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ECOLOGY AND LAND CAPABILITY ANALYSIS OF THE CHAPARE PROJECT AREA

A REPORT FOR USAID/BOLIVIA UNDER

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DR. JOSEPH A. TOSI, Jr.
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SUMMARY

The report which follows is part of the overall AID evaluation team effort to evaluate socio-economic potential and environmental problems in the Chapare Project Area. Work was undertaken between January 20 and February 17, 1983 with field trips into the region during six days. The bulk of the time was devoted to review of previous survey documents and to map construction and interpretation in the Cochabamba office of PRODES. This work could not have been completed in the short time available without the dedicated and competent assistance of my three counterparts: Ing. Juan Carlos Quiroga, Ing. Ramiro Iriarte, and Daniel Guerra (Director of the Instituto Nacional de Colonización office in Cochabamba).

Amongst the several products of the work are the field determination and drawing of a detailed and reasonably accurate ecological (bioclimatic) map of the 422,000 hectare project area employing the Holdridge Classification System of World Life Zone and the derivation and drawing from the integrated components of this map and a recent landforms-soils map of PRODES of a new land capability map of the region. The land capability map is then used to draw off the proportionate areas of land in each of six capability classes in each of the nine micro-regions into which the Chapare has been divided for administrative and planning purposes. It is found that this large region has, on the whole, only a low to moderate agricultural potential except in microregions 3, 5, and 7 under the prevailing "Traditional" agrarian technologies employed by the ~~colonists~~ into this region. Two micro-regions are located in the mountains and have no agricultural potential at all. They are recommended for protection of natural forests in order to safeguard an untapped but large hydroelectric potential with some limited managed forest production. Much of the ~~remainder of the~~ region in the lowlands in too wet

for agriculture but has a high potential for managed forest production, alone or in combination with agro-forestry.

The report goes on to examine individually in more detail, each of the nine micro-regions from the viewpoint of crop ecology and land use capability, and discusses possible development options in view of the regions inherent limitations of an ecological nature, especially overly wet climates, exceeding poor soils, and periodic or continual flooding.

Amongst the general recomendations of the report are the institution of an actual land use project to be updated every two to three years on the basis of new aerial photography, detailed survey of soils from the fertility and productivity viewpoint in areas classed as agricultural, the projection of new highway construction northward into the drier climatic areas rather than westward or eastward, the institution of farm planning by trained teams as the organizing principle for both extension and research, the incorporation of forestry extension programs, agro-forestry, and forestry related farming systems in the development context, and the promotion of local forest industrial systems based upon the vast woody biomass volumes present in the areas as a result of shifting cultivation. Finally, a list is provided of bush and tree crops which should perform satisfactorily or better in the Chapare environment and which should be introduced on an experimental basis.

II. ISSUES/CONFLICTS

(ENVIRONMENTAL)

1.0 General Purpose and Background

This land capability analysis establishes an objective foundation of ecological facts concerning the comparative suitability of the lands in the Chapare Project area for sustainable human occupance and socio-economic development. Despite more than a decade of planned, purposeful settlement there, no full and comprehensive evaluation of the physical environment has been undertaken, presumably because all development institutions involved have been either ignorant or unwilling to concede the importance of the region's possible ecological limitations for agriculture.

The analysis shows that both officially-held and widely-popularized beliefs in a high agricultural potential for the Chapare are substantially in error. Positive attainments in the development process have, unquestionably, been significantly limited through the resultant planning failure, and the concommitant failure to achieve original agriculture goals may very well have been a major influence behind the voluntary decision by a majority of the settlers to turn to coca production as a major economic pursuit.

The present analysis illustrates more precisely where the error lies through a quantification and synthesis of all key environmental factors, specially as these relate to crop ecology, animal husbandry, forest productivity, and some pertinent aspects of infrastructure and human well-being. It further shows how the on-going development process might be re-oriented to take advantage of the particular opportunities which are offered by the specific ecological circumstances of the Chapare region. These opportunities are not, by-and-large, "agricultural" in the traditional sense of the word or as perceived by the majority of Bolivians.

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2.0 Data Base and Procedures

In some ways, the Chapare region may have been overstudied. Reconnaissance level soil studies, in particular, have been undertaken repetitively in much of the same area (MACA, 1964, 1974; SAI-MACA, 1973; MACA, 1978; INC, 1976; Macias, 1978; SNA-FAB-PRODES, 1980). These studies fail to build up each other, are based on often disparate criteria and classificatory systems, and except in one or two cases, rely upon air photographic interpretation with little or no ground truth.

A bioclimatic survey of Bolivia based upon the Holdridge system of world life zones (MACA-OAS, 1975) includes the Chapare region but is at too small a scale (1:1,000,000) and upon too inaccurate a planimetric base for direct application in the work undertaken here. However, in the monograph which describes and discusses the life zone map, there is an unequivocal set of fully qualified statements to the effect that the bioclimates and soils which predominate in the Chapare are unsuited to the traditional agricultural pursuits. This counsel is largely overlooked in several recent development studies funded by national and international agencies (Macias, 1978; Multinational Agribusiness Systems, Inc., 1979; OAS-GOB, 1980).

It is possible, if not a particularly easy task, to sift through the voluminous and redundant works which attempt to substantiate a classical tropical development scenario for the Chapare and to obtain thereby a workable set of data on the climate, geomorphology, soils, and vegetation of the region. In the present case, due to time limitations, this course has been followed. Field data, particularly soil profiles and laboratory analyses published as part of the more recent Servicio Nacional de Aerofotogrametría FAB-PRODES integrated study of natural resources of the

Chapare (1980) have been supplemented by detailed life zone mapping and other field observations of the geomorphology and soils, current land utilization and natural vegetation. Other team members, especially G. Morris and his national counterparts, have supplied essential information on climatology and geomorphology for my analyses.

3.0 Physical Environment

Essential parameters for the determination and mapping of major land use capability are (a) bioclimate, (b) landforms and physiography, and (c) soils and drainage. Bioclimate is primordial inasmuch as it affects vegetation and other biota directly as well as indirectly through its influence on geomorphology and the edaphic factors. Bioclimate is the feature of landscape least studied and appreciated in the spectrum of environmental factors affecting the Chapare, hence it will be given more space and attention herein whilst soils will be viewed in the context of already published and fully documented studies.

3.1 Bioclimate as Life Zones

According to the Ecological Map of Bolivia (MACA-OAS, 1975), Bolivia is largely a Subtropical - Warm Temperature country. The northern half, which includes the Chapare region, is Subtropical except for a small area in the extreme north (Pando) which falls in the Tropical latitudinal region. At lower elevations, the Subtropical basal belt, characterized by an annual range of mean monthly air tempetatures in excess of 5 degrees Celsius, is interspersed at some locations by life zones of the basal Tropical region. These life zone anomalies present in the Chapare, occur whenever mean annual biotemperatures, usually slightly lower than 24 degrees C., are conjoined with annual precipitation totals locating them in intermediary (transition) positions between two Subtropical region basal belt life zones on the Life

DIAGRAM FOR THE CLASSIFICATION OF WORLD LIFE ZONES OR PLANT FORMATIONS

by L.R. Holdridge

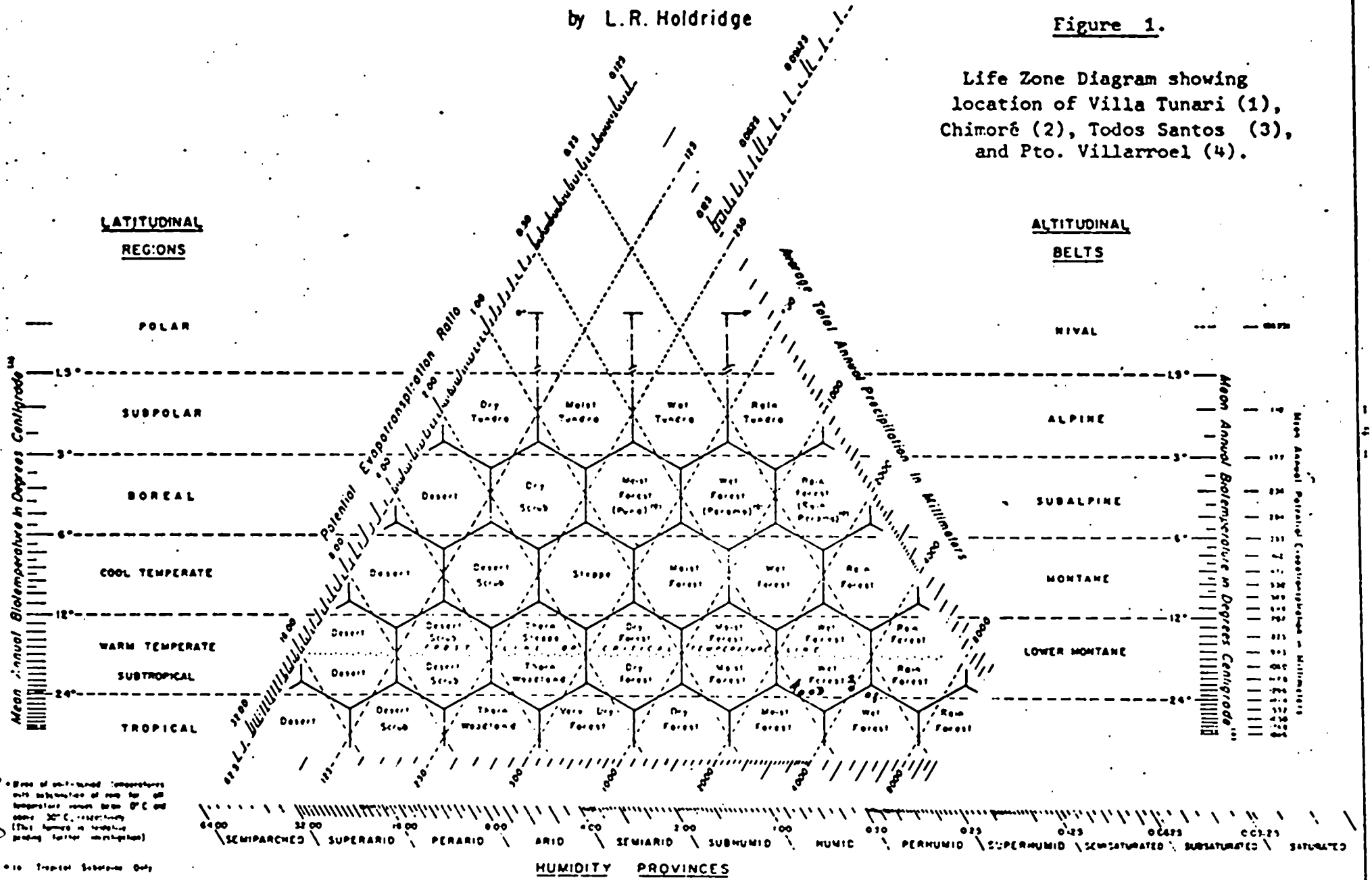

Figure 1.

Life Zone Diagram showing location of Villa Tunari (1), Chimoré (2), Todos Santos (3), and Pto. Villarroel (4).

TROPICAL SCIENCE CENTER, San José C.R. May 1966

Zone Diagram (Figure 1). Characteristically, areas with such climates resemble, in their natural vegetation, soils, and physical environment for living, the true Tropical region life zones. However, they ordinarily have a wider-than-Tropical annual range of mean monthly air temperatures and annual photoperiod and are similar to the Subtropical formations in this respect. They are therefore classed as "transitional to Subtropical" in life zone theory and practice.

3.1.1. Latitudinal regions, air temperatures, and photoperiod

The Subtropical latitudinal region is similar to the Tropical region in many respects. Because it does not in its Basal or sea level belt, include areas which experience frost or critically low air temperatures, "Tropical", or frost-sensitive plant and animal species prevail at lower elevations, that is to say, below the elevation line which is taken to separate the Subtropical (Basal) belt of life zones from the Subtropical Lower Montane belt, above which frost or critically low air temperatures will occur and the biota are all cold-tolerant species.

The Chapare region is essentially Subtropical. Mean monthly air temperatures (see Table 1 - Table 6) range somewhat more than 5 degrees C. over the average year. The wider-than-Tropical temperature range responds to latitudinal position (16 - 18 degrees South) with near coalescence of the overhead sun passage in the longer-day summer and significant sun-angle in the shorter-day, winter months, and also to the influence of "surazos" or cold air masses which penetrate into the eastern lowlands of Bolivia from the Argentina plains in the wintertime. In the lowlands, the coolest months, June and July, average around 21 degrees C., and nighttime temperatures then drop into the 10 - 15 degrees range. Extreme lows approaching 5 degrees C. are experienced at that time.

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As compared to the true Tropics, air temperatures are characteristically higher in the summer months in the Subtropics. Heat may become, in fact, unpleasantly high with daily maxima in the mid or upper 30-degree range and occassional maxima near 40 degrees C. In the Southern Hemisphere, these high temperatures are reached just prior to the onset of the heavy rains and at the time of the overhead sun, from November to early January, being ameliorated thereafter by the cooling effect of these rains.

The more pronounced-than-Tropical range of air temperatures and photoperiod in the Chapare is a bioclimatic feature of appreciable significance to crop performance in the region. This feature has been largely overlooked by the many experts who have given opinion and advice on its agricultural potential. The somewhat longer days and higher temperatures of the summer period favor certain short-term annuals such as maiz, rice and beans during this longer-day period. Conversely, many true tropical perennial species, which require uniform year-round temperatures and photoperiod may be adversely affected in their growth by the shorter days and low night temperatures of the winter months. Little research has been undertaken, however, to establish such requirements and responses on a species-by-species, or variety basis, and yet it is clear that many tropical species which have been tried in the Chapare are not performing well there. Before further attempts are made to correct these production problems with soil amendments or enhanced cultural practices, attention should be given to the climatic adaptability of the species themselves.

