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PROPOSAL FOR A DETAILED LAND USE CAPABILITY SURVEY OF SELECTED SUBREGIONS OF THE EASTERN ANDEAN SLOPES AND PIEDMONT OF BOLIVIA

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OUTLINE FOR A PROPOSAL AND CONSULTANT'S REPORT

ON

A DETAILED LAND USE CAPABILITY SURVEY OF SELECTED SUBREGIONS OF THE EASTERN ANDEAN SLOPES AND PIEDMONT OF BOLIVIA

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A PROPOSAL FOR A DETAILED LAND USE CAPABILITY SURVEY OF SELECTED SUBREGIONS OF THE EASTERN ANDEAN SLOPES AND PIEDMONT REGION OF BOLIVIA

by

Joseph a. Tosi Jr., Ph.D.

I
INTRODUCTION

This report covers the need, feasibility, recommended procedures, and staffing for an AID-sponsored project of detailed land-use capability survey in selected sub-regions of the Eastern Andean Slopes and Piedmont regions of Bolivia. It is based upon a short period of work from January 16 through 28, 1984, in La Paz, Cochabamba, and Santa Cruz. During this period, the consultant reviewed the existing data base and identified and interviewed key government and other institutional persons sympathetic to the aims of, or capable of supporting, ecologically-based land capability studies deemed prerequisite to land-use and development planning for these regions.

A draft report and plan was submitted to USAID/Bolivia on January 28 and, following its review by AID/Bolivia and Joint Environmental Service (JES), this final report was prepared for submission through the International Institute for Environment and Development (IIED) to the AID mission in Bolivia. Terms of reference for this work are appended.

Purpose of Land Use Capability Surveys

The Earth's lands vary in complex ways in all those physical and ecological characteristics which are the primordial determinants of their comparative suitability for specific agrarian-economic uses. Failure to recognize and quantify the full gamut of environmental variables prior to planning and promotion of development in either settled or pre-settlement areas invariably leads to inefficient or even deleterious long-term utilization of the land resource base as well as waste of the resources invested in the development project. Concommitantly, human economic misery and social discord may also

ensue. The purpose of land use capability surveys, then, is to provide an objective basis of knowledge concerning the lands to be developed, especially as regards climate, topography, drainage, soils, and the natural biota as organized into landscape components having specific land use and production potentials under given systems of production technology. The survey presents this information in the form of maps at a scale suitable for detailed planning for maximum sustainable productivity in agriculture, animal husbandry, forestry, and watershed protection.

Surveys Undertaken in Bolivia

Land use capability surveys have been undertaken in only very limited parts of the Bolivian national territory. Until recently, these surveys were integral parts of reconnaissance-level soils surveys carried out by the Soils Department of the Ministry of Agrarian Affairs and Agriculture. They employed a local modification of the U.S.D.A Soil Conservation Service classification system, known as the "8-Class System" (Klingebiel and Montgomery, 1961). This system has come under attack in recent years as unsuited to tropical environments. With the advent of satellite remote sensing imagery, small scale mapping of soils and actual land use has been attempted using interpretation techniques supported by limited ground truth.

In 1983, as part of the Environmental Assessment and area evaluation for the Chapare Region Development Project, land use capability was mapped provisionally on about 400,000 ha. at a medium scale using the classification system devised for Colombia by Tosi (1972). This system is based upon the World Life Zone System of Ecological Classification devised by L.R. Holdridge (1967,1971) and employs a full range of environmental parameters which must be determined objectively for each landscape unit separately prior to determination of its major land use capability class. Three Bolivian technicians were trained in use of this system in this first exercise and USAID/Bolivia subsequently supported an intensive, short training program largely specialized to it for another 25 national technicians in October-November 1983. The system is now well accepted amongst Bolivian professionals and there is considerable interest in having it applied to large areas of the country.

Regional Development Planning in the Eastern Andean Slopes and Piedmont

During the latter half of 1983, one of the technicians trained during the Chapare project was contracted by USAID/Bolivia to make a comprehensive review of the natural resources of the "Development Corridor", so-called (see Map No. 1). As part of this review, he undertook to prepare an exploratory-scale map (1:200,000 scale) of land capability in this corridor, employing an empirical system based in the Tosi classification and environmental data from diverse sources accumulated during the natural resources overview (Quiroga, 1984). The purpose of this review was to provide information needed for an integral assessment of the potential for rural development in this large region.

North of the 17th parallel, the Bolivian territory east of the Altiplano is Tropical or Subtropical and moist to wet, climatically (Unsueta, 1975); south of that line, it is Warm Temperate and dry. Current interest in development programming centers upon the northern segment of the corridor which includes the "Yungas" or eastern, humid, Andean slopes and valleys and wet piedmont-plain areas where tropical and subtropical, frost-sensitive plant species can be grown for export to the colder highlands, especially La Paz and Cochabamba areas. These regions include some long-settled mid-elevation, moist, valley areas, mostly close to the Altiplano, and large areas of sparsely-settled, generally lower country, much of it still in virgin forest. Penetration roads are being constructed into the sparsely-settled regions as a response to population growth in crowded highlands and increasing national needs for food and fiber. Oil exportation in the Piedmont of La Paz and Santa Cruz Departments, now underway on the piedmont plains adjacent to the mountain front, appears to be promising, and road construction for test drilling will shortly encourage both timber extraction and spontaneous colonization in much of this region. In the Piedmont of Cochabamba Department, a good and expanding highway infrastructure, much of it constructed with assistance of the United States Government, has already led to massive colonization from nearby over-crowded highlands. An agricultural pattern strongly biased to the cultivation of coca, one of the few crops ecologically adapted to high productivity in the excessively wet foothills, has evolved in this region, for which no sound planning based upon land capability classification was underta-

ken prior to settlement. A repetition of this costly and unwise investment in development can be foreseen for the larger, remaining region unless the land capability evaluation now proposed by USAID/Bolivia is implemented and its findings used as the basis for long-term regional development planning and program execution.

