is a major source of inequity.

Group 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.

Group 6 Institutional considerations.

Institutional strength	:	Potential collaborators exist.
CIAT's comparative advantage	:	Previous or current CIAT research can contribute to finding solutions.

Internationality : The agroecosystem 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 8). 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 9, 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 9. Only if we doubled the weights for equity and sustainability, and halved those for growth and feasibility, would the semi-arid pasture and manual cultivation systems rank higher than the conglomerate of savanna agroecosystems, for example.

Table 8. 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 9. 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