3.1.2 Life zones, humidity provinces, and precipitation

The Chapare has been, for administrative purposes, divided into nine micro-regions, so-called. These regions do not reflect any natural regionality, however, being arbitrarily delineated. Micro-regions 1 and 2 differ

from all others, however, in being located in the steep and rugged mountain front area along the axes of the main Cochabamba-Villa Tunari highway (Region 2), and the highway and a side road leading to the mountain village of Tablas Montes via Rancho Durazno (Region 1). Only these two regions include life zones in the Lower Montane and Montane altitudinal belts of the Subtropical region (Figure 1). Each is dominated by superhumid climates: Subtropical, Lower Montane, and Montane, rain forest life zones (Map. No. 1). Steep to very abrupt, nearly precipitous long slopes combine with these excessively wet climates nearly everywhere in region 2 and only to a somewhat lesser degree in region 1. Soils are consequently shallow or stony, natural landslides may occur at any time and do so with frequency, and valley bottoms are narrow and encumbered with the gross stony debris of mixed sedimentary rocks of such slides. Given these circumstances, plus the presence of excessive clouds and fog, frequent rain squalls, and infertile, shallow soils, virtually all of the land in micro-region 2 and very large parts of region 1 combine physical circumstances totally adverse to any economic utilization. These areas have, on the contrary, very high potential for the production of hydroelectric energy, and should be set aside and jealously guarded against any human use, including the harvesting of forest trees, in order to protect this energy resource.

The remaining six micro-regions are comprised largely of lands in the piedmont and outwash plains at lower elevation. They comprise mostly low hills on the south and vast alluvial fans and terraces to the north where the many rivers emerging from the superhumid mountain front deposit great quantities of sediment and eventually reach base level. Morris (this survey) has discussed the hydrology, geomorphology, and landforms of these two adjacent regions. PRODES (SNA-FAB-PRODES, 1960) has classified the landforms

in considerable detail and mapped their distribution, also, as part of the soils map of the region.

Two life zones, the Tropical wet forest, transition to Subtropical, and the Subtropical wet forest, cover the greater part of the foothills and lowland plains in micro-regions 4 to 9, inclusive. The wetter of the two, the Tropical wet forest, prevails over the western and southern parts, comprising dissected low hills, alluvial fans, high terraces, and related landforms. In Region 4, perhaps a third of the area on the south is occuped by moderately high, very steep, deeply-dissected hills which fall in the Subtropical rain forest life zone. Rainfall there exceeds 5.000 mm. annually, and soils are extremely poor as well as erodable. Much of the remainder of this microregion lies totally within the Tropical wet forest, with more than 4.100 mm. of rain fall annually. This is the wettest, --and agriculturally poorest -- of the micro-regions centered on the lowlands. It is probable, moreover, that these very wet life zones extend northwestwards in similar topography to be the dominating bioclimates in the Isiboro-Sécure National Park, where this park spreads out over the lowland plain. Further promotion of colonization should be avoided in both areas, as they are not suited to sustained cultivation of crops other than coca.

Region 4 is the poorest of the remaining 6 micro-regions for Ag. production.

N.B.

The Tropical wet forest life zone is the predominant bioclimate in micro-region 6, the southern part of which is also in Subtropical rain forest, while perhaps 20 percent or less of the land, in the extreme north falls in Subtropical wet forest. Micro-region 6, because of a predominance of excessively wet climates, is also a problem area for future development. Significantly, it includes the town of Sinahota, a major center for trade in coca and illicit coca processing supplies.

This life zone is encountered to a lesser extent in micro-regions 3, 5,

7, and 8. It does not occur at all in micro-region 9. The southern third, approximately, of regions 3, 7, and 8 fall in this or the even wetter Subtropical rain forest. Development planning should take account of this physical handicap in the areas affected, as delineated upon the new Life Zone Map (Map No. 1).

The Tropical wet forest, transition to Subtropical, is climatically adverse to field agriculture or to use of the land for pastoral purposes. This assertion is based upon long experience and observation in other parts of the American tropics where identical conditions are encountered. The typical location within it has no effectively dry month in the average year while six or more months are effectively wet, that is to say, have such large rainfall surpluses over evapotranspirational requirements (of even the full original forest biomass) that soils are saturated continuously. Soil saturation is responsible for heavy leaching of nutrients, high acidity, aluminium toxicity, low base exchange capacity, and while it lasts, blocks nitrogen formation by aerobic soil bacteria and the supply of essential oxygen to plant roots. From a practical point-of-view, the effectively wet months make all field operations difficult or impossible, and are conducive to the proliferation of plant pathogens which cannot be controlled by fungicidal spray inasmuch as these are washed off the leaves shortly after application.

Many other liabilities consequent on this climate could be enumerated. Among them, are tha problems engendered in animal husbandry. Pasturing of livestock, in particular, leads to soil compaction, root-cutting of established forrage grasses by hooves sinking into saturated, muddy soils, and, on hillsides, to aggravated soil erosion through the mechanical effect of cattle trailing on wet soils. Nutritious pasture grasses cannot develope,

or are soon replaced, due to the aggressive invasion of competitive wild plants which require periodic burning for any economic control. Yet burning of grasslands is difficult or impossible in this ever-wet climate. Most grasses established artificially tend to overgrow, to become heavy with water and develope woody, unpalatable stems low in net-energy and protein content. Only by regulated harvest through hand cutting, carrying, and the stable-feeding of livestock, is it possible to obtain a continous supply of nutritionally acceptable fodder from planted grasses or legumes in this (and wetter) life zones. Because water buffalo are adapted to exploting the native wild plants of the early successional seres in the wet tropics, they, alone, offer some possibility of adapting livestock production to this life zone. However, experimental work is still necessary in this respect if economically efficient systems of production using water buffalo are to be developed.

In addition to being overly rainy, this life zone is characterized by an elevated percentage of cloudy days and a reduced number of hours of full sunshine. This impides evapotranspiration and photosynthesis, hence plant growth and productivity in general and favors the proliferation of pathogenic diseases of both the leaves and the roots of most cultivated species. Some species, as for instance mango, do not fruit at all for lack of dry weather for flowering and pollination.

Tables 1 through 6 have been drawn up to show the annual march of air temperature and biotemperature, precipitation, and the resultant hydric balance in a deep well-drained soil at six stations recording rainfall and temperature data in the Chapare lowlands. Of these, Tables 1 through 3 are located within the Tropical wet forest life zone. Chipiriri Experiment Station records the most precipitation, 4.852 mm. per year average over a

14 year period. With a biotemperature of 23.3 degrees C. at Chipiriri, mean annual evapotranspiration there amounts to 1.373 mm. under full high forest vegetational cover, considerably less in successional and cultivated vegetations. As a consequence, there is a precipitation surplus over water need amounting to at least 3.479 mm. per year. This water must pass through or over the soil on its way to the sea and does so with devastating effects on soil fertility and plant life. At Chipiriri, the effectively wet season begins in mid-October and continues uninterrupted until early May, over six months during which the monthly runoff is equal to or greater than two times the potential evapotranspiration in millimeters of rainfall. As an Experimental Station, Chipiriri appears to serve no useful function other than to prove the virtual impossibility of agriculture under these conditions.

Slightly less rainy, Villa Tunari (Table 1) shows a similar pattern as Chipiriri while la Jota (Table 3), with somewhat more rainfall than Villa Tunari, has a concentration of excessive rainfall in only four and one half months. A longer period of record (presently only four years), will be necessary before the longer term pattern can be established with any certainly at La Jota. It is probably similar to Villa Tunari, however.

Table 7 shows the monthly precipitation and standard deviation of monthly precipitation for five long term stations in the Chapare. Three, Chipiriri, Villa Tunari, and Jatun Chaco (in Micro-region 4) are Tropical wet forest bioclimates. The table shows that there is relatively low variation about the monthly means during the wettest months at all stations, with coefficients of variation ranging from only 0.24 to 0.43; these months will always be excessively wet. As the less-rainy period arrives, however,

Table 1 Water Balance in the Zonal Association with Mature Natural Vegetation for .....Villa Tunari, Chapare

Elevation 300 msnm meters Latitude 16°58' South Longitude 65°22' West PET/R = 0.30

Average Years of Record	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1. Mean Air Temperature °C	26.9	26.1	25.3	25.3	24.0	21.4	21.3	24.4	23.2	26.0	26.1	26.5	24.8
2. Mean BIOTEMPERATURE °C	22.7	23.9	23.7	24.5	24.0	21.4	21.3	24.3	23.2	24.0	23.9	23.4	23.4
3. POTENTIAL EVAPOTRANSPIRATION mm.	113	109	118	119	120	104	106	121	112	120	116	117	1375
~~4. Adjusted Potential Evapotranspiration mm.~~													
5. Precipitation mm	772	637	577	323	244	195	132	112	209	338	464	563	4566
6. Actual Evapotranspiration mm	113	109	118	119	120	104	106	121	112	120	116	117	1375
7. Water Surplus mm	659	528	459	204	124	91	26	-	97	218	348	446	
8. Soil Moisture Recharge mm	-	-	-	-	-	-	-	-	9	-	-	-	
9. Soil Moisture Depletion mm	-	-	-	-	-	-	-	9	-	-	-	-	
10. Water Stored in Soil at End of Month mm	457	457	457	457	457	457	457	448	457	457	457	457	
11. ALL RUNOFF mm	659	528	459	204	124	91	26	-	88	218	348	446	3191
12. Soil Moisture: Deficiency at End of Month mm	-	-	-	-	-	-	-	9	-	-	-	-	
13. Precipitation Deficit mm	-	-	-	-	-	-	-	9	-	-	-	-	
14. Total Moisture Deficit mm	-	-	-	-	-	-	-	18	-	-	-	-	
15. Moisture Condition	MUY HUMEDO				HUMEDO						MUY HUMEDO		

Life Zone: Tropical wet forest transition to Subtropical

Years of Record

Temperature 1978-982 Precipitation 19 años

Observations: Seven and one-half excessively wet months in the average year

Table 2 Water Balance in the Zonal Association with Mature Natural Vegetation for ...Chipiriri - Estación Experimental

Elevation 411 meters Latitude 16°-55' South Longitude 65°-19' West PET/R = 0.28

Average: Years of Record	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1. Mean. Air Temperature °C	26.4	25.8	25.4	24.8	23.3	21.2	22.0	21.8	22.8	25.5	25.8	26.4	24.3
2. Mean BIOTEMPERATURE °C	23.5	24.2	24.4	24.5	23.2	21.2	22.0	21.8	22.8	24.4	24.2	23.5	23.3
3. POTENTIAL EVAPOTRANSPIRATION mm.	118	110	122	118	116	103	110	109	110	122	117	118	1373
4. Adjusted Potential Evapotranspiration mm.													
5. Precipitation mm	717	770	614	348	326	238	131	149	194	360	396	631	4852
6. Actual Evapotranspiration mm	118	110	122	118	116	103	110	109	110	122	117	118	1373
7. Water Surplus mm	599	660	492	230	210	135	21	40	84	238	279	513	
8. Soil Moisture Recharge mm													
9. Soil Moisture Depletion mm													
10. Water Stored in Soil at End of Month mm	485	485	485	485	485	485	485	485	485	485	485	485	
11. ALL RUNOFF mm	599	660	492	230	210	135	21	40	84	238	279	513	3479
12. Soil Moisture: Deficiency at End of Month mm													
13. Precipitation Deficit mm													
14. Total Moisture Deficit mm													
15. Moisture Condition	MUY HUMEDO				HUMEDO						MUY HUMEDO		

Life Zone: Bosque muy humedo Tropical transición a Subtropical

Years of Record

Temperature 8-years Precipitation 14 years

Observations: Relación Escorrentia a ETP = 2.54

Table 3 Water Balance in the Zonal Association with Mature Natural Vegetation for .....La Jota, Chapare

Elevation 235 meters Latitude 16°-59' South Longitude 65°10' West PET/R = 0.30

Average Years of Record	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1. Mean Air Temperature °C	26.5	26.5	26.2	25.9	23.5	21.9	21.8	23.0	23.3	25.3	26.2	26.7	24.7
2. Mean BIOTEMPERATURE °C	23.4	23.4	23.8	24.1	23.5	21.9	21.8	23.0	23.3	24.5	23.8	23.1	23.3
3. POTENTIAL EVAPOTRANSPIRATION mm.	117	107	119	117	117	106	109	115	113	122	115	115	1372
~~4. Adjusted Potential Evapotranspiration~~ -mm.													
5. Precipitation mm	701	852	793	213	177	167	90	138	182	307	382	626	4628
6. Actual Evapotranspiration mm	117	107	119	117	117	106	109	115	113	122	115	115	1372
7. Water Surplus mm	584	745	674	96	60	61	-	23	69	185	267	511	
8. Soil Moisture Recharge mm	-	-	-	-	-	-	-	-	-	-	-	-	
9. Soil Moisture Depletion mm	-	-	-	-	-	-	19	-	-	-	-	-	
10. Water Stored in Soil at End of Month mm	463	463	463	463	463	463	444	463	443	463	463	463	
11. ALL RUNOFF mm	584	745	674	96	60	61	-	23	69	18	267	511	3108
12. Soil Moisture Deficiency at End of Month mm	-	-	-	-	-	-	19	-	-	-	-	-	
13. Precipitation Deficit mm	-	-	-	-	-	-	19	-	-	-	-	-	
14. Total Moisture Deficit mm	-	-	-	-	-	-	38	-	-	-	-	-	
15. Moisture Condition	MUY HUMEDO			HUMEDO								Muy Hum.	