Feasibility of Conducting Detailed Land Use Capability Survey

The present review indicates that a detailed land use capability survey of the entire region is neither feasible nor desirable, mostly in consideration of cost and time factors. Much of the region is of relatively difficult access, with climate, topography, and relief being prohibitive over perhaps 50 to 70 percent of the area (Map No. 1). The exploratory land capability map of the Development Corridor being prepared for AID by J.C. Quiroga will suggest the approximate location of specific subregions some of which included lands of preponderantly agricultural potential, others of only forestry or protection potential. If these subregions are delineated precisely, those of agricultural potential can be targeted for detailed land capability survey and mapping while those having only forestry or protection potential can be reserved to these uses alone in the regional development plan, with special surveys oriented to these latter uses being carried out by the agencies of government entrusted with their development and permanent management, or protection.

In the original delineation of the Development Corridor, little attention was given to the Piedmont Plain sector. Extensive parts of it having possible potential for agricultural settlement and infrastructural development planned or underway were excluded, principally in the Department of La Paz. Conversely, the Corridor survey included the highest mountain peaks and ridges of the Andean front adjacent to the Altiplano, which has no productive potential at all. A revised set of limits for the area to be surveyed is therefore proposed here, as shown by the stipled area on the appended map (Map No. 1). These limits largely eliminate further consideration of the high mountains while simultaneously extending the area to be studied northwards onto the piedmont plains of La Paz Department. Before the procedures recommended herein for the selection of subregions to be surveyed can be set in motion, it will be necessary for the Quiroga exploratory map of land capability to be extended into those areas not included originally in his study.

Otherwise, the stage is largely set -- or will be with the completion and delivery of the Quiroga land capability map -- for the detailed land use capability survey and mapping of selected subregions in the Eastern Andean slopes and piedmont regions in the three departments of La Paz, Cochabamba, and Santa Cruz. Two major steps must be taken. First, the expert selection and definition of the subregions themselves based upon the Quiroga map and the concommitant characterization of these subregions in terms of present land utilization and vegetational cover and, second, the actual field mapping of selected individual subregions by trained field crews, on a priority basis following step one. The overall study recommended in Chapter III of this report is based upon the foregoing considerations, is feasible at reasonable cost, and is highly worthwhile as a basis for rationalized development and settlement planning for the region as a whole.

Brief Geographical Description of the Region

The region under consideration, as defined on the LANDSAT mozaic photograph of Bolivia (Map No. 1) comprises two adjacent and geographically-related sectors. That closest to the highlands is known in Bolivia as the "Yungas" or Eastern Andean Slopes and Valleys. It is a physiographically and climatically complex region of pronounced local relief, with alternating mountain spurs and deeply incised valleys, generally long, continuous slopes, a structurally-controlled and complex river drainage pattern, and great local variations in air temperatures, rainfall, moisture availability, and soils qualities. Given these conditions, a complex pattern of local, small landscape units having individually distinctive environments and, hence, land use capabilities and economic potentials, is developed in this region. In the absence of detailed, definitive land capability studies and maps, this very complexity is an obstacle to efficient and environmentally harmonious land use. Undertaken before development initiatives are made, such studies constitute the essential guidelines for planning. Production units are necessarily small and farms heterogeneous.

Beyond the "yungas" or eastern slopes region lies the geomorphological "piedmont" of low foothills and high plains at the base of the Andes. This is a very different environment from the preceding. It has low relief, flat to rolling terrain, long gentle slopes inclined to the east, an alternation of alluvial fans, braided river channels and shifting river beds, and low-lying floodplains. Soils vary in quality but tend to be poor, drainage is locally impeded and rainfall is excessive locally, while temperatures are generally

moderate-to-high. Landscape units in this physiographic province tend to be relatively large such that the terrain lends itself to larger-scale, including commercial, agricultural or forestry production units. Bioclimatic conditions being locally so variable, this becomes a major factor in determination of land capability and of the specific crops and cropping practices suited to each specific environment. Failure to take climate into account was one of the principal failings of the Chapare development incentive of the last two decades, and may have been instrumental in the adoption of coca as a major crop there (Tosi, 1983).

Acknowledgements

In the following section (II), the data base for the studies recommended in III is summarized. I am indebted to many people in Bolivia who made my search for and perusal of these materials possible in the very short time of my visit. Chief among them were J.C. Quiroga, currently completing the natural resources survey of the "Development Corridor" and Rene Ballon of CIASER (ERTS-GEOBOL). I am also indebted to Robert V. Thurston, Head of the Rural Development Division of USAID/Bolivia for directing me to sources and persons of essential significance to the undertaking. For their time, interest, and cooperation I wish to thank all those persons whose names are listed as interviewed in the Appendix. Finally, I have a great debt of gratitude to the secretaries of the Rural Development Division of USAID, in La Paz, especially María Esperanza Espinosa, who typed the draft for the recommended study under great pressure on the last day of my consultancy.

II

DATA BASE: REQUIREMENTS AND AVAILABILITY

Base Maps: Scales and Accuracy

One of the principal limitations for detailed land survey in the less-developed parts of Bolivia is the unavailability of accurate, planometric-topographic maps at medium-to-large scale. The greater part of the Eastern Andean Slope and Piedmont region in La Paz Department and the westernmostpart of Cochabamba Department, lacks coverage (sheets) of the projected National Map at both 1:250,000 and 1:50,000 scale (IGM, 1983). Map No. 1 indicates the area lacking such coverage. These sheets would normally be considered indispensa-

ble as a base for final presentation of survey data and very useful, if not essential, for both field orientation of the survey and topographical analyses. However, aerial photographs and satellite imagery can be substituted effectively for all these purposes. Final printing of the map product can be made on aerial photomozaic offset-prints.

In the absence of published topographic sheets of the National Map being prepared by the IGM, a set of medium-scale planimetric maps (1:250,000 scale) have been drawn up for the Development Corridor by J.C. Quiroga and the staff of the Centro de Investigaciones de Sensores Remotas (CIASER), formerly the ERTS-GEOBOL program of the Servicio Geológico de Bolivia. These maps are, for their scale, accurate and contain good hydrographic and infrastructural detail. J.C. Quiroga has subsequently used them as a base for his development of thematic maps: geomorphology, hydrography, soils, actual land use, and land use capability, at this general scale. These maps, combined with recent satellite imagery, will provide the essential basis for sub-regional delineations and survey project planning and field orientation.

Climatic Ecology: Life Zone Maps, Climatic Maps

In 1975, the Ministerio de Asuntos Campesinos y Agropecuarios (MACA), published the Mapa Ecológico de Bolivia and an accompanying monograph covering the life zones of Bolivia, their geographic distribution, climatic ecology, vegetation and soils, and present and recommended land utilization. The map is presented at 1:1,000,000 scale which is really too small to provide the accuracy and detail required for a land capability survey based on the Tosi classification and methodology (1972). However, this map provides a good general orientation base from which more detailed, larger-scale ecological maps can be elaborated by trained field observers. The national map is currently being used as one data base for the exploratory survey of land capability being conducted by J.C. Quiroga. Detailed life zone mapping will be a necessary adjunct to application of the Tosi classification system to detailed mapping of the two regions in question.

Landforms-Geomorphology

Geology and such related fields as geomorphology are well-developed sciences in minerally-rich Bolivia. The Development Corridor area, like

many other areas being explored for minerals, has been surveyed generally by the Servicio Geológico de Bolivia (GEOBOL). In recent years, these surveys have been augmented by the use of remote sensor imagery (ERTS, LANDSAT) and there is a well-developed capability in CIASER to project this type of survey. Geomorphology in particular has benefited from the application of remote sensor pictures, as can be appreciated from the national mozaic image (Map No. 1, this report).

As part of the assessment of natural resources in the Development Corridor, J.C. Quiroga, working with CIASER, has prepared a map at 1:250,000 scale of the landforms in this entire region. This data is one of the bases for his exploratory classification of land capability. However, much more detail than is available from these images will be necessary for the detailed mapping of land capability proposed here. This detail may be developed by direct field observation upon large-scale aerial photography as a base. The general data presently available will serve as a guide to selection of the subregions and to orientation of field work in detailed mapping.

Geology and Soils

Soils information is lacking for large parts of the two regions. Some exploratory and reconnaissance level mapping has been undertaken in limited areas of interest to the government for pioneer settlement, and in a few of the older, long-settled mid-elevation valleys of the Eastern Andean Slopes region but both the accuracy of these maps and the quality of the soils data which supports them may be suspect.

Fortunately, the surface geology of the region is reasonably well-known and, if combined with existing life zone (bioclimatic) data, can be used to make useful and oftentimes quite accurate inferences as to the attributes of the soils in each landform position. This approach has been taken by Quiroga in his derivation of major land use capability for the development corridor.

Soils data are essential to the detailed mapping of land capability. The methodology proposed (Tosi, 1972), however, calls for the determination of edaphic factors directly in the field, in each landscape unit defined on the map, thus obviating the need for prior soil survey. Given the fact that existing soils surveys are almost universally at a reconnaissance level or scale, their data even when available are of little practical use to detailed land use capability survey employing this methodology.

Vegetation and Present Vegetation Cover: Actual Land Use

Actual vegetational cover and land use had not been studied in Bolivia until the advent of satellite imagery, about fifteen years ago. The quality of high-resolution, multi-band spectral (filter) imagery made available by the most recent LANDSAT series has been particularly useful for landscape interpretations at a general level of observation and has been used by CIASER and J.C. Quiroga to develop, respectively, maps of vegetational cover and land use (GEOBOL, 1978) and a thematic map of the vegetational cover of the Development Corridor (Quiroga, 1984).

These two maps will be useful in step one of the recommended study, when a specialist would assist the project in establishing the geographical limits of sub-regions, in characterizing these sub-regions from the point of view of actual and potential economic development, and in establishing priorities for detailed survey amongst the sub-regions defined.

Aerial Photographs, Radar Images, and LANDSAT Imagery

A review of remote sensor imagery available for the two regions revealed that some sort of coverage existed for practically every part of the total area. This coverage, however, varies greatly in type (aerial photographs, side-looking radar images, satellite photographs), scale, resolution, and age.