Life Zone: Tropical wet forest transition to Subtropical

Years of Record

Temperature 4. years Precipitation 4. years

Observations:

Table 4 Water Balance in the Zonal Association with Mature Natural Vegetation

for ...Chimore, Chapare

Elevation 235 meters Latitude 16°42' South Longitude 64°49' West PET/R = 0.34

Average Years of Record	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1. Mean Air Temperature °C	26.4	26.2	26.5	25.3	23.0	22.3	22.4	22.0	24.3	26.5	28.0	27.0	25.0
2. Mean BIOTEMPERATURE °C	23.5	23.8	23.4	24.5	23.0	22.3	22.4	22.0	24.3	23.4	20.0	22.5	22.9
3. POTENTIAL EVAPOTRANSPIRATION mm.	118	108	117	119	115	108	112	110	118	117	97	112	1351
~~4. Adjusted Potential Evapotranspiration -mm.~~													
5. Precipitation mm	543	531	423	200	140	198	131	113	87	313	427	761	3957
6. Actual Evapotranspiration mm	118	108	117	119	115	108	112	110	118	117	97	112	1351
7. Water Surplus mm	425	423	306	171	25	90	19	3	-	196	330	649	
8. Soil Moisture Recharge mm	-	-	-	-	-	-	-	-	-	31	-	-	
9. Soil Moisture Depletion mm	-	-	-	-	-	-	-	-	31	-	-	-	
10. Water Stored in Soil at End of Month mm	396	396	396	396	396	396	396	396	365	396	396	396	
11. ALL RUNOFF mm	425	423	306	171	25	90	19	3	-	165	330	649	2606
12. Soil Moisture: Deficiency at End of Month mm	-	-	-	-	-	-	-	-	31	-	-		
13. Precipitation Deficit mm	-	-	-	-	-	-	-	-	31	-	-		
14. Total Moisture Deficit mm	-	-	-	-	-	-	-	-	62	-	-		
15. Moisture Condition	MUY HUMEDO			HUMEDO							MUY HUMEDO		

Life Zone: Subtropical wet forest

Years of Record

Temperature 1964-68 Precipitation 1966-67

Observations:

Table 5 Water Balance in the Zonal Association with Mature Natural Vegetation for ....Todos Santos, Chapare

Elevation 329 meters Latitude 16°-47'South Longitude 65°-10' West PET/R = 0.45

Average: Years of Record	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1. Mean Air Temperature °C	26.3	26.8	26.4	24.6	22.2	22.3	21.4	21.6	23.3	27.1	26.2	27.3	24.5
2. Mean BIOTEMPERATURE °C	23.6	23.4	23.7	24.5	22.2	22.3	21.4	21.6	23.3	22.3	23.8	21.8	22.8
3. POTENTIAL EVAPOTRANSPIRATION mm.	118	107	118	119	111	108	107	108	113	112	115	109	1345
4. Adjusted Potential Evapotranspiration -mm.													
5. Precipitation mm	493	435	390	212	160	135	100	94	108	244	252	388	3011
6. Actual Evapotranspiration mm	118	107	118	119	111	108	107	108	113	112	115	109	1345
7. Water Surplus mm	375	328	272	93	49	27	0	0	0	132	137	279	
8. Soil Moisture Recharge mm										26			
9. Soil Moisture Depletion mm							7	14	5				
10. Water Stored in Soil at End of Month mm	301	301	301	301	301	301	294	280	275	301	301	301	
11. ALL RUNOFF mm	375	328	272	93	49	27	0	0	0	106	137	279	1666
12. Soil Moisture: Deficiency at End of Month mm							7	21	26	-			
13. Precipitation Deficit mm							7	14	5	-			
14. Total Moisture Deficit mm							14	35	31	-			
15. Moisture Condition	MUY HUMEDO			H U M E D O								Muy Humedo	

Life Zone: Subtropical wet forest

Years of Record

Temperature ..(?) Precipitation ..16..

Observations: During one half of years, the months of July, August, and September will be noticeably dry; with possible effective dryness in August-September.

Ratio of Runoff to PET = 1.24

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Table 6 Water Balance in the Zonal Association with Mature Natural Vegetation for ....Pto. Villarroel

Elevation 325 meters Latitude 16°-50' South Longitude 64°-43' West PET/R = 0.50

Average: Years of Record	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1. Mean Air Temperature °C	26.5	25.1	26.1	23.9	21.1	19.3	21.0	22.1	23.7	24.7	24.7	25.1	23.6
2. Mean BIOTEMPERATURE °C	23.3	24.5	23.9	23.9	21.1	19.3	21.0	22.1	23.7	24.4	24.4	24.5	23.0
3. POTENTIAL EVAPOTRANSPIRATION mm.	116	112	120	116	106	93	105	110	115	122	118	122	1355
~~4. Adjusted Potential~~ Evapotranspiration mm.													
5. Precipitation mm	511	310	392	124	191	98	70	96	103	256	215	364	2730
6. Actual Evapotranspiration mm	116	112	120	116	106	93	105	110	115	122	118	122	1355
7. Water Surplus mm	395	198	272	8	85	5				134	97	242	
8. Soil Moisture Recharge mm										61			
9. Soil Moisture Depletion mm							35	14	12	-			
10. Water Stored in Soil at End of Month mm	273	273	273	273	273	273	238	224	212	273	273	273	
11. ALL RUNOFF mm	395	198	272	8	85	5	-	-	-	73	97	242	1375
12. Soil Moisture: Deficiency at End of Month mm							35	49	61	-			
13. Precipitation Deficit mm							35	14	12	-			
14. Total Moisture Deficit mm							70	63	73	-			
15. Moisture Condition	W E T			M O I S T								WET	

Life Zone: Subtropical Wet forest

Years of Record

Temperature 6. years Precipitation .6. years

Observations: Four excessively wet months; July, August, and September may approach effective dryness in one year in four.

Table 7. Monthly Precipitation and Standard Deviation of Precipitation for Most Reliable Chapare Stations

Station		Millimeters per Month 1	2	3	4	5	6	7	8	9	10	11	12	Year
Chipiriri	$\tilde{M}$(8)	718	770	614	348	326	238	131	149	194	360	396	631	4875
16°- 55' S. 411m.														
65°- 19' W.	α	236	184	266	162	188	142	55	88	131	214	195	217	
	c.v.	0,33	0,24	0,43	0,47	0,58	0,60	0,42	0,59	0,68	0,53	0,49	0,34	
Todos Santos	$\tilde{M}$(16)	493	435	390	212	160	135	100	94	108	244	252	388	3011
16°- 47' 329m.														
65°- 10	α	207	146	179	127	67	125	40	54	50	108	104	126	
	c.v.	0,42	0,34	0,46	0,50	0,42	0,92	0,49	0,58	0,45	0,44	0,41	0,32	
Villa Tunari	$\tilde{M}$(19)	772	637	577	323	244	195	132	112	209	338	464	563	4566
16°- 58' 437m.														
65°- 22'	α	250	244	207	162	118	179	72	66	120	134	246	244	
	c.v.	0,32	0,38	0,36	0,50	0,48	0,91	0,54	0,59	0,57	0,40	0,53	0,43	
Pto. Villarroel	$\tilde{M}$(6)	511	310	392	124	191	98	70	96	103	256	215	364	2730
16°- 50' 325m.		271	283	143	66	60	57	32	33	68	81	83	133	
64°- 43'	α													
	c.v.	0,53	0,91	0,36	0,53	0,32	0,59	0,46	0,34	0,66	0,32	0,39	0,36	
Jatun Chaco	$\tilde{M}$(10)	795	710	643	359	262	152	87	148	204	323	357	596	4646
16°- 57' 397m.														
65°- 45'	α	225	274	229	198	103	76	62	87	119	172	138	182	
	c.v.	0,28	0,39	0,36	0,54	0,39	0,50	0,72	0,59	0,58	0,53	0,39	0,30	

deviation from the mean increases significantly, reaching close to one hundred percent in June, which is one of the driest months. This means, of course, that in some years, the winter (drier season) may experience lowered rainfall totals approaching effective dryness in June, July, and August. On the other hand, it also means that these months may be effectively wet, with no dry season. Thus they may constitute a risky period for the farmer unless he sticks to permanent crops. Under no circumstances of rainfall does the soil dry out to the point of harming the deeper-rooted perennials, in this climate.

Rainfall decreases progressively as one goes northwards from the mountain foothills onto the vast Amazonian plain. Only a few kilometers north of Villa Tunari, (more to the west and less to the east along the main highway), precipitation decreases to less than 4.000 mm. per annum. It reaches 3.000 mm. at Todos Santos and 2.700 mm. at Puerto Villarroel, the last station providing data before Trinidad in the Beni. Vegetational observations suggest that the steady-state climate of the outer plains is characterized by somewhat less than 2.000 mm. of rain and that this isohyet may be encountered not far to the north of the northern limit of the Chapare Project area, as defined. However, within the area, only the lines separating the Subtropical from the Tropical wet forest, and again, the Subtropical wet forest from the Tropical moist forest (transition to Subtropical), were located in the course of field observations during the present study.

The line separating the Tropical wet forest from the Subtropical wet forest is of major concern because the latter, while not the best of life zones for agriculture, is considerably superior to the former in this respect. It occupies, moreover, a rather large area directly to the north

and to the east, in micro-regions 7, 8, and 9 whilst the Tropical moist forest, although the best of all for agricultural development of the life zones present in the Chapare, scarcely enters into the development area at all (Map No. 1).

Subtropical wet forest is perhumid, just like the Tropical wet forest, but has somewhat less excessive rainfall and total cloudiness, a greater number of hours of full sunshine, lower relative humidity, and a greater daily temperature range. These characteristics are, other factors being equal, reflected in the soils, which are slightly less leached of nutrient and less subject to nutrient loss when fertilizers are applied. Soils are, again, subject to saturation conditions for a shorter period of time, thus extending the growing season, particularly for seasonal crops.

The foregoing remarks apply only to the lowland areas mapped in this life zone, for temperatures are relatively higher there than the general average for the life zone (20 degrees C.) and these higher temperatures lead to a greater evapotranspiration rate. In the mountains between 800 and 1.800 meters, where the Subtropical wet forest is most widely extended in Bolivia (MACA-OAS, 1975), humidity conditions and their effects upon soils and agriculture are essentially identical to those described heretofore for the Tropical wet forest life zone.

The Subtropical wet forest is the comparatively best life zone for agriculture in the Chapare Project area as defined. Better areas, climatically speaking, lie just to the north of it (Tropical moist forest, transition to Subtropical) but these areas are currently unreachable by road. It would be advisable, nevertheless, to extend the limits and the roads of the Project area northwards, especially in micro-regions 3, 5, and 7, in order to open up and make availble the superior farming lands which are

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included in the Tropical moist forest, transition to Subtropical). A belt at least ten kilometers wide, appears to fall in this life zone, but is barely included on its southernmost fringe in the present boundaries for the Project. Further to the north, where the Tropical moist forest gives way to the even drier Subtropical moist forest, seasonal flooding and drainage become major obstacles to conventional agriculture. For these reasons, every effort should be made to confine further suttlement and to promote more intensive, diversified agriculture, in the areas delineated upon the map as Subtropical wet forest and Tropical moist forest, transition to Subtropical life zones (Map No. 1).

N.B.

3.2 Natural vegetation and Development Potential

Prior to its fairly recent colonization by settlers from the ecologically distinctive Andean highland valleys and slopes, the Chapare region was covered by a solid mantle of virgin evergreen hardwood forest. Reports of early scientific surveys (e. g., Gerlow, 1937 cited in Arce et al, 1963) indicate that the forest on the lowland plains and foothills, in both the Tropical wet and the Subtropical wet forest life zone areas, (between the Isiboro and Chimoré rivers) was amongst the tallest, densest, contained the largest trees, had the greatest variety of species and the greatest per hectare timber volumes of any forests to be encountered in Bolivia. This enormous and fast-growing biomass attested to a fact known today that these two life zones offer probably the best conditions for natural forest growth in the world. As has been the case elsewhere in the tropics, this forest luxuriance was mistakenly interpreted as agricultural (rather than forestry) opportunity and the entire original biomass has been felled to make room for the field crops of hopeful colonists.

In the process of colonization, only a small proportion of this valuable

standing timber was actually utilized. The greater part, as much as 90 percent, was left to rot or was burned in the process of slash-and-burn agriculture, an agricultural system copied from the local native communities. Inasmuch as most of the nutrients for the natural forest system are retained in the standing vegetation itself rather than in the soil, their abrupt and total release by burning only led to their loss by leaching or vaporization and the further impoverishment of an already poor and infertile soil. A further negative effect of the mis-use of this system of farming by masses of environmentally-displaced colonists on comparatively small, family size land units, was to totally remove the original forest stands and thus deprive the natural regeneration which follows fallowing of cropped land of any seed source of the more valuable timber trees which the natural forest originally contained (see D. McCaffrey report). Second growth ("chume") forests abound in the area today but are notable for the absence of regeneration of the fast-growing heliophytes, mostly valuable species such as cedro, verdolago, almendrillo, urupi, gabón, paquío, tarumá, laurel, and ochoo, species which they would normally contain were even occasional large old trees to be left scattered about the landscape as seed sources. The total deforestation of this region led to the impoverishment of both its soils and its forestry economic potential.

N.B.

In imitation of native practices, today's colonists in the Chapare rotate crops with natural second growth forest. This process allows them to cultivate a piece of ground and obtain satisfactory if not high yields on a periodic basis without the purchase of currently expensive fertilizers.[1/]

1/ Which are oddly enough, still imported into the country rather than manufactured locally from abundant available national raw materials. A fertilizer plant should be a priority item for international or bilateral assistance programs in agriculture and industrial development.

Fast-growing "pioneer species" despite soil depletion, rapidly invade abandoned fields and develop into a moderately tall and dense forest within ten years time, thus indicating the very high potential for managed natural forest production as an alternative to agriculture in the region. Studies reported by Bazan in OAS-GOB, 1980, indicate about 60 cubic meters of usable wood in a hectare of 5 year old chume. Given the exponential rate of growth in such forests, nearly 150 cubic meters could be expected in ten years, or 15 meters average per year. In the current practice of felling and burning chume every three to five years to make toom for one or two years of low-yielding rice or a longer rotation with bananas (Hoffman, 1983), an enormous volume of wood suitable for such industrial purposes as the manufacture of paper pulp, charcoal, or box and form lumber or for conversion to cattle feed through steam or alcali hydrolysis is going up in smoke. This amounts to a loss to the farmer in several ways. First, given appropriate industrial development (and this could be small local industry in most cases) he loses the wood as a saleable product. Second, by burning the wood, he further depletes the soil of nutrients. There is substantial doubt, in fact, if the present system of short-term rotations under forest can be continued without drastically reducing soil fertility and productivity on most farms.

Viewed integrally, there is still a very high forestry potential in the Chapare region, especially in the Tropical wet forest life zone area where good, alternative opportunities to forestry scarcely exist. Forestry, or agro-forestry, could also be expected to yield positive and permanent benefits to the majority of landholders there in the Subtropical wet forest life zone area. Among the requirements for such a development to succeed would be (1) feasibility studies for local manufacture of mechanical paper

pulp, charcoal, boxes and vegetable crates, treated posts and poles, and cattle feed from hydrolyzed wood chips, (2) studies of wood yields and species composition of chume at varying ages on different sites (as classified herein, Map No. 2), (3) a program in agro-forestry which would include provision of seed and seedlings and technical assistance for the re-establishment of the more valuable native tree species. The forestry prospective will be dealt with further in a later section of this report.

3.3 Soils and Landforms

With very few exceptions, the soils which have developed in the Chapare Project area are of very poor quality for agriculture or grazing.