Responsibility for acquiring, processing, and utilization of this imagery is shared by the Instituto Geográfico Militar and the Servicio Nacional de Aerofotometría. CIASER is also deeply involved in acquiring and utilizing imagery, but principally that obtained through a bi-lateral program with the United States (NASA). Satellite photographs are available for the entire area of the two regions and are of high quality and acceptable resolution but cannot be enlarged beyond a scale of 1:250,000. Further enlargement leads to a loss of resolution. This imagery is combined with a well-developed capacity to process, print, and interpret these pictures, including computer processing and interpretation techniques. CIASER might be considered for participation in the project, particularly in Step One.

For Step 2, the actual field mapping of selected sub-regions, recent, large-scale (1:40,000 or larger), good quality photographic prints are essential. Such photography is said to be lacking for a large area of La Paz De-

partment and western Cochabamba Department in the proposed regions of study (See Map No. 1, this report), according to the IGM (1983), but the SNA claims that photographs are available for much of this area. The matter could not be settled satisfactorily due to the secretiveness of the military establishment during my short visit. A follow-up inquiry is recommended.

Because no significantly large area of radar coverage exists for these regions, it is probable that new aerial photography will have to be flown for at least some areas. This step should be deferred until Step 1 is completed, that is to say, until subregional limits have been defined and priorities set for their survey. New aerial photography would then be limited to selected subregions for which no good-quality, recent photographic imagery exists. The determination of new aerial photographic needs might be an additional task to be performed in Step One.

III. RECOMMENDED STUDY

A. Study Design and Location

1. Objectives

(a) To prepare a set of detailed photomaps and reports identifying and describing the major use-capabilities of lands within the Sub-Andean and the Piedmont physiographic provinces in the Bolivian Departments of La Paz, Cochabamba, and Santa Cruz. Lands studied in detail would correspond to those in sub-regions identified, at an exploratory level of study, as having a major part of their total land area in land units of real agricultural potential, whether presently settled or not, and presently settled areas generally unsuitable for agriculture.

The principal product of the work would be a set of maps presented as over-prints upon aerial photographic mozaics at a scale of approximately 1:50,000 fir areas having a moderate-to-high potential for agricultural settlement and development given appropriate infrastructure and development-support, and at 1:100,000 or smaller scale for areas having predominantly forest production or site protection land use capabilities, except for those already converted to agricultural land use (1:50,000).

A companion product of the survey would be a set of written reports or monographs covering the sub-regions mapped in detail, describing the specific physical and ecological attributes of the land-units defined on the photomaps, their present vegetation cover, crop production potentials, recommended farming, including agro-forestry, systems, and the land-tenure and administrative arrangements these would favor. For settled areas, present land use and its apparent consequences for environment and human living quality would be assessed and recommendations made for necessary changes or improvements, as a basis for agricultural extension, research, or resettlement programs.

For each sub-region having a predominantly forest production or site protection capability only, second-generation studies might be undertaken by a team or teams of forestry and watershed management (hydrology) technicians, with appropriate maps and reports covering native forest composition, volumes, economic potential, watershed protection qualities, as well as potable water, irrigation, and hydroelectric potential. Only in these cases of such sub-regions being

currently under spontaneous or planned colonization pressure would detailed studies of land use capability be undertaken in them (as a third priority) in the anticipated first-generation project.

(b) To train national technicians in the underlying ecological, geographical, and technological principles of the land use capability classification to be applied; field methods for detailed land capability survey, and objective methods of field observation and reporting.

(c) To establish cadres of trained technicians for future projections of this activity in other parts of the national territory of Bolivia.

(d) To provide departmental development planners and resource management staffs with the necessary guidelines for an intelligent and efficient realization of their tasks in these regions of the country.

(e) To provide USAID/Bolivia with the land use capability information essential to coordination with appropriate national institutions and to complete the overall Corridor Assessment analyses (and Syntheses) for development-support programming.

2. Operational Plan

In approximate order of execution, the following steps are suggested:

1/ Extend the exploratory (reconnaissance) level land-use capability map for the Development Corridor Assessment being prepared by J.C. Quiroga (1984) to cover those sections of the Piedmont and adjacent High Plain physiographic provinces not presently included therein, as shown (Map. No. 1). This step is prerequisite to all others and should be undertaken well in advance of general project organization.

2/ With the short-term assistance of an USAID-appointed technical advisor, analyze the Quiroga map at 1:250,000 and define homogeneous subregions having at least 50 percent of the local landscape in lands classified as suitable for any or all of the three agricultural land uses as classified thereon, and out-

line the boundaries of these subregions. Similarly, identify subregions having predominantly forestry as highest use-capability, distinguishing the boundaries of the latter with subregions of predominantly protective capability alone.

3/ Determine the availability of good-quality aerial photographs at 1:50,000 scale or larger for all subregions of agricultural potential. Photographs should be no older than ten years. Arrange to have all areas not covered by recent good images at these scales photographed by the Servicio Nacional de Aerofotometria. The on-set of the dry season in May-July will be the best time, weather-wise, for obtaining this imagery.

4/ Employing most-recent Landsat imagery, aerial photographs very recently taken, and other data sources as available, project actual land use and land tenancy information onto each subregion map at 1:250,000, thereby distinguishing between occupied and unoccupied (i.e., virgin or abandoned) areas and, wherever occupied, intensity-of-farming and farm-density parameters.

5/ Select subregions in order of priority for field survey in each of the three departments. Priority would be given, first, to already-settled subregions having moderate-to-high agricultural potential overall; second, to subregions having low-to-very low present population densities but moderate-to-high agricultural potential, overall, and third, to subregions demonstrating apparent significant human settlement or exploitative activity in agricultural pursuits but for which agricultural potential is low to non-existent, overall. All subregions for which forestry production or protection capabilities alone predominated and in which no significant human population could presently be discerned would not be surveyed in at least the early stages of the project.

6/ Organize and conduct a four-to-six week training program for potential survey team members with technical assistance support contracted by USAID/Bolivia. One representative subregion having agricultural potential and reasonable accessibility would be selected in one of the three departments and used as a common traning area for team aspirants from all three departments participating in the survey. The total number of participants would depend upon financial resources and leadership personnel available but at least one four-man team will be desirable for each department's share of the total area to be covered under the project (see Personnel).

An essential step in each subregion surveyed will be to refine and detail the life zone (bioclimatic) map therein. Training will include recognition of life zones and their boundaries directly in the field from vegetational

indicators, and methods of cartographic representation. Each subregion will be mapped in detail for life zone concurrently with other mapping activities.

7/ Organize field teams from amongst qualifying participants in the training exercise.

8/ Following training, personnel selection, and team organization, each departmental team or teams will proceed inmediately to execute a regular program of life zone and land use capability mapping directly in the field employing the classification and methodology proposed (Tosi, 1981), necessarily upon aerial photographs covering the subregion under study. Although some pre-mapping from existing data and aerial photographic interpretation is contemplated, pre-mapping will be provisional and subject to verification in the field in all cases. Appropriate field tests will be made in each land unit defined upon the photographic base and data will be recorded for all parameters prescribed during the on-site inspection. (This methodology will have been the principal subject of the initial training provided by the TA specialist's (6/) and was the subject of an intensive three weeks short course for professional personnel of Bolivian institutions held in Tarija in November 1983 under USAID auspices. National technicians already trained in this methodology should be given priority for employment as team leaders if the proposed survey is undertaken.

9/ Periodically throughout the project execution, a TA advisor in land capability classification provided by USAID should review survey operations, procedures, progress, and problems. A land use ecologist might also be engaged for a short period, say one month, near the outset of the first six months of field operations. This advisor would set up criteria for observing and recording subsidiary and supportive information for the reports: as for instance ecological attributes of the subregions from the viewpoint of crop production, animal husbandry, agro-forestry, and soil conservation (see: III-A-1-a, paragraph 3). This advisor might also participate in the training program.

10/ Prepare aerial photographic mozaics for each subregion. Transfer field-mapped land unit boundaries onto photomozaics in central office and arrange for offset printing of these photomaps.

11/ Prior to proceeding on to another subregion, each team would spend an appropriate period of time revising field notes and preparing the written re-

port or monograph on the subregion just teminated. This material would be reviewed by the Project Coordinator and, possibly, by a TA Advisor from USAID, and then printed in sufficient copies for both departmental planning needs, AID's RD Division, and other potential users of the material, as for instance, IBTA and the extension services, INC, the CDF, and others.

B. Institutional Format

Amongst several possible alternatives (MACA, CIASER, Ministerio de Planificación, etc.), it seems that the best possible option for a national institutional base of operations is the "Departmental Development Corporation". The corporation, one for each department of the country, is organized to deal directly with the environment and is an administrative center where integration of departmental and national services and programs take place. According to Freeman et al (1980)..."the DDC's are well situated to reveal--and thus avoid--unwanted environmental impacts caused by the action of one sector of the economy on another...several DDC's have now turned to rural development questions... Thus, they could become institutional focal points for remedial or preventive actions aimed at natural resources use...However, because DDC's aim to foster economic activity, a basic addition to their philosophy or doctrine would be needed." The project proposed here would, it seems, provide just such a philosophy inasmuch as it proposes to both seek and justify an effective utilization of the natural resource base in underdeveloped and undeveloped rural areas. As mentioned by Freeman et al (op. cit.),..."a land-use capability classification is fundamental...In the absence of such information, resource development and utilization is chaotic, poorly-organized, competitive, and extremely wasteful of the resource base." It might be added that without it, also, planning for sustainable development is a virtual impossibility.

Interviews with the head and several technicians of the three departmental development corporations having jurisdiction in the area of survey (CORDEPAZ, CORDECO, CORDECRUZ), revealed a sincere interest in participating in the project and enthusiasm for both its procedures and objectives. They are willing to provide technical personnel and guidance, administration for personnel and logistics, and to incorporate the findings of the survey into their ongoing programs and planning for development and natural resources survey.

It is recommended, therefore, that each corporation be made responsible for survey activities in its departmental area. Direct costs could be covered under AID-sponsored national programs (e.g., P.L. 480 funds).

C. Personnel and Training Requirements

1. Coordination

It is suggested that coordination of this project be vested directly in USAID/Bolivia, which agency would contract the long term services of a qualified specialist in natural resources surveys and land capability survey, as Technical Coordinator with full responsibility for overall planning and execution of the program, under the supervision and guidance of the head of the Rural Development Division of USAID/Bolivia.

2. Team Leaders

An undetermined number of field teams are proposed to be organized for this survey. (The precise number cannot be suggested until such time as Steps 1 through 5 of the Operational Plan have been completed and especially Steps 1 through 3 which will permit an estimate of the total number and area of the subregions to be surveyed.) A further factor affecting team numbers will be available financing versus the time framework: obviously, more money and more teams will equal shorter total time involvement.