This poor quality is manifest, above all, in their high to extremely high acidity, their low content of available plant nutrients, and their moderate to very high content of 1:1 lattice alumina-silicate minerals. Essential elements for plant growth, especially phosphorus and potassium and some minor elements are notably deficient and under the existing conditions of soil acidity and aluminium toxicity cannot be efficiently supplied through the application of chemical fertilizers.

The area's soils do vary appreciably, however, in their comparative "poorness", some being reasonably suited to production of specific crops given appropriate management techniques and others being either hopeless or extremely costly to manage for sustained production. The variation in soil quality has been laid out in the chemical analyses published in the study for PRODES by SHA-TAB-PRODES (1980).

A soils map based upon the aforementioned field and laboratory study is available at 1:50,000 scale. This map is intensive-reconnaissance in intensity and shows the distribution of soils associations by physiographic (landform) units employing the U.S. Soil Taxonomy system of

classification (Soil Survey Staff 1975). This map and study, after field review for general accuracy, was adopted as the basis for soils evaluations in the present interpretation of land use capability.

The physiographic units are broken down into (1) Regions and (2) Physiographic units or landforms. Each landform within a region is assigned an association-consociation name for the soils encountered within it, and one or more typical profiles are completely described for each association.

The six regions are: (1) Mountains, (2) Hills, (3) Piedmont (4) High Terraces, (5) Middle Terraces, and (6) Low Terraces. These are further broken down as listed in ANNEX A of this report. There are a total of 58 Association-Consociation groups, mapped individually within the Chapare. Most of these appear within the Project area, as defined, and are delineated on the Land Capability Map (Map No. 2) which accompanies the present report.

3.2.1 Landforms and soils consociations

It was not possible nor is it particularly necessary, to elaborate here upon the many soils encountered in the area. However, it may be well to summarize the general relationship between soils and landforms in order to facilitate an understanding of the discussions which follow regarding land capability and crop ecology.

Areas classed and mapped in the Mountain category include most of the land above 600 meters elevation, including the higher foothills and the Andean mountain slopes to above 3.000 meters elevation. These higher lands lie mostly in micro-regions 1 and 2 and include Entisols, Ultisols, and Inceptisols, mostly the former on eroding surfaces, which predominate areally, and the latter on surfaces of accumulation, which are very limited in area. Many of the soils in this group are classed as "Lithic", ~~which is to say they are shallow, stony, or both.~~ The parent rocks in this unit are the principal source of

the sediments which make up and continue to accumulate on the adjacent lowland plains and foothills. They are mostly rocks of sedimentary origin, ranging from Cambrian to late Tertiary in age, derived apparently from sediments eroded from old land surfaces with senile soils. They lack many important basic minerals and this fact is undoubtedly at the root of the poverty of the soils derived from them in the Chaparc.

Areas classed and mapped in the Hills category include the more broken foothills slopes and outliers, very high stream terraces, small alluvial fans, and small interspersed shallow upland valleys. Again, Entisols (Troporthents) predominate, in association with some Oxisols, on the residual or eroding surfaces while Inceptisols (mostly Typic Dystropepts) are classed as the major soils on the sedimentary areas of accumulation. Many of these soils are sandy or gravelly, excessively drained internally, and very low in all nutrients. This and the preceeding region is largely included in Subtropical rain forest and Tropical wet forest life zones and has little economic potential.

The Piedmont occurs wherever the larger rivers emerge from the mountains and deposit their coarse sediments in broad alluvial fans characterized by very wide bedload channels with braided streams at low water. These fans may be bordered by high benches or hanging terraces and some broader, sloping, outwash plains, all interspersed between rivers with backwaters and poorly-drained depressions. The Piedmont includes some of the best-drained soils of the region, including the more fertile Typic Eutropepts on the alluvial fans, but the predominating soils are infertile Dystropepts, with Oxisols on the bench terraces. Most soils are stony or infertile or both. None of the high bench terraces are currently receiving floodwaters, so they are particularly infertile under the very high rainfall conditions (Tropical wet

forest).

Spreading out northwards from the Piedmont are a succession of progressively lower alluvial plains, termed "terraces" in the PRODES study. In the High Terrace zone, the rivers are still well-entrenched in the land surface and present a series of river terraces which are rarely if ever inundated for more than a few hours. The highest and best drained of these are never actually flooded. The rivers run through them on linear, sloping courses, often with braided channels where the less-heavy coarse materials -- and gravels of the bedload, -- are still being deposited. The main highway runs through this physiographic region along much of its east-west section between Villa Tunari and Chimoré and it is in this zone that many of the problems with the bridges occured in the recent floods. Wide beds of aggradation are typical of this zone and bridges must be built to span the entire bed even if this is rarely occupied by floodwaters.

The High Terrace region falls largely in the belt of Tropical wet forest life zone. It is fortunate, therefore, that its soils are predominantly Inceptisols high in sand and with excellent permeability, that is to say, free-draining. Despite the high rainfall and great water surpluses which are rapidly eliminated from even the flattest terrain, the several terrace-type soils-groupings are about evenly divided between relatively fertile ones (Typic Eutropepts) and relatively infertile ones (Typic Dystropepts, Orthents, Tropudults). The principal problems with the soils in this zone are their susceptibility to leaching and soil-climate problems, especially saturation during a long period of the year. This grouping of soils, like those that follow but to a lesser degree in terms of area, is interspersed with poorly-drained depressions and floodlands ("vegas") along

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the river margins.

The Middle Terrace region adjoins the foregoing on the north. There is a slight but significant elevational difference and the rivers enter this zone with normal water levels only slightly below the uppermost level of the plain. The ground water table is closer to the surface even at low water and floodwaters may in occassional years even overflow, albeit for short periods, the best-drained (i.e., highest) terrace surfaces. As a result, the well-drained and moderately well-drained terraces in this zone are amongst the best in the region for agriculture. They include Typic Eutropepts, which are comparatively fertile. While these are permeable soils, there is a tendency for groundwaters, when these rise, to block their deep leaching and even to bring some nutrients again to the rooting level. A further advantage of this landtype is its location in the Subtropical wet forest bioclimate, such that it benefits from comparatively lesser rainfall surplus, greater sunshine, and generally more favorable growing conditions. As a liability, a greater proportion of the land in the region is categorized as flooded backwaters, poorly drained depressions, basins, and abandoned stream meanders. Such areas have little or no economic potential other than forestry at prevailing technological levels in the region.

The last grouping of soils,, those furthest to the north and east, are the so-called Low Terraces. Bioclimate is most favorable where they occur but drainage has changed from a minor to a major problem. In the Low Terrace zone the major rivers have virtually reached base level and meander widely over the plain, changing couses frequently. Normal stream levels are only slightly below the general land surface and nearly all the land may be flooded when rivers rise to full flood peak. This means that new, fine sediments (silts and clays) are deposited with some frequency even well away from the

main streams, and sands are deposited close to the riverbanks on slightly elevated natural levees. Only the interfluvial basins farthest from the main streams fail to receive an occassional dusting of new sediments. These are consequently both deeply depressed, permanently wet or flooded with shallow water, infertile, and anaerobic (hydromorphic). Other soils tend to be relatively fertile in the surface layer at least, but are somewhat shallow over the permanent ground water table. In this category, only the moderately well-drained terraces, those subject to short-term inundation, and the natural levees have agricultural potential and, unfortunately, lands in these categories represent a diminished proportion of the total area in the physiographic region. Vast areas, despite the somewhat drier climate are comprised of swamps, lagoons, abandoned meander channels, flooded or seasonally flood depressions, flooded backwaters, and poorly-drained terraces. Most of these lack any economic potential other than as ~~rich and~~ essential feeding grounds for river fish at the time of seasonal floods, for the management of wild animals, or for forestry.

4.0 Major Land Use Capability

N.B. Good lead in sentence to production section:

Land use capability classification is prerequisite to planning for successful and sustainable rural land occupance. The term refers to the ecological suitability of any small, physically homogeneous of land for specified types of economic utilization on a continuous basis (without causing deleterious effects in the short or long term in the original productive capacity of the land unit). Failure to plan land development upon such a basis can, as it has already in the Chapare, lead to gross mistakes and to eventual economic and social stress, costly or impossible to remedy.

Several land use capability classifications have been devised and applied to tropical conditions, but the bulk of these are not ecological

in their derivation or objective in their application. For this reason, the system devised in 1972 by Tosi (1981) for Columbian environmental conditions has been adapted to the problem of classifying the Chapare environments, integrally, for major land use capability. This classification is based upon the World Life Zone System of Ecological Classification of L. R. Holdridge (1967), already known and applied in Bolivia (MACA, 1975). A nearly identical classification is currently used under official governmental decree, in Perú, where it has been found very satisfactory for the purposes outlined.

The Colombian classification by Tosi is based upon the premise that bioclimate, as integrated in the life zone hexagons (Figure 1), is a primary determinant of land use capability. The classification therefore sets up a multi-factorial integration of bioclimatic with physiographic and edaphic parameters to establish the major use capability of land in five major or general categories of land utilization. The quantitative values for individual physiographic and edaphic factors are varied to fit the specific effects of climate upon them and upon the potential vegetative cover in each of the tropical and subtropical life zones on the diagram. Values are derived mathematically from the Universal Soil Loss Prediction Formula of Wisch meier and Smith. Four different levels of land-using technology are recognized and integrated into the classification, such that a given land unit can be identified for capability simultaneously under each level. These levels are (N) Primitive, (T) Traditional, (A) Advanced, Artesanal, and (M) Mechanized. All

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categories of technology, land use capability, and class divisions of the environmental parameters are precisely defined and special keys are provided to be used in each distinctive life zone as identified upon the ground.

This classification has been adapted for use in the Chapare based upon the life zone map constructed during the consultancy and upon the physiographic-

soils map of SNA-FAB-PRODES, as discussed heretofore. Of the five regular major use capability categories recognized in the classification, only the fourth, (F) Production forestry, has been subdivided into two sub-classes for added precision in locating areas for specific uses in planning. The land in the Project Area has been classified simultaneously, as well, under two of the four technological system categories, (T) Traditional and (A) Advanced, Artesanal.

4.1 Mapping Procedure and Final Product

Given the field data on life zone distributions, a map was first constructed to show the detailed location of life zones in the Project Area (Map No. 1). Ecological boundaries from this map were transposed to scale upon the landforms-soils map at 1:50,000 (SNA-FAB-PRODES, 1980). Each soils association-consociation unit upon the latter map was thus classified as to its bioclimatic affinity.

A parallel step in the mapping process was the classification of each landform-soils association-consociation group in the PRODES survey as to average slope characteristics, micro-relief, soil depth, texture, stoniness, permeability, inherent fertility, pH, erosion suffered, salinity, and flood risk. These determinations, necessary for the application of the land capability classification, involved detailed interpretation and computations from the PRODES (1980) field and laboratory data for representitive soil profiles.

Finally, each of the PRODES-unit keys was converted to an alphabetical code (ANNEX A- This report). The life zone identification followed by the new code for landform-soil was then entered into each distinctive land unit delineated on the PRODES map as a denominator in a fractional code system. Land use capability as derived from the keys in Tosi (1981) for these values was then determined for each combination of bioclimate and landforms-soils

(ANNEX B-This report) and subsequently entered on the map in the numerator position of the fraction, in the following order:

L.U. Capability: Traditional Technology-(L.U.Cap.: Advanced Tech. if different)

Life Zone / Physiographic Region - Landform-Soils Sub-division

The final product of this procedure, most clearly visible when each area of conterminous units having the same land use capability is colored differenly, was a map (No. 2) at 1:50,000 subsequently reduced to 1:100,000 scale. This map retains the original divisions of the PRODES landforms-soils map and the life zone map as well as showing use capability at the two technological levels. By statistical block count and planimeter, the areas of each category were then derived from this map, by micro-region, and are presented, for each technological level, as Table 8A and 8B.

4.2 Major Land Use Capability Classes: Interpretation

Symbol A: Clean-tilled crops is the highest level in the classification. Lands in this category will support continuous open-field cropping or, in seasonal climates without irrigation, an annual rain-fed crop planted in bare soil and cultivated for weed suppression, without loss or decrease of the land's original productive qualities due to soil erosion, leaching, or structural modifications due to compaction and without resulting in off-site harm to soils, vegetation, or the hydrographic regime. These are, by definition, the "best lands" for agriculture, (and livestock production). The physical requirements for inclusion will vary, however, not only in absolute terms but also as a function of the land-using technology being applied. An "Advanced" technology, be it "Artesanal" or "Mechanized", ordinarily permits poorer grade land to come into this category as compared to a "Primitive" or "Traditional" technological systems-level of farming, inasmuch as soil conserving practices

are implicit in the former but not in the latter systems. In most cases, any of the lower level land uses are admissable as alternative uses on lands in this category, for which uses they will be superior to lands classified directly in those uses. For example, other factors being equal, forests will be more productive on A-Category lands than on F-Class (Forest Production) lands.

Symbol P: Permanent Crops and Pasture is the next-to-highest level in the classif ication. Lands in this category will not, however, support continuous cultivation of clean-tilled crops. At the technological levels of their classification they may be used for pasturing livestock of for the production of any, usually semi-permanent or permanent crops which do not require the repeated clean-tillage of the soil, or which leave the soil surface without a protective vegetation cover for any extended period of time. Qualification for this category is based on the same criteria as in Category A: the retention of original soil productivity potentials under continuous use and absence of deleterious off-site effects. As in the previous category, these lands will support, and in fact be more productive in, forest or tree crop production systems, as an alternative land use where economics do not permit their highest-intensity utilization.

Symbol C: Permanent Crops Without Pasture include lands with marginal physical conditions for crop production. Their use for grazing of livestock is proscribed inasmuch as this use will lead to site deterioration and/or deterious off-site effects. Many of these lands are either in sloping, erodible areas, in seasonally-flooded flatlands, or have low inherent fertility due to aluminium toxicity. The majority of lands in this category are best suited to long-term perennials, and in particular to bush and tree crops which provide full soil protection at all times. The ground cover, is

regulated by crop shade and leaf litter as a protective mulch. Coffe, oil and peach palm, tree-shaded cacao, rubber, fruit orchards, and nut groves, are the sort of production systems which fit into this category. Coca, incidentally, requires clean tillage, does not fit, and should be excluded from areas so-classed on the map. Banana, papaya, and pineaple require more-than-acceptable tillage and lead to adverse site deterioration. They are not recommended either. Agro-forestry, a term currently in voque amongst development planners for the tropics, implies the sort of land-using technologies which are applicable on sites falling in this category.