It is proposed that each team--at least one in each development corporation--be composed of at least four members plus a driver and possibly other support personnel in less accessible areas. The team leader would be an experienced field technician, preferably an Ingeniero Agronomo specialized in soils survey, Ing. Forestal or Ingeniero Civil specialized in photo interpretation or natural resources survey. The team leader would have full authority over the team, in coordination with the Technical Coordinator, prepare monthly work schedules, supervise pre-mapping, participate directly in the field training and subsequent mapping, and prepare the final report for each subregion surveyed.

Insofar as possible, team leaders would be contracted from amongst those national technicians already trained in the proposed methodology of land capability classification under USAID auspices, in 1983.

3. Field Technicians

The methodology proposed permits the employment of subprofessional level personnel for the routine labor of life zone and land capability mapping.

The field technician, so-called, should be a vigorous outdoor type with no prejudice towards arduous daily labour traipsing around the countryside and oftentimes overnighting in less-than-comodious situations. He should also be a secondary school graduate, intelligent, cooperative and friendly, and enthusiastic about the work.

Given four-to-six weeks of direct training in the field by the Technical Coordinator and the Team Leader, assisted by the Technician Advisor in Land Capability Classification (USAID), a field technician will be competent to go off on his own each day and undertake classification work in the area assigned to him by the team leader. (Once every four or five days, he would be accompanied by the team leader).

4. Auxiliary Personnel

(a) Field: the characteristics of each subregion will essentially dictate the number and sorts of auxiliary personnel that will be required. It is proposed that each team have one four-wheel drive vehicle assigned, with driver, for subregions accessible by road. In other areas, water transport may be required and a boatman or men as well as cook and extra laborers assigned. Some of this personnel may be hired locally within the region. For regular field work, guides and macheteros may be necessary, depending on the area.

(b) Office: in each development corporation, a small office and drafting area will be desirable, and a cartographic draftsman and secretary may be employed to transfer field data to aerial photographic mozaics and to copy field notes and reports.

D. Technical Assistance Requirements

The methodology proposed for this survey has no recognized equivalents; it is essentially an objective, ecological system (Tosi, 1981) with roots in the Life Zone System of World Ecological Classification (Holdridge, 1967). It is, furthermore, the only system known that allows direct classification of land capability without prior recourse to detailed mapping of soils. In order to obtain technical assistance, it will be necessary to employ practitioners of this methodology from, or known to, its originators (Tropical Science Center, San José, Costa Rica).

The key personnel seen as necessary are (1) a life zone ecologist-geographer, (2) a land-use capability mapping specialist, and (3) a land-use ecologist-agronomist.

(1) The role of the life zone ecologist-geographer would be to assist the Technical Coordinator in defining the territorial limits of the subregions to be delineated on the Corridor Assessment Land Use Capability Map at 1:250,000, to make preliminary appraisals of demographic and human settlement (including land tenancy) situation in each subregion, to establish priorities for study amongst the subregions in each department, and to assist in the training of the field teams with special emphasis on life zone ecology (recognition of life zones from vegetational indicators, establishment of life zone limits in the field, recognition of natural associations for the pre-mapping of land units upon the aerial photographs, etc.)

(2) The land use capability mapping specialist would be responsible for assistance to the Technical Coordinator, team leaders, and field technicians in all matters relating to the direct application of the proposed mapping methodology in the office and field. He would participate, first, in the training period proposed for all field teams at the outset of the project and would return for short periods during the life of the project to review work and assist in solving problems arising from the application of the methodology in the course of the field work.

(3) The land use ecologist-agronomist would provide both training and expert advice on the subjects relating to gathering of ancillary field observations and applications of the survey data to planned development in each subregion studied. Present and potential crop, livestock, and woodlot management systems would be examined with this assistance, as well as problems of soil conservation and watershed management, new crops and cropping systems would be proposed, and best development options at the site-specific level suggested for undeveloped agricultural subregions. The land use ecologist-agronomist would assist, initially, either in the training course or immediately thereafter when the field teams dispersed to their home departments to start work on specific subregions, preferably the first. He might return, funding permitting, near the close of the first months of regular fieldwork to assist team leaders and the Technical Coordinator in the interpretation of survey data and in developing a report format which included a practical synthesis and projection of the data for development planning purposes.

No other technical assistance is proposed for the first-generation series of subregion surveys. Technical assistance in forest management and in wildlands management for protective purposes should be contemplated, however, for a second-generation set of studies of the non-agricultural subregions.

E. New Aerial Photographic Imagery

All mapping of land capability and life zone classes under this methodology requires aerial photographs as a base. Preferably, maps of areas surveyed should be printed on aerial photographic mozaics in order that users may have a visual appreciation of both location and of the landscapes involved. Inasmuch as land utilization tends to change in developing regions over relatively short spans of time, aerial photographs used in mapping of those regions should be as recently taken as possible. Recent photographs, furthermore, greatly facilitate the work of field mapping and permit a simultaneous mapping, if desired, of actual land utilization.

At the time of this consultancy, it was found that the greater part of the overall region to be covered had some sort of aerial photographic coverage. There is no general agreement, however, between the Instituto Geográfico Militar and the Servicio Nacional de Aerofotometría as to the true extent of that coverage, particularly in the Sub-Andean and Piedmont sections of the Corridor in La Paz and western Cochabamba departments where a big gap is said to exist (Map No. 1). Further information on this point may be forthcoming prior to the remittance of my final report through IIED, but it is certain that existing photography is in part outdated (older than ten years in settled areas, older than twenty years in unsettled areas), at varying scales (from 1:20,000 to 1:80,000) and of greatly varying quality and degree of resolution.

It is expected, therefore, that some new aerial photography will be required. This will be both to fill in existing gaps and to provide current imagery of areas for which there are only outdated photographs. The amount, cost, and scale of this photography cannot be established until (a) subregions have been delineated, areas established, and priorities ascertained and, (b) further information is received from Ing. J.C. Quiroga as regards both existing photographic coverage, scale, and age and the cost of flying new imagery per unit area/scale.

Provisions should be made in the budget for new aerial photography as well as for the purchase of prints and photomozaics of existing photographs. The Servicio Nacional de Aerofotometría will fly specific areas on request in their own aircraft--preferably May-July when weather is optimal---at direct cost to the client. About one month is required for delivery of images following photography itself.

F. Equipment and Logistics

The major equipment needs of this project will be for transport and housing. Because land capability mapping is undertaken in the field, directly and comprehensively, field teams must each be supplied with longer-distance transport, be it heavy-duty vehicles for rough roads or sturdy boats equipped with outboard motors for use on the rivers, and possibly horses or mules for on-trail use in lightly-populated areas. Probably each of these modes of transport will be required by each team at some time during the life of the project. It may be more desirable to hire locally as needed, especially boats and horses, than to purchase. One vehicle, preferably a four-wheel drive carry-all equipped with front-end winch, should be purchased, new, for each team.

Daily field procedure normally involves dropping off individual team members in assigned local areas for mapping. They then proceed on foot or on horseback as the situation dictates, to progressively cover their areas and are picked up again at the end of the day's work for return to the local base camp or village in which all are temporarily quartered.

For all subregions having good agricultural potential but low present population density, it may be necessary to establish temporary, portable field camps. These camps would include two large well-constructed, waterproof tents with mosquito netting, one for sleeping of the team and the other as a combined dining, cooking, and field office area Additional tarps may be required. A set of cooking and eating utensils and a portable gasoline stove will also be required, snake bite and first aid kits, and preferably a small field generator and a single sideband short wave radio. It is possible that only one team would require the use of a portable camp of this nature at any one time, presuming a well-coordinated project, thus reducing the total cost for this item. However, each technician would need personal sleeping gear and special rain gear as well.

Technical equipment for each team member will include aerial photographs of the areas under study, other auxilliary maps for reference, aluminum or plastic clipboard, pocket stereoscope, PH-color test or electric meter, soil auger, clinometer, compass, and a copy of the field manual for the methodology. The team as a whole will need (preferably) a mirror stereoscope, field glasses, camera, small portable drawing table, field notebooks, and related supplied.

Finally, it is recommended that a budget allowance be made for occasional overflights by light aircraft for at least the team leader. Such flights might precede detailed work in each subregion in order to familiarize the team

with the more general aspects of the subregion, infrastructure, settlements, accessibility, etc.

Scopes of Work

Technical Coordinator/Land Use Specialist

General

The Technical Coordinator/Land Use Specialist will be engaged for the life of the project. He will continue the analyses and further development of the data and findings prepared for the Natural Resources Component of the Corridor Assessment and will coordinate, help prepare, execute, and finalize a more detailed land use capability study for selected sub-regions of the eastern Andean slope and piedmont region. The land use specialist will work under the supervision and policy guidance of the USAID Agricultural Development Officer.

Specific Tasks

The Technical Coordinator/Land Use Specialist will carry out the following specific tasks:

1. Organize, systematize, and catalog, for continued use, the information and data collected for the Natural Resources Component of the Corridor Assessment.
2. Prepare and provide for the relevant agricultural and natural resources institutions briefings on the content and significance of the Natural Resources Assessment.
3. Conduct further analyses of the Natural Resources Assessment including a preliminary determination of priority areas to be studied in more depth during the Detailed Land Use Capability study. Existing background information and basic data which will be needed to carry out the Land Use study will be gathered and organized in the most useful fashion for conducting that exercise. Other specific analyses will be done based on Mission recommendations and suggestions made after the review of the Natural Resources Assessment.
4. Based on the Scope of Work for the Land Use Capability study, prepare more detailed plans, logistical arrangements, personnel requirements and budgets for conducting that exercise, working in conjunction with the participating agencies, including the Executive Secretariat of the PL 480 Title III Program.
5. Assist the Rural Development Division and the PL 480 Executive Secretariat in preparing scopes of work and other documentation needed to contract the services of outside consultants and Bolivian technicians who will participate in the Land Use study.
6. Serve as the principal counterpart and Mission contact for the study teams, as well as carry out technical and training tasks as part of the study team effort.
7. Help analyze and prepare the final reports derived from the Land Use study exercise.

Scope of Work

Life Zone Ecologist/Geographer

General

The Life Zone Ecologist/Geographer will provide approximately one man-month of assistance to the Technical Coordinator and other TA specialists provided by USAID in defining the territorial limits of the subregions to be delineated on the Corridor Assessment Land Use Capability Map at 1:250,000 scale, make preliminary appraisals of demographic and human settlement characteristics, and establish priorities for detailed mapping of land use capability in each subregion. He will also assist in the training of the field teams with special emphasis on direct field recognition of life zones and their boundaries from vegetational indicators and the further recognition of natural associations and association-groupings as a basis for pre-mapping of land units upon the aerial photographs to be used in direct field mapping of land use capability.