Symbol Γ: Production Forestry includes all lands with site conditions adverse to any continuous or extend agricultural use. These lands will produce acceptable crops of timber from native tree species under natural conditions without causing adverse soil or off-site effects as the result of management operations, such as logging and extraction, at the technological levels of their classification. In the present analysis, the Γ-Category has been subdivided into Γ_1 and Γ_2 units.

N.B.

Γ_1 includes lands too poor for agricultural production or grazing but of comparatively high quality for forestry or a combination of forestry with short, intermittent cycles of slash agriculture such as is practiced by native peoples. Under the latter system, however, only small fields may be opened and the major part of the land must be retained in native forest or in forest plantations at any given time. Of the two sub-categories, only Γ_1 lands are recommended for forest tree plantations.

Γ_2 lands have conditions adverse to any field cropping or tree plantations. They may be managed under specified technology, for the permanent production of timber crops in naturally regenerating native forests.

Symbol X: Protection (under undisturbed natural vegetation) is the final

category of the classification. It includes all lands having physical site conditions which are either adverse to any economic use of the soil or which will lead to severe on or off-site damage if used in any way, including for the harvesting of natural forest trees. The category includes lands which are permanently flooded or flooded for long period each year, areas of rock outcrop, stream overflow debris, and gravel beds, and steeply sloping lands in hills and mountains with high rainfall and runoff. Such lands, if exploited in any way, invariably deteriorate and do not sustain exploitation and may cause serious off-site effects in the process.

4.3 Traditional versus Advanced Technological Systems in Land Use

Current land using technology in the Chapare may be classed as "Traditional" verging on the "Primitive". By-and-large, farmers there have been in the region for only about ten to fifteen years, coming from highland regions with a totally different physical environment and farming traditions. They have learned what they do know about dealing with the new environment by painstaking personal effort, taking clues from the original natives, old-timer colonists, and each other. Officially-sponsored research and extension efforts have been fumbling, poorly oriented, and apparently of little positive benefit to date (see Stansifer report). By trial-and error, under severe limitations with respect to marketing of products, the typical colonist has learned how to deal, in a modest way, with production problems on his often arbitrarily located small farm. Hoffman (1983) has identified and documented eight distinctive traditional system of cultivation currently practiced by Chapare farmers. All of these systems rely upon forest fallow periods for soil fertility restoration, and all but one system involve the production of semi-permanent and/or permanent crops throughout the major portion of time that the land is actively in crop cultivation. Annual crops

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are interplanted with semi-permanent or permanent ones for a short term income at the beginning of each cropping cycle. Except for coca production, farmers do not use purchased fertilizers or pest and disease control chemicals, and, in no case, do they use improved crop varieties. Livestock is of inferior quality. Hand labor is the rule in all farm operations. There are no work animals. Soil conservation is not conscientiously practiced, or understood.

N.B. yet social analysis

In classifying land for use capability, therefore, primary emphasis has been given to the "Traditional" level of technology as set up in the Land Capability Classification (Tosi 1981). Because it is excepted that Project implementation will reinforce research and extension, marketing infrastructure and processing facilities, and otherwise give impetus to adoption of new technology through economic incentives and technical assistance, it is also worthwhile to see what the region looks like in terms of land capability under an "Advanced, artesanal" technological system. Lands have therefore also been classified in the latter context.

4.4 Land Capability in the Chapare: Findings

Mapped distributions of the land capability classes (Map No. 2) and Table 8 indicate a generally low to moderate agricultural potential for the Project Area, depending upon which level of technology is assumed. Only about 30 percent of the total land area is suitable for any type of agriculture, including agro-forestry, at Traditional levels of technology. The forestry potential, however, is high.

N.B. good lead-in for getting into forestry i.e. changing focus of project.

Although actual land use was not mapped (and never has been), casual observation suggests that current use is generally consistent with capability at the Traditional level except in the Hills and Mountain physiographic regions, particularly in Micro-regions 1, 2, and the southern parts of 3, 4,

Table 8 A : Absolute and Relative Area by Land Use Capability Classes and Micro-region in the Chapare Project Area under TRADICIONAL technology

Microregion		A	P	C	F_1	F_2	X	Total
1	has.	-	-	-	1,825	8,275	80,836	90,936
	%	0.0	0.0	0.0	2.0	9.1	88.9	
2	has.	-	-	620	6,402	12,325	15,425	34,772
	%	0.0	0.0	1.8	18.4	35.4	44.4	
3	has.	1,825	8,950	17,550	14,075	3,250	2,600	48,250
	%	3.8	18.5	36.4	29.2	6.7	5.4	
4	has.	-	2,522	12,327	15,992	9,437	10,547	50,825
	%	0.0	5.0	24.2	31.5	18.6	20.7	
5	has.	1,875	9,850	4,925	12,925	1,250	2,775	33,600
	%	5.6	29.3	14.7	38.5	3.7	8.2	
6	has.	-	5,625	9,775	8,900	4,775	10,650	39,725
	%	0.0	14.2	24.6	22.4	12.0	26.8	
7	has.	-	19,150	6,900	24,800	2,900	10,325	64,075
	%	0.0	29.9	10.8	38.7	4.5	16.1	
8	has.	375	7,200	11,575	11,125	5,775	3,100	39,150
	%	1.0	18.4	29.6	28.4	14.7	7.9	
9	has.	-	2,475	11,225	5,125	425	2,125	21,375
	%	0.0	11.6	52.5	24.0	2.0	9.9	
Total	has.	4,075	55,772	74,897	101,169	48,412	138.383	422,708
	%	1.0	13.2	17.7	24.0	11.4	32.7	100
		31.9			35.4		32.7	

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Table 8 B : Absolute and Relative Area by Land Capability Classes and Micro-regions in the Chapare Project Area under ADVANCED, ARTESANAL technology

Micro-region		A	P	C	F_1	F_2	X	Total
1	has.	-	775	-	1,050	8,275	80,836	90,936
	%	0.0	0.8	0.0	1.1	9.1	89.0	
2	has.	-	70	550	6,402	12,325	15,425	34,772
	%	0.0	0.2	1.6	18.4	35.4	44.4	
3	has.	6,025	25,650	6,725	5,400	3,250	1,200	48,250
	%	12.5	53.2	13.9	11.2	6.7	2.5	
4	has.	-	15,486	6,588	8,767	9,437	10,547	50,825
	%	0.0	30.5	13.0	17.2	18.5	20.8	
5	has.	15,350	8,575	-	7,750	1,250	675	33,600
	%	45.7	25.5	0.0	23.1	3.7	2.0	
6	has.	-	16,450	4,375	3,475	4,775	10,650	39,725
	%	0.0	41.4	11.0	8.8	12.0	26.8	
7	has.	8,525	24,725	4,450	18,425	2,900	5,050	64,075
	%	13.3	38.6	6.9	28.8	4.5	7.9	
8	has.	375	21,375	1,350	7,175	5,775	3,100	39,150
	%	1.0	54.6	3.4	18.3	14.8	7.9	
9	has.	3,775	11,225	-	5,450	425	500	21,375
	%	17.7	52.5	0.0	25.5	2.0	2.3	
Total	has.	34,050	124,331	24,038	63,894	48,412	127,983	422,708
	%	8.1	29.4	5.7	15.1	11.4	30.3	100
		43.2			26.5		30.3	

6, 7, and 8. In these areas, there has been settlement, mostly spontaneous, of lands classed as suitable only for forestry (F) and, in not a few locations, only for absolute protection (X). This settlement is located along or within walking distance of the existing highway and penetration roads. It is reported that some of this settlement and clearing took place in spite of opposition by the National Colonization Institute. The National Agrarian Reform Institute actively promotes settlement as part of a policy to use the Chapare for the disposal of surplus people from the overcrowded highlands.

4.4.1 Micro-regions 1 and 2 include no significant area of land having agricultural potential at either technological level. Ninety percent of the land in MR-1 is classed as suitable only for Protection (X), the remainder for Forest Production (F). However, land clearing for shifting cultivation followed by grazing of livestock was observed to be occuring in this region, not only on lands classed for forestry but also on protection-class lands. The National Agrarian Reform Institute has divided up formerly large private landholdings in the area as family-sized farms. Farmers are producing locoto peppers, corn, arracacha, and some potatoes on the better F_1 lands under a system of shifting cultivation, around Tablas Monte. In other areas the principal land use is livestock grazing in both cleared land and in degraded natural forest. The grazing is leading to severe erosion and vegetational deterioration and should be discontinued in favor of forestry or protection, as recommended on the map. Further settlement of people in this MR should be discouraged and strict land use controls should be imposed on present inhabitants.

U.B. include in paper as support environmentalists.

Under Advanced technological system, some 775 hectares will pass into the Permanent Crops and Pasture (P) category. An extention agent should

be assigned permanently to promote fruit orchards (peaches, cherimoya, etc.) on these lands and to aid farmers in perfecting their present shifting cultivation system on intensive Forest Production (F_1) lands. Locoto, arracacha, and green leafy vegetables under long-term rotation with timber plantations could stabilize land use and heighten productivity and human carrying capacity in the region without further damaging the watershed and its hydroelectric potential.

4.4.2 Micro-region 2 is in similar circumstances, except that somewhat more than one half the total area is classed as suitable for some form of forest production, (mostly F_2). The forestry lands are located on the bench terraces bordering the major rivers. Some but not all are currently being utilized for shifting cultivation or for permanent crops such as banana, papaya, and pineapple, which are sold to passing truckers. The transport advantage being very great, there is a real danger that these scattered roadside farmers will expand clearing onto the very steep Protection category lands uphill from their farms, causing major landslides and problems of a similar nature affecting the highway infrastructure and the hydrographic regime downstream. A program to eliminate agriculture from non-agricultural land along the main highway is of particular importance. People located here should be given preference for relocation onto the lower plains and the present legislation designating these lands as National Protection Forest should be enforced.

4.4.3 Micro-region 4 is in an intermediate situation. Roughly seventy percent of its total area of 50,000 hectares is totally unsuitable for agriculture, but can be used in great part for intensive forest production (F_1). Some thirty percent of the area on its northern borders' with well-drained high terraces is suitable for Permanent crops without Pasture (C) at present

levels of technology and, were this technology to be upgraded an additional 15 percent of land, taken from what is now in the F_1-class, could enter into this production category.

This is one of the most important areas of coca production at present. Tembe, or pejiballe (peach palm), with its relatively high-valued palm heart, would withstand the high rainfall conditions of the predominating Tropical wet forest life zone here, and this might be a priority area for peach palm production as a substitute for the coca. Replacement could be gradual, on lands classed as P and C. With a high technology system of tembe production, lands classed in the P_1 category on some soils could also be devoted to this crop.

Few other tree crops will perform well in this micro-region but the following should be introduced and tested at the Chipiriri Experiment Station: breadfruit, jackfruit, carambola, African oil palm, abaca (Manila hemp), rambutan, pulusan, guaraná, cocona, and yautia (see Table 9). Forestry systems to be recommended are considered following sections of this report.

4.4.4 Micro-region 6 is only marginally better than MR-4 in terms of suitability for agriculture. As in the former case, there are no lands apt for Clean Tillage (A) but a total of 38.8 percent of the area can be used for Permanent Crops, 14.2 percent falling in the higher quality P category and the remainder in the C or Agroforestry class. By introducing an Advanced level of technology, and additional 13.6 percent of the area could be brought from the Forestry category into the Permanent Crop categories (compare Table 8A and 8B).

This micro-region scarcely reaches into the Subtropical wet forest at all and has a large area on the south of Mountain and Hill region

physiography, much of which is in the Subtropical rain forest. Twenty-six percent of the area falls in the Protection (X) category and 34 percent in Forest Production (F). On the Piedmont and High Terrace sectors, soils are variable but suffer, as in the case of MR-4, from the excessive rainfall of the Tropical wet forest life zone. These conditions limit the crop choices severely. Tembe is, again, the crop of choice, and other species which should perform well with appropriate varietal introductions and improved farming practices, are banana and plantain, Indian wheat, Kola nut, dasheen or taro, oil palm, cinnamon and cassia, Manila hemp, and possibly some of the other species recommended for trial plantings at Chipiriri in MR-4. On very deep, well-drained soils, such as those found in the Piedmont and High Terrace landform types (P, Ppi, possibly TA), tea would be expected to perform well in the Tropical wet forest life zone areas of this and other micro-regions. Tea is a calcifuge and aluminium accumulator and requires deep, well-drained acid soils for best performance. Approximately 5.000 hectares meeting these conditions are found in MR-6.

4.4.5 Micro-region 7 follows 6 in order of increasing suitability for agricultural development. Forty-point-seven percent of its total area can be used for crops, all Permanent under Traditional technology; and 18 percent more of the total area could be added to this if Advanced technologies were instituted. This micro-region has a decided advantage in that it is very large (64,000 hectares, approximately) and 30 percent of this area falls into the P - Permanent Crops with Pasture category at Tradicional land use levels. Furthermore, some 8.500 hectares can be utilized for Clean Tilled Crops (A) under Advanced technology. The reason for this favorable situation is that a very large part of the micro-region falls in the Subtropical wet forest life zone which, as was discussed previously, is

significantly less restrictive to agriculture.

Of the non-agricultural lands, the greater part, some 38.7 percent of the total area, fall in the intensive Forest Production (F_1) category under Traditional production methods. These lands are, for the most part, eliminated from agriculture only because of their poor drainage or seasonal flooding characteristics. They will produce crops of such excellent swamp-forest timber species as the native sangre de toro (Virola spp.) and the exotic orey (Campnosperma panamensis). Under introduced Asiatic technologies, some lands in both the X and the F_1 categories could be converted to continuous clean tillage for the production of paddy rice. Excellent soils exist in the Middle Terrace landform region under symbols TMo, TMb, and TMm for such a conversion, and water control is possible in all three types.

N.B.

The roster of economic plants which are known to be or are probably adapted to the Subtropical wet forest bioclimate is much larger than that for the wetter bioclimates, as can be appreciated from Table9. From the species on this list the Chapare farmers now have commercial success in this life zone with pineapple, papaya, several citrus species, banana anad plantain, rice, yuca, peanut, maiz, and tomato. Houseyard fruits of excellent quality such as sugar apple, giant granadilla, annatto tree, water apple, ice cream and machete bean, and guava were observed in the area. These as well as breadfruit, peach palm, capsicum chiles, citrus, taro or dasheen, squash, gruya, sweet potato, vegetable sponge, beans, sugarcane, cowpeas and yautias are undoubtedly grown as an occassional subsistence crop or as fodder for dooryard pigs and chickens.