Specific Tasks

The Life Zone Ecologist/Geographer will carry out the following specific tasks:

1. Review the information and data collected for the Natural Resources Component of the Corridor Assessment.
2. Assist the Technical Coordinator/Land Use Specialist in establishing criteria for the definition of limits of ecological subregions on the Corridor Assessment Base Map, applying as a data base all information gathered during the Corridor Assessment Natural Resources Survey, with special emphasis on the Land Use Capability Map at 1:250,000 scale prepared from these materials.
3. Advise and assist the T.C./L.U. Specialist in applying these criteria and defining the limits of the ecological subregions.
4. Advise and assist the T.C./L.U. Specialist in acquiring, evaluating, and applying demographic and socio-economic criteria on a geographic basis to the determination of priorities for field surveys in the subregions established in 3.
5. Advise the T.C./L.U. Specialist as to logistical arrangements, personnel and equipment requirements, and budgets for field survey of detailed land use capability in the subregions, according to priority, in each department.
6. Assist for at least two weeks time, in the field training program for all field teams which will take place at the outset of the project's operations, with special emphasis on training in the recognition of life zones and associations in the field and in aerial photographic interpretation.

Scope of Work
Land Use Capability Mapping Specialist

General

The Land Use Capability Mapping Specialist will provide approximately two men-months of technical assistance to the project, assisting the Technical Coordinator/Land Use Specialist, team leaders, and field technicians in all questions relating to the theory and practical application of the proposed mapping methodology in the laboratory and field. He will be an authority on and experienced user of the Objective System of Land Use Capability Mapping based upon the Life Zone System of Ecological Analysis (Tosi, 1981).

Specific Tasks

The Land Use Capability Mapping Specialist will undertake the following tasks, among others:

1. Prepare training materials for and participate in a four-to-six weeks training exercise in on-the-job land use capability classification for all teams to be engaged in the survey program.
2. Provide instruction in the basic theory and methodology to be employed.
3. Supervise and participate directly in the pre-mapping and field mapping training in one (or more) subregions selected for the training exercise.
4. Test and rate participants (team leaders and field technicians) in terms of their suitability for the work, at the close of the training period.
5. Return to Bolivia for one or two short follow-up visits to the project for the purpose of reviewing on-going field mapping, resolving problems which may have arisen as to interpretation, and providing guidance as to final report preparation.

Scope of Work
Land Use Ecologist/Agronomist

General

The Land Use Ecologist/Agronomist will provide approximately one man-month of technical assistance to the project, with emphasis on training and expert advice on the land use ecology of agriculture, livestock production, and agroforestry as specifically related to the application of the survey data to planned development in each subregion. He will participate (Preferably) for about two weeks in the field training exercise to instruct all participants in the theory and methods of land use ecology as applied to landscape planning with emphasis on actual and potential crop, livestock, and woodland management systems in relation to problems of soil conservation and watershed management, new crops and cropping systems, and maximum-productivity, sustained-use land management. He will return for an additional two weeks during the first six months of the project to review progress, problems, and report projections.

Specific Tasks

The Land Use Ecologist/Agronomist will undertake the following, amongst other, tasks:

1. Prepare training materials covering this specialty for use by project leaders and by participants in the initial training exercise in land use capability mapping.
2. In collaboration with the other TA advisors, instruct trainees in actual land use mapping as part of the overall field training exercise.
3. Teach conterminous field observation and data recording procedures for actual land use, farming systems, crop ecology, soil conservation, and watershed management.
4. On a subsequent trip or trips, visit each departmental field survey team in the field and review on-going procedures and progress and provide assistance with report format and data interpretation.
5. Advise the Agricultural Development Office in all matters regarding the utilization of the survey data and reports in development planning.

Persons Interviewed

Lic. Osvaldo Vega	Coordinador, USAID/Corporaciones de Desarrollo
Lic. Leonardo Guevara	Gerente General, CORDEPAZ
Lic. Percy Jimenez	Coordinador, USAID/CORDEPAZ
Ing. Juan Bilbao	Jefe, Depto. Proyectos, CORDEPAZ
Ing. Juan Mendoza	Técnico, Depto. Proyectos, CORDEPAZ
Lic. Roxana Ibarnegaray	Jefe, Depto. Planificación, CORDEPAZ
Ing. Alberto Rodriguez	Gerente General, CORDECO
Ing. Waldo San Martín	Coordinador, USAID/CORDECO
Ing. Hipólito Céspedes	Gerente, División de Recursos Hídricos y Naturales, CORDECO
Ing. Constantino Soto	Técnico en Suelos, CORDECO
Ing. Carlos Gumucio	Técnico en Geología, CORDECO
Ing. Luis C. Sánchez	Técnico en Hidrología, CORDECO
Ing. Pastor Saenz	Coordinador, USAID/CORDECRUZ
Lic. Zenar Arancibia	Jefe, Unidad Planificación Rural, CORDECRUZ
Ing. Gerardo Mogrovejo	Jefe, Recursos Naturales a.i., CORDECRUZ
Ing. Osvaldo Rosales	Técnico, Recursos Naturales, CORDECRUZ
Ing. Rene Valenzuela	Director, CIASER (ERTS-GEOBOL)
Ing. Rene Ballon	Geólogo-Geomorfólogo, CIASER
Lic. Humberto Mercado A.	Jefe, Uso de la Tierra y Fotointérprete, SNA
Lic. Leslie McTyre	Director, Depto. Ciencias y Tecnología, Min. Planificación
Mayor Antonio Pérez	Jefe, Depto. Geografía y Recursos Naturales, IGM
Robert V. Thurston	Head, Rural Development Division, USAID/BOLIVIA