But these same species, and many others indicated in Table 9, are potentially commercial crops if the economics look right. Amongst those for introductory trials or limited commercial testing, I would suggest:

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TABLE 6 Economic Plants with probable adaptation to Chapare climates and soils with notes on product, economic scale of production, research requirements if any, and recommended life zones.

SCIENTIFIC NAME	COMMON NAME	PRODUCT	ECONOMIC SCALE	REQUIREMENT	LIFE ZONES
Anacardium Occidentale	Cashew	Fruit, Nut, Oil	C	Test plantings	bh-T△; bmh-ST
Ananos comosus	Pineapple	Fruit	C,S	Plant Out	bh-T△; bmh-ST
Annona reticulata	Custard Apple	Fruit	C,S	Plant Out	bh-T△; bmh-ST
Annona muricata	Soursop	Fruit	C	Test plantings	bh-T△; bmh-ST
Annona squamosa	Sugarapple	Fruit	S	Plant Out	bh-T△; bmh-ST
Arachis hypogaea	Peanut	Vegetable	C,S	Plant Out	bh-T△; bmh-ST
Artocarpus altilis	Breadfruit	Vegetable	S,F	Plant Out	bh-T△; bmh-ST; T△
Artocarpus integrifolia	Jackfruit	Vegetable	S,F	Plant Out	bh-T△; bmh-ST; T△
Averrhoa carambola	Carambola	Fruit	C,S	Plant Out	bh-T△; bmh-ST; T△
Bactris utilis	Peach palm	Fruit, Vegetable T	C,S, F	Plant Out	bh-T△; bmh-ST; T△
Bixa orellana	Annatto tree	Dye	C,S	Plant Out	bh-T△; bmh-ST
Cajanus cajan	Pidgeon pea	Vegetable	S	Plant Out	bh-T△; bmh-ST
Calocarpum viride	Green Sapote	Fruit	C,S	Plant Out	bmh-ST; bmh-T△
Camelia Sinensis	Tea	Beverage	C	Test Planting	bmh-ST; T ; bp-ST
Canarium ovatum	Pili Nut	Edible Nut	C,S	Trial Planting	bh-T△; bmh-ST
Canavalia gladiata	Sword bean	Vegetable	S,F	Test Planting	bh-T△; bmh-ST
Canna edulis	Gruya	Vegetable	S,F	Plant Out	bh-T△; bmh-ST
Capsicum annuum	Hot pepper	Spice	C,S	Plant Out	bh-T△; bmh-ST
Carica papaya	Papaya	Fruit	C,S	Plant Out	bh-T△; bmh-ST
Caryocar nuciferum	Sauri-nut	Edible Nut	C,S	Trial Planting	bh-T△; bmh-ST
Chrysophillum Cainito	Star Apple	Fruit	C,S	Plant Out	bh-T△; bmh-ST; T△
Cinnamomum zeylandicum	Cinnamon	Spice	C	Test Planting	bmh-ST; bmh-T△

SCIENTIFIC NAME	COMMON NAME	PRODUCT	ECONOMIC SCALE	REQUIREMENT	LIFE ZONES
Cinnamomum cassia	Cassia	Spice	C	Test Planting	bmh-ST; bmh-T▲
Citrus aurantifolia	Lime	Fruit	C,S	Plant Out	bh-T▲; bmh-ST
Citrus limonia	Lemon	Fruit	C,S	Plant Out	bh-T▲; bmh-ST
Citrus paradisi	Grapefruit	Fruit	C,S	Plant Out	bh-T▲; bmh-ST
Citrus nobilis	Tangerine	Fruit	C,S	Plant Out	bh-T▲; bmh-ST
Citrus reticulata x paradisi	Tangelo	Fruit	C,S	Test Plant	bh-T▲; bmh-ST
Citrus sinenis	Sweet Orange	Fruit	C,S	Plant Out	bh-T▲; bmh-ST; MB
Cocos nucifera	Coconut	Fruit, Oilseed	C,S,F	Test Plant	bh-T▲; bmh-ST
Coffea robusta	Congo or Robusta Coffee	Beverage	C,S	Test Plant	bh-T▲; bmh-ST
Coix lacruma-jobi	Job's Tears-Indian Wheat	Grain, Forrage	C,S,F	Plant Out	bmh-ST; bmh-T▲
Cola acuminata	Kola nut	Beverage	C	Trial Planting	bmh-ST; bmh-T▲
Colocasia esculenta	Dasheen, Taro	Vegetable	C,S,F	Plant Out	bmh-ST; bmh-T▲
Corchorus spp.	Jute	Fiber	C	Trial Planting	bh-T▲; bmh-ST
Cucurbita spp.	Squash-Pumpkin	Vegetable	C,S	Plant Out	bh-T▲; bmh-ST
Curcuma longa	Tumeric	Spice	C	Trial Planting	bh-T▲; bmh-ST
Cyperus esculentus	Chufa	Vegetable	S	Trial Planting	bh-T▲; bmh-ST
Dioscorea spp.	Yam	Vegetable	C,S	Trial Planting	bh-T▲; bmh-ST
Diospyros discolor	Mabola, Velvet apple	Fruit	C,S	Trial Planting	bh-T▲; bmh-ST
Elaeis quineensis	African oil palm	Oilseed	C	Plant Out	bh-T▲; bmh-ST; T▲
Eteocharis dulcis	Water chestnut	Vegetable	C	Trial Planting	bh-T▲; bmh-ST
Elettaria Cardomomum	Cardamon	Spice	C	Trial Planting	bh-T▲; bmh-ST
Eugenia aquea	Water Apple	Fruit	C,S	Plant Out	bh-T▲; bmh-ST; T▲
Eugenia cuminii	Jambolan	Fruit	C,S	Trial Planting	bh-T▲; bmh-ST
Eugenia Jambos	Rose Apple	Fruit	C,S	Plant Out	bh-T▲; bmh-ST

SCIENTIFIC NAME	COMMON NAME	PRODUCT	ECONOMIC SCALE	REQUIREMENT	LIFE ZONES
Eugenia javanica	Java apple	Fruit	C,S	Trial Plant	bh-T▲; bmh-ST
Garcicia mangostana	Mangosteen	Fruit	C,S	Trial Planting	bmh-ST; bmh-T
Hevea brasiliensis	Rubber	Latex	C	Plant Out	bh-T▲; bmh-ST
Hibiscus Cannabinus	Kenaf	Fiber, Forrage	C,S,F	Trial Planting	bh-T▲; bmh-ST
Hibiscus esculenta	Okra	Vegetable	C,S	Trial Planting	bh-T▲; bmh-ST
Inga edulis	Ice cream bean	Fruit, Vegetable	C,S	Plant Out	bh-T▲; bmh-ST
Inga heterophylla	Machete beaw	Fruit, Vegetable	C,S	Plant Out	bh-T▲; bmh-ST
Ipomoea batatas	Sweet potato	Vegetable	C,S	Trial Planting	bh-T▲; bmh-ST
Lecythis zapucajo	Sapucaya nut	Edible Nut	C,S	Trial Planting	bh-T▲; bmh-ST
Luffa cylindrico	Vegetable sponge	Vegetable, Other	C,S	Plant Out	bh-T▲; bmh-ST
Macadamia spp.	Macadamia nut	Edible Nut	C,S	Trial Planting	bmh-ST
Malphigia glabra	Barbados cherry	Fruit	C,S	Trial Planting	bmh-ST
Mammea americana	Mamey apple	Fruit	C,S	Trial Planting	bh-T▲; bmh-ST
Maranta arundinacea	Arrowroot	Vegetable	C,S,F	Plant Out	bh-T▲; bmh-ST; T▲
Mucuna deeringrana	Velvetbean	Fodder	S,F	Trial Planting	bh-T▲; bmh-ST; T▲
Musa x paradisica	Banana, Plantain	Fruit	C,S,F	Plant Out	bh-T▲; bmh-ST; T▲
Musa acuminata	Red-leaved banana	Fruit	C,S,F	Plant Out	bh-T▲; bmh-ST; T▲
Musa textilis	Abaca, Manila Hemp	Fiber	C	Plant Out	bh-T▲; bmh-ST; T▲
Myrciaria cauliflora	Jaboticaba	Fruit	C,S	Trial Planting	bh-T▲; bmh-ST
Myristica fragrans	Nutmeg; Mace	Spice	C	Trial Planting	bh-T▲; bmh-ST; T▲
Nephelium lappaceum	Rambutan	Fruit	C,S	Trial Planting	bh-T▲; bmh-ST; T▲
Nephelium mutabile	Pulusan	Fruit	C,S	Trial Planting	bh-T▲; bmh-ST; T▲
Oryza sativa	Common Rice	Grain	C,S	Plant Out	bh-T▲; bmh-ST
Passiflora quadrangularis	Giant granadilla	Fruit	C,S	Plant Out	bh-T▲; bmh-ST

SCIENTIFIC NAME	COMMON NAME	PRODUCT	ECONOMIC SCALE	REQUIREMENT	LIFE ZONES
Passiflora edulis	Maracuyá	Fruit	C,S	Plant Out	bh-T▲; bmh-ST
Paullinia cupana	Guaraná	Beverage	C,S	Trial Planting	bh-T▲; bmh-ST; T▲
Phaseolus vulgaris	Common Bean	Vegetable	C,S	Varietal Selection Trials	bh-T▲; bmh-ST; MB
Pimenta officinalis	Allspice	Spice	C	Trial Planting	bh-T▲; bmh-ST
Pimenta acris	Bay run tree	Essential Oil	C	Trial Planting	bh-T▲; bmh-ST
Piper nigrum	Black pepper	Spice	C	Trial Planting	bh-T▲; bmh-ST
Psidium quajara	Guava	Fruit	C,S,F	Plant Out	bmh-ST; T▲; bp-ST
Saccharum officinarum	Sugarcane	Other	C,S,F	Plant Out	bh-T▲; bmh-ST
Solanum hyporhodium	Cocona	Fruit	C,S	Plant Out	bmh-ST; T▲; bp-ST
Spondias mombin	Hog plum	Fruit	C,S	Plant Out	bh-T▲; bmh-ST
Spondias purpurea	Red mombim	Fruit	C,S	Plant Out	bh-T▲; bmh-ST
Theobroma bicolor	White cacao	Beverage	S	Plant Out	bh-T▲; bmh-ST; T▲
Theobroma cacao	Cacao	Beverage	C,S	Plant Out	bh-T▲; bmh-ST
Vigna sinensis	Cowpea	Vegetable	C,S,F	Trial Planting	bh-T▲; bmh-ST
Xanthosoma sp.	Yautia	Vegetable	C,S,F	Plant Out	bh-T▲; bmh-ST; T▲

Key to Economic Scale:

C = Commercial or Industrial

S = Subsistence

F = Forrage

Key to Life Zones:

bh-T = Tropical moist forest transition to Subtropical

bmh-ST = Subtropical wet forest

bmh-T = Tropical wet forest transition to Subtropical

bp-ST = Subtropical rain forest

bmh-MB = Subtropical Lower Montane Wet forest

* List does not include pasture or forrage grasses or garden vegetables. Plants not on list are not recommended for the Chapare.

sugarapple and soursop, peach palm, pili nut, robusta coffee, swamp taro, mangosteen, rubber, macadamia nut, jaboticaba, rambutan, pulusan, maracuyá, black pepper, and allspice. It will be noted that with the exception of the taro, pepper, and maracuyá all are perennials and either large bushes or trees. They would, therefore, fit well into the permanent crops-tree plantation matrix which is implicit as a crops production system in the F and G land use capability categories in this and other micro-regions with large areas of Subtropical wet forest. Swamp taro, a giant variety of dasheen, and water chestnut should be tested as specialized crops for permanently wet depressions and seasonally flooded lands. Wherever these areas receive annual overflow of sediment-laden river water, soil fertility is high and these species should prosper. Dasheen is excellent feed for both humans and hogs, water chestnuts are a choice item in Chinese cookery and are canned for export.

4.4.6 Micro-region 8 turns out to have about 49 percent of its total land area in land capability categories A, P, and C. It is roughly similar to Micro-regions 7 and 5 in this respect. But this region has a somewhat different combination of soils and bioclimates whilst achieving the same averages. For one thing, it has a subtantially large area of adverse climates in Subtropical rain and Tropical wet forest life zones in its southern extremity, but these negative biclimates are combined with exceptionally deep and well-drained, occassionally-fertile soils of the Piedmont and High Terrace landform types. This is one of the few areas where cattle raising under pasture systems are applied. P category lands are the only ones suitable for this purpose in the micro-region. Land units in the P, Pa, and TA landform types in Subtropical wet forest would be the lands of choice for experiments of the modular type suggested by Hinojosa. About 3,500 Hectares in these types are available in a belt near the Satja River from which to select a trial area. Some of this land is already in cattle production under traditional grazing systems; results do not appear outstanding.

Micro-region area to be used by Hinojosa experiments SOP to experiment mendations

Micro-region 8 has a rather large area in lands of the F category. There is already a sawmill near Ivirgarsama and these lands could be put into sustained yield management for sawlog production as most of them are conveniently located in the northern part, near the town. Current use of these lands for shifting cultivation and cattle raising is causing serious soil erosion and rural proverty is manifest.

change to forestry.

4.4.7 Micro-region 5 is one of the two micro-regions with the highest agricultural potential in the Project Area. In it, 50 percent of all land is of agricultural quality at Traditional levels and 71 percent if Advanced techniques are employed. It also has the largest area of land in the

Clean-tillage category (A): 1875 hectares. This land comprises well-drained middle terraces in the Tropical moist forest transition to Subtropical life zone.

A much larger area suitable for clean tillage is available if advanced technologies are applied: 15,350 hectares shifting from P to A in subtropical wet forest life zone on high, well-drained terrace soils, for the most part. Some of the accretion (5,650 Ha.) comes, however, from the inclusion of depressed terrace areas with only forest production capability (F1). Clean-tillage would only be for the production of paddy rice, with adequate water control on these lands. The Clean-tillage (A) lands are otherwise the lands which could be devoted to commercial dryland rice production, in the Subtropical wet forest life zone area as shown on the map (Map N° 2), and to peanut production, rice, maize, or sugarcane in the Tropical moist forest life zone area. However, these same lands in the Tropical moist forest area (about 1,875 ha.), and on another 1,825 hectares in adjacent MR-3, might more advantageously be devoted to the production of cacao, inasmuch as they are the lands best-suited for this crop in the entire Chapare Project Area. Cacao might also be tried, but only experimentally at first, on the well-drained, subelevated high terraces (TAs) and moderately well-drained subelevated high terraces (TAsi) in the Subtropical wet forest life zone area of this and adjacent MR-3. Almost 7,000 hectares are available.

The very large area of land in the P and C categories in region 5 and the fact that the bulk of this land is in the Subtropical wet forest life zone indicates that there would be a significant positive response to research and extension efforts concentrated there for the promotion of both traditional and new permanent crops and cropping systems. Working on the

N.B.

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base of established agroforestry practice as outlined by Hoffman and described by Pool (this survey), research and extension personnel should attempt to introduce new cultivars of higher-than-average economic potential into the existing systems, to modify those systems over time, and to enhance their overall productivity and output through on-farm testing of modified production practices.

A major recommendation can be made in this regard; forest fallow cycle (chume) should be lengthened to at least ten years in all systems where such a fallow is used at all; at the time of clear-felling, the woody biomass should be harvested as a crop, all woody small, non-merchantable debris including bark, small branches, etcetera being chopped and left to decompose as an organic mulch on the soil surface rather than being burned; and occassional large trees of timber quality species in the chume should be left standing both as a seed source for nearby second-growth and to come to full economic stature and volume prior to harvest. This recommendation requires another: that a forest industrial component for the local conversion of the woody biomass into paper pulp, hydrolyzed stock feed, treated posts and poles, and small dimension stock and lumber products be included in the agro-industrial development aspects of the Project.

N.B.

4.4.8 Micro-region 3 is similar in many respects to MR-5 except that it is larger and has an appreciably greater total area of the poorer, C-category lands. Also, its southern half, more or less, is occupied by Tropical wet forest, part of which overlies Hill landforms and these hills are extremely steep and dissected. Northwards, however, the Tropical wet forest overlies mostly well-drained High Terraces, compensating in part for the excessive rainfall, for these soils tend to be deep and well-drained internally. Under Traditional technology, most of this southern area is of only intensive

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forestry capability (F1) but with Advanced technology, the land might be used for agroforestry in the C Category, and this raises the total agricultural area from 59 to almost 80 percent of the total land area of 48,250 hectareas in the micro-region.

Truly, this is the agro-forestry area of greatest potential in the Project Area, while there is a substantial additional area for Clean-tillage and for Permanent Crops with Pasture on the northern half, where both Subtropical wet forest and Tropical moist forest life zones provide greatly improved climatic conditions for agriculture. Remarks concerning these climates and crop adaptability made in connection with the MR-5 and MR-7 areas are generally applicable here as well and will not be repeated.

The micro-region is apparently fully settled at the present time. It has one of the best secondary roads of the region running through it via San Miguel, 14 de Septiembre and San Francisco. This and other secondary roads should be extended northwards into the Tropical moist forest life zone areas just beyond the present boundaries of the MR in order to open up these climatically moist, potentially richer agricultural regions to settlement. New road construction under the Project should be directed in this way rather than westwards (in MR-4) or southwards (in MR-8) if ecologically (and economically) rational expansion of colonization is to be achieved.

4.4.9 Micro-region 9 occupies a smaller area than any of the other micro-regions (only 21,375 ha.). Under Traditional technology is has the largest total percentage of its area in lands suitable for agriculture, but the bulk of these are C-category lands: 52.5 percent. These lands enter into this category largely because of their more favorable climate: there is no Tropical wet forest at all and Tropical moist forest occupies the northernmost part of the area. Soils, conversely, are rather poor, being Low Terrace

landforms between the Ivirgarsama and Ichilo Rivers. They are subject to frequent and rather deep flooding, have high ground water tables, and are not particularly fertile. Crop production potential is therefore limited to species which can tolerate wet feet: breadfruit and jackfruit, possibly rubber and cacao -- on sites where floodwater keeps moving to provide soil oxygen. These conditions are met on the natural levees, moderately well-drained low terraces, floodable low terraces, and riverbank complex (TBd, TBm, TBi, and TBc) in this micro-region. On the north, particularly, in the Tropical moist forest, conditions are optimal for cacao on the better-drained sites. Rubber might be grown given attention to drainage, on the moderately well-drained low and medium terraces in the Subtropical wet forest life zone area which occupies the entire micro-region south of Puerto Villarroel. Evaluation of the performance of existing plantations there and trial plantings should preceed any large commercial promotion, however.

MR-9 is a problem region because of the flooding problem. On lands classed for Permanent Crops and Pasture (P), however, a water buffalo option might be extended over a very large area of lands along the highway (C-category under Traditional technology). Buffalo, unlike cattle, are able to prosper on the poorer forrage and intermittent flooding conditions which occur on these lands.

Another possible crop for these lands is swamp taro or dasheen (Colocasia esculenta). Giant swamp varieties are available from the Southeast Asia and Pacific regions. Dasheen is an excellent, easily digested starchy food suitable for local and regional human consumption and can be used as a main food source for swine production. By adding tembe as the main protein source, plus plantain, breadfruit, jackfruit, and kudzu, swine may be raised efficiently to good size entirely on locally produced rations.

Away from the highway, much of the floodable land in MR-9 is still in forest today, apparently because people have not been able to learn how to cope with the flooding. This land has appreciable stands of second-growth and some virgin timber but the timber trees are dispersed, being intermixed with very large numbers of wild palms and some bamboo (Guadua sp.). Attempts should be made to develope these lands withour just wiping out the original standing biomass. Many of the palms, such as the chonta (Astrocaryum sp.) and the pachuba (Iriatea exorcisa) are valuable for their fruits or palmito and many other species are also present, which sould be investigated. The bamboo, of course, highly tolerant of the flooding, is eminently suitable for many farm construction purposes as well as being a potential source of long-fiber paper pulp.

These remaining forests in the floodable lands should therefore be studied further and a program should be set up for their rational utilization prior to or in connection with future farm development wherever higher-than-forestry uses are recommended on the land capability map. For the Forest Production lands (F), explitation might be best regulated through the establishment of communally-owned and operated forests, with technical assistance provided initially by the Project.

will the farmers go for it?

(III RECOMMENDATIONS)

5.0 Actual Land Use Survey and Continuing Land Use Surveys

Although much of the Chapare lowlands are settled in either planned or spontaneous colonies, and although the general location of specific types of production is known to PRODES experts (e.g., Hoffman), actual land use and its extention at a detailed level is unknown and unmapped. A detailed map and objectively-derived field data on area-by-area crop location and productivity, species, and varieties grown, areas occupied, production systems

employed, and related social and economic factors simply does not exist for the Project Area. Yet this type of information is essential to rational planning for further development there.

An actual land use map, once prepared, can be compared by overlay with the land capability map (Map N° 2) to determine areas of appropriate and inappropirate land uses under existing technologies and to identify areas with advanced technology already in place, if any. The comparison will identify especially those areas where actual land use is not consonant with capability, both those over-used (indicating a need for withdrawal or readjustment in use) and those not used up to capability, (indicating an opportunity for new development or increase in the levels of farming or forestry, intensity). These are essential investigations for the orientation of an extension (and certain aspects of a related research) program.

An actual land use mapping project is recommended, therefore. Existing, most-recent aerial photographs are available to be used as a basis for pre-mapping by photo-interpretation, followed by field ground checks of actual land use in the Project Area. Crop, pasture, and forestland boundaries and vegetational cover upon each field, indicating crop and crop-mixtures would be identified. Notes on crop quality and productivity would be added. From the photographs, a final map at 1:50,000 scale would be compiled for use by farm planning teams (see 7.0). The work would be centered in PRODES and some of their field staff would assist in mapping, under an AID-designated project leader especially trained in the mapping techniques.

In order to monitor progress of the project, it will be desirable to repeat the actual land use mapping at least once every two or three years. Changes in land use, crop area and location, farming intensity and practice, will emerge from comparison of the maps. Before each new survey, new aerial

6D

photographs should be taken. Budget provisions should be made for this photography. (Satellite imagery is not suitable for this type of inventory, lacking the resolution needed for derivation of detail). The initial survey should take place before the Project itself is fully designed or initiated.

6.0 Detailed Study of Soil Fertility and Agrometeorology in Production Areas

The existing PRODES (SAN-FAB, 1980) soils map is at a too general a level for farm planning purposes. It is therefore essential that a more accurate and detailed soils map be prepared for all areas shown in the Clean-tillage, Permanent Crop, and Intensive Forestry (A, P, C, F1) category areas on the Land Capability Map. This mapping work should begin with existing colonies and settled areas as indicated by the Actual Land Use Map (recommended above) and proceed subsequently to cover those areas designated for future colonization. Farm planning and extension cannot proceed without such a base.

It is suggested that more practical and technologically appropriate parameters than have been used heretofore be applied in the soils survey work. The methodology and focus of Bool et al (1975) according to fertility is suggested for a map at a semi-detailed to detailed level-of-observation and scale.

In addition, in order to attain a better stratification of environments for planning production objectives and farm design, there is a need for a denser and more systematically distributed network of agro-meteorological stations in the project area. At least five major and ten minor (precipitation recording) stations should be added to the existing network.

7.0 Farm Planning Teams

The improvement of agriculture, even on small farms in the ten to twenty hectare range, requires as a pre-condition, the preparation of a farm plan, including a map of future production subdivisions and cropping

tie this into extension
gradually rotate in staff at medal farms

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and rotation schedule. Such a plan should be based upon a detailed survey and map of the physical conditions present on the farm, individually. The survey need not enter into academic-type details on soils but rather indicate the soils, slope, drainage unit-combinations and their inherent individual production possibilities, crop adaptations, requirements as to farming practices, and calendar of synchronized annual activities.

The U.S.D.A. Soil Conservation Service pioneered the farm planning technique in the U.S. and their model is still the best known for the sort of extension activity anywhere. Teams of planners including a soils conservation-plant nutrition expert and a farm management-economist visit individual farms on invitation of the proprietors and cover his terrain on foot to prepare such a plan and map. It is recommended that a similar procedure be followed in The Chapare Project. If a detailed soil map is prepared for entire community areas before hand, (see 6.0 above), then this process might be effected more rapidly and efficiently. This would be an integral part of the research and extension activities of the Project.

8.0 Forestry Extension and Forest Industrial Base

N.B. lead-in to forestry section!

Almost 150,000 hectares are classed as suitable only for forestry in the Chapare Project area (Table 8A). This is somewhat more land than all land of agricultural potential taken together at Traditional levels of farming technology. A further large area of land, used in shifting cultivation on agricultural quality land for soils fertility restoration reasons, is in secondary natural forest (chume) at any given time. Probably close to 200,000 ha. in all is producing and will probably continue to produce woody biomass under all forestry and agro-forestry productions systems throughout the immediate future. This large area and its forest cover re-

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presents an enormous under-exploited raw material base for the eventual supply to local industries, as has been pointed out previously in this report and by McCaffrey (this survey). In order that this resource be efficiently utilized rather than wasted as is currently occuring, two things are necessary, (1) a forestry extension program to teach farmers how to get the most out of their woodlots, community intensive-forestry areas, and natural sustained-yield forests, and (2) the creation of a local industrial base for the elaboration of wood products from the raw material which thousands of small farms and forests can supply.

McCaffrey has suggested the details of such programs. The land capability survey supports his contention that it is necessary and would be economically and technically feasible. Initially, a study should be commissioned to determine the most economical mix of forest industrial enterprises to be fostered.

Forestry extension should be conducted integrally with agricultural extension, as should its research aspects, if true agro-forestry production systems are to be developed in the Project Area.

9.0 Agro-forestry as a Major Production Emphasis

N.B. This is what they do now: 60c avafes

Farmers in the Chapare are today practicing a rudimentary form of agro-forestry. It has been their experience that clean-tilled annuals and pasturing of livestock are uneconomic except as small scale components of semi-permanent and permanent, mostly bush and tree cropping systems in rotation with naturally regenerated forest fallows. The land capability analysis indicates that their experience is valid and that while greater productivity and an enlarged assortment of commercial crops can probably be grown, it is not adviseable to alter this essential agro-forestry focus. A crop matrix of the larger fruit, gum, nut, oil, and latex trees may eventually be designed to obviate the present necessity for short term rotations with forest, however, at least upon the better lands. Tradional systems of beef livestock production do not fit in the region anywhere, and should not be promoted.

Farm extension programs and their related onsite research and trial plantings should be concentrated in the northern area in Subtropical wet forest life zone and oriented towards building upon the present farm cropping systems as outlined by Hoffman (1983). Trained agro-forestry technicians should be the central elements amongst the extension activity personnel and should lead the way to experimental design and trial of what might best be called "enhanced" and "more-finely tuned" systems of producing such permanent crops as banana, plantain, papaya, yuca, and citrus, while downplaying coca and replacing it progressively with high yielding and profitable tree crops such as peach palm, robusta coffee, rubber, tea, and others named in this report. Both mixed and single species plantings should be tested to determine the best types for given land and soil situations. Under intensive

W.B.

forestry, the prefered activity in much of the southern area (Tropical wet forest life zone), emphasis should be placed on systems under which second growth stands are held long enough between short term open-field croppings of subsistence crops to provide a good economic timber crop upon felling. Farmers should be encouraged to harvest and deliver their own wood to roadside. No-burn systems of ground preparation, including the Central American "tapado" system of bean and corn production under brush mulch, should be introduced. More beans should be grown in the region: people are badly nourished in general and beans are the best vegetable source of protein.

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ANNEX A
(ANEXO A)

TABLE OF EQUIVALENTS AND SYMBOLS EMPLOYED ON LAND CAPABILITY MAP
(TABLE DE EQUIVALENTES Y SIMBOLOS USADOS EN EL MAPA DE CAPACIDAD DE USO MAYOR DE LA TIERRA)

Physiographic Unit (Unidad Fisiográfica)	Local Landform (Forma Terrestre Local)	PRODES Soil Map Symbol (Símbolo en el Mapa de Suelos de PRODES)	Land Capability Map Symbol (Símbolo en el Mapa Presente)
Mountains (Montañas)	High hills (Colinas Altas)	A.1.1	MCA
"	Dissected high hills (Colinas altas disectadas)	A.1.2	MCAd
"	Long slopes (Pendientes)	A.1.3	MS
"	Dissected long slopes (Pendientes disectadas)	A.1.3.1	MSd
"	Very steep long slopes (Pendientes muy escarpadas)	A.1.3.2	MSvs
"	Steep long slopes (Pendientes escarpadas)	A.1.3.3	MSs
"	Hills with short and dissected slopes (Colinas con pendientes cortas y disectadas)	A.1.3.4	MCAsd
"	Valleys with Colluvial and Alluvial Sediments (Valles con Sedimentos Coluvio-Aluviales entre Colinas)	A.1.3.5	MCAv
"	Steep stream banks (Interfluvios)	A.1.3.6	MCAl
Low Hills (Colinas Bajas)	Low hills (Colinas Bajas)	A.2.1	CB
"	Dissected low hills (Colinas bajas disectadas)	A.2.2	CBd
"	Deeply dissected low hills (Colinas bajas fuertemente disectadas)	A.2.3	CBdd
"	Very dissected Slopes (Pendientes muy disectadas)	A.2.4	CBsvd

Physiographic Unit (Unidad Fisiográfica)	Local Landform (Forma Terrestre Local)	Old Symbol (Símbolo Viejo)	Symbol (Símbolo Nuevo)
Low Hills (Colinas Bajas)	Slightly dissected slopes (Pendientes ligeramente disectadas)	A.2.5	CBsd
"	Deeply dissected slopes (Pendientes fuertemente disectadas)	A.2.6	CBdd
"	Plateau (Mesetas)	A.2.7	CBp
"	Sloping plateau (Mesetas con pendientes ligeramente inclinadas)	A.2.8	CBpi
"	Slightly sloping slopes (Pendientes ligeramente inclinadas)	A.2.9	CBs
"	Alluvial terraces (Terrazas Aluviales entre colinas)	A.2.10	CBt
"	Valleys with Colluvio-alluvial Sediments (Valles con sidimentos coluvio-aluviales)	A.2.11	CBv
"	Severely eroded low hills (Colinas Bajas fuertemente erosionadas)	A.2.12	CBse
Piedmont (Pie-de-Monte)	Piedmont (Pie-de-monte)	A.3.1	P
"	Alluvial Fan (Abanico Aluvial)	A.3.2.1	Paa
"	Sloping plateau (Mesetas con Pendientes ligeramente inclinados)	A.3.2.3	Ppi
"	Poorly-drained terraces (Terrazas mal drenadas)	B.1.1	Ptmd
"	Upland depressions (Bajios)	B.1.2	Ptb
High Terraces (Terrazas Altas)	Well-drained high terraces (Terrazas altas bien drenadas)	B.1.3.1	TA
	Moderately well-drained high terraces (Terrazas altas moderadamente bien drenadas)	B.1.3.2	TAm

Physiographic Unit (Unidad Fisiográfica)	Local Landform (Forma Terrestre Local)	Old Symbol (Símbolo Viejo)	Symbol (Símbolo Nuevo)
High Terraces (Terrazas Altas)	Poorly-drained high terraces (Terrazas Altas mal drenadas)	B.1.3.3	TAp
"	Slightly sloping high terraces (Terrazas Altas ligeramente inclinadas)	B.1.3.4	TAt
"	Well-drained, subelevated high terraces (Terrazas altas subelevadas bien drenadas)	B.1.3.5	TAs
"	Moderately well-drained subelevated high terraces (Terrazas altas subelevadas moderadamente bien drenadas)	B.1.3.6	TAsi
"	Riverbank Complex (Complejo de orillares)	B.1.4	TAc
"	Floodable backwaters (Vegas de Inundación)	B.1.5	TAo
Middle Terraces (Terrazas Medias)	Moderately well-drained middle terraces (Terrazas medias moderadamente bien drenadas)	B.2.1.1	TMm
"	Poorly-drained middle terraces (Terrazas medias deficientemente drenadas)	B.2.1.2	TMp
"	Well-drained middle terraces (Terrazas medias bien drenadas)	B.2.1.3	TM
"	Floodable middle terraces (Terrazas medias con influencias de inundación)	B.2.1.4	TMi
"	Floodable backwaters (Vegas de inundación)	B.2.2	TMo
"	Poorly-drained depressions (Depresiones mal drenadas)	B.2.3	TM
"	Riverbank Complex (Complejo de orillares)	B.2.4	TMc
"	Natural levees (Diques naturales)	B.2.5	TMd

Physiographic Unit (Unidad Fisiográfica)	Local Landform (Forma Terrestre Local)	Old Symbol (Símbolo Viejo)	Symbol (Símbolo Nuevo
Middle Terraces (Terrazas Medias)	Basins (Bacines)	B.2.6	TMbs
"	Depressions (Bajios)	B.2.7	TMb
"	Abandoned meanders (Meandros Abandonados)	B.2.8	TMm
Low Terraces (Terrazas Bajas)	Abandoned meanders (Meandros abandonados)	B.3.1	TBm
"	Frequently flooded depressions (Bajios con Fuerte Influencia de Inundación)	B.3.2.1	TBb
"	Depressions with low vegetation (Bajios con vegetación baja)	B.3.2.2	TBbi
"	Depressions with low and sparse vegetation (Bajios con vegetación baja y rala)	B.3.2.3	TBbp
"	Swamps (Pantanos)	B.3.3	TBh
"	Floodlands (Vegas de Inundación)	B.3.4	TBo
"	Natural levees (Diques Naturales)	B.3.5	TBd
"	Basins (Bacines)	B.3.6	TBbs
"	Poorly-drained low terraces (Terrazas bajas mal drenadas)	B.3.7.1	TBp
"	Moderately well-drained low terraces (Terrazas bajas moderadamente bien drenadas)	B.3.7.2	TBm
"	Floodable low terraces (Terrazas bajas con influencia de inundaciones)	B.3.7.3	TBi
"	Riverbank Complex (Complejo de orillares)	B.3.8	TBc
"	Floodable backwaters (Vegas de Inundación)	B.3.9	TBo

ANNEX B
ANEXO B

SUMMARY - RESUMEN

LAND USE CAPABILITY CLASSIFICATION FOR CHAPARE REGIONS FOR TWO MANAGEMENT INTENSITIES:
T = Traditional and A = Advanced Artesanal

(Capacidad de Uso Mayor de la Tierra en la Region del Chapare referida a dos Intensidades de Manejo Tecnológico) T = Tradicional y A = Artesanal Avanzado

Símbolos	Unidad Fisiografica	Zonas de Vida e Intensidad														Observaciones
Symbols	Physiographic Unit	bp-M		bp-MB		bmh-MB		bp-ST		bmh-T		bmh-ST		bh-T		
		T	A	T	A	T	A	T	A	T	A	T	A	T	A	
	(Mountains) (Montañas)															
A.1.1 (MCA)	Colinas Altas	X	X	X	X	F2	F2	X	X	F2	F2	-	-	-	-	
A.1.2 (MCAd)	Colinas Altas Disectadas	X	X	X	X	X	X	X	X	F2	F2	-	-	-	-	
A.1.3.1 (MSd)	Pendientes Disectadas	-	-	X	X	-	-	F2	F2	-	-	-	-	-	-	
A.1.3.4 (MCAsd)	Colinas con Pendientes Cortas Disectadas	-	-	-	-	-	-	-	-	X	X	-	-	-	-	
A.1.3.5 (MCAv)	Valles con Sedimentos Coluvio-Aluviales entre colinas	-	-	-	-	-	-	F1	F1	F1	F1	-	-	-	-	
	(Hills) (Colinas Bajas)															
A.2.1 (CB)	Colinas Bajas															
A.2.2 (CBd)	Colinas Bajas Disectadas	-	-	-	-	-	-	-	-	F2	F2	-	-	-	-	
A.2.3 (CBdd)	Colinas Bajas Fmte. Disectadas	-	-	-	-	-	-	X	X	-	-	-	-	-	-	
A.2.5 (CBsd)	Pendientes Ligeramente Disectadas	-	-	-	-	-	-	F2	F2	F2	F2	-	-	-	-	
A.2.9 (CBs)	Pendientes Ligeramente Inclinadas	-	-	-	-	-	-	F1	F1	F1	F1	-	-	-	-	
A.2.10 (CBt)	Terrazas Aluviales entre Colinas	-	-	-	-	-	-	F1	F1	F1	F1	-	-	-	-	

Símbolos	Unidad Fisiografica	Zonas de Vida e Intensidad														Observaciones
Symbols	Physipgraphic Unit	bp-M		bp-MB		bmh-MB		bp-ST		bmh-T		bmh-ST		bh-T		
		T	A	T	A	T	A	T	A	T	A	T	A	T	A	
A.2.11 (CBv)	Valles con Sedimentos Coluvio-Aluviales entre Colinas	-	-	-	-	-	-	C	C	A	A	-	-	-	-	
A.2.12 (CBse)	Colinas Bajas Fuertemente Erosionadas	-	-	-	-	-	-	-	-	X	X	X	X	-	-	
	(Piedmont) (Pie de Monte)															
A.3.1 (P)	Pie de Monte	-	-	-	-	-	-	P	P	P	P	P	P	-	-	
A.3.2.1 (Paa)	Abanico Aluvial	-	-	-	-	-	-	C	_	C	P	-	-	-	-	
A.3.2.3 (Ppi)	Mesetas con Pendientes Ligeramente Inclinadas	-	-	-	-	-	-	-	-	Fl	Fl	C	P	-	-	
B.1.1 (Ptmd)	Terrazas mal Drenadas	-	-	-	-	-	-	-	-	Fl	P	Fl	P*	-	-	Pastos solamente o Arroz inundado
	(High Terraces) (Terrazas Altas)															
B.1.3.1 (TA)	Terrazas Altas Bien Drenadas	-	-	-	-	-	-	-	-	C	P	P	P	-	-	
B.1.3.2 (TAm)	Terrazas Altas Moderadamente Bien Drenadas	-	-	-	-	-	-	-	-	Fl	Fl	Fl	C	-	-	
B.1.3.4 (TAt)	Terrazas Altas con Pendientes Ligeramente Inclinadas	-	-	-	-	-	-	-	-	Fl	C	C	P	-	-	
B.1.3.5 (TAs)	Terrazas Altas subelevadas Bien Drenadas	-	-	-	-	-	-	-	-	P	P	P	A	-	-	
B.1.3.6 (TAsi)	Terrazas Altas subelevadas Moderadamente Bien Drenadas	-	-	-	-	-	-	-	-	-	-	P	A	-	-	

Símbolos Symbols	Unidad Fisiográfica Physiographic Unit	Zonas de Vida e Intensidad														Observaciones
		bp-M		bp-MB		bmh-MB		bp-ST		bmh-T		bmh-ST		bh-T		
		T	A	T	A	T	A	T	A	T	A	T	A	T	A	
B.1.4 (TAc)	Complejo de Orillares	-	-	-	-	-	-	-	-	F2	F2	F2	F2	-	-	
B.1.5 (TAo)	Vegas de inundación	-	-	-	-	-	-	-	-	F1	F1	F1	P	-	-	
	(Middle Terraces) (Terrazas Medias)															
B.2.1.1 (TMm)	Terrazas medias Moderadamente Bien Drenadas	-	-	-	-	-	-	-	-	F1	C	P	P	A	A	
B.2.1.2 (TMp)	Terrazas Medias Deficientemente Drenadas	-	-	-	-	-	-	-	-	-	-	F1	F1	F1	F1	
B.2.1.3 (TM)	Terrazas Medias Bien Drenadas	-	-	-	-	-	-	-	-	F1	C	C	P	P	A	
B.2.1.4 (TMi)	Terrazas Medias con influencia de inundación	-	-	-	-	-	-	-	-	-	-	-	-	F1	F1	
B.2.2 (TMo)	Vegas de inundación	-	-							X	X	X	A*	X	A*	A* Arroz inundado o búfalo de agua
B.2.4 (TMc)	Complejo de Orillares	-	-	-	-	-	-	-	-	F2	F2	F2	F2	F2	F2	
B.2.6 (TMbs)	Bacines	-	-	-	-	-	-	-	-	-	-	X	X	-	-	
B.2.7 (TMb)	Bajios	-	-	-	-	-	-	-	-	-	-	F1	A*	F1	A*	A* Arroz inundado, Búfalo de Agua (F1) Virola Campnospe:
B.2.8 (TMm)	Meandros Abandonados	-	-	-	-	-	-	-	-	-	-	F1	A*	F1	A*	A* Arroz Inundado, Búfalo de Agua (F1) Virola Campnosperma
B.3.1 (TBm)	Meandros Abandonados	-	-	-	-	-	-	-	-	-	-	X	F1*	-	-	F1* Plantaciones de Virola Campnosperma

Símbolos	Unidad Fisiográfica	Zonas de Vida o Intensidad														Observaciones
Symbols	Physiographic Unit	bp-M		bp-MB		bmh-MB		bp-ST		bmh-T		bmh-ST		bh-T		
		T	A	T	A	T	A	T	A	T	A	T	A	T	A	
	(Low Terraces) (Terrazas Bajas)															
B.3.2.2 (TBbi)	Bajios con Vegetación Baja	-	-	-	-	-	-	-	-	-	-	X	X	-	-	
B.3.2.3 (TBbp)	Bajios con Vegetación Baja y Rala	-	-	-	-	-	-	-	-	-	-	-	-	F2	F2	
B.3.6 (TBbs)	Bacines	-	-	-	-	-	-	-	-	-	-	X	F1*	X	F1*	F1* Plantaciones de Virola, Campnosperma
B.3.7.1 (TBp)	Terrazas Bajas Mal Drenadas	-	-	-	-	-	-	-	-	-	-	F1	A*	F1	A*	A* Arroz inundado - Búfalo de Agua
B.3.7.2 (TBm)	Terrazas Bajas Moderadamente Bien Drenadas	-	-	-	-	-	-	-	-	-	-	C	P	-	-	
B.3.7.3 (TBi)	Terrazas Bajas con influencia de inundaciones	-	-	-	-	-	-	-	-	-	-	P	A*	P	A*	A* Arroz inundado
B.3.8 (TBc)	Complejo de Orillares	-	-	-	-	-	-	-	-	-	-	F2	F2	-	-	
B.3.9 (TBo)	Vegas con influencia de Inundaciones	-	-	-	-	-	-	-	-	-	-	F1	F1*	-	-	F1* Plantaciones de Virola, Campnosperma