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Technical Evaluation of USAID CCH-Chagas' Disease Control Project Bolivia - August 1992

by

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Acronyms

A.I.D.	Agency for International Development
CCH	Community and Child Health
CDC	United States Centers for Disease Control
ELISA	Enzyme-linked Immunosorbent Assay
IDB	International Development Bank
MPSSP	Ministerio de Prevision Social y Salud Publica
NGO	Non-governmental organization
PAHO	Pan American Health Organization
PMA	Programa Mundial de Alimentos
SNEM	Servicio Nacional de Eradicación de Malaria
UNGECH	Unidad de Gestion de Chagas
USAID	United Stated Agency for International Development
VBC	Vector Biology and Control Project
WHO	World Health Organization

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1. Executive Summary

In response to a request from USAID/Bolivia, the Vector Biology and Control Project sent a team of four scientists to conduct a technical evaluation of the Chagas' disease control project. This pilot project is supported under the Community and Child Health (CCH) project and is designed to develop and field test community-based control methods for eventual use in a national program for the control of Chagas' disease.

Chagas' disease is endemic and widespread in Bolivia and represents a critical national public health problem. A national program must aim for sustainable disease control through community-based activities for house and peridomicilary improvement, health education and judicious use of insecticides. Other components of a national program are a safe blood supply to eliminate infection through transfusions with infected blood and control of congenital transmission of the disease.

The evaluation team met with USAID, Ministry of Health and project staff in La Paz, reviewed project activities and accomplishments, as well as plans for future activities. The evaluation team also reviewed project baseline data, visited project sites to inspect house and peridomicilary improvement, and reviewed laboratory facilities and the health education and community participation activities in Cochabamba, Chuquisaca and Tarija, including those managed by collaborating PVOs.

This complex and multi-faceted pilot project has made important progress during a year and a half of activities. Extensive baseline data detailing the magnitude of the disease in the pilot communities have been collected. Low-cost operational schemes for house and peridomicilary improvement have been pretested, and manuals documenting these activities have been written. Laboratory work on insecticides, and other aspects of vector control have been accomplished. Community organization and motivation and health education have received a great deal of attention as well.

In general, the evaluation team felt that the project had made significant achievements. Many of the components necessary for a national Chagas' disease control program have been effectively pretested. In reviewing future project plans, together with project staff, evaluators made several recommendations, which appear in detail in the report.

The evaluation team strongly believes that the pilot project should be extended in time so that all of the technical information required for a national Chagas' disease control program can be obtained.

2. Sumario Ejecutivo

En respuesta a una solicitud de USAID/Bolivia, el Proyecto de Biología y Control de Vectores (BVC) envió un grupo de cuatro científicos para obtener una evaluación, técnica, del proyecto de Control de la Enfermedad de Chagas'. Este proyecto piloto es financiado por el Proyecto de Salud Comunitaria e Infantil (CCH) y está diseñado para desarrollar y probar, en el campo, métodos de control basados en acciones de la comunidad que puedan ser aplicados a un Programa Nacional para el Control de la Enfermedad de Chagas'.

El grupo evaluador se reunió con personeros de la Misión USAID y del Ministerio de Salud en La Paz y revisó las actividades del proyecto y sus logros, así como los planes para actividades futuras.

La enfermedad de Chagas' es endémica y ampliamente diseminada en Bolivia y representa un serio problema de salud pública. Un Programa Nacional debe hacer énfasis en medidas de control sustentables con base en la participación de la comunidad, para el mejoramiento de la vivienda y sus partes aledañas, en programas de educación en salud y en el uso prudente de insecticidas. Otros componentes de un Programa Nacional deberán incluir un mecanismo para garantizar la eliminación de la posibilidad de adquirir la infección por transmisión sanguínea, y medidas de control para evitar la transmisión congénita de la enfermedad.

El grupo evaluador también revisó los datos de base del proyecto, visitó los lugares en donde se desarrolla para inspecionar las condiciones de trabajo de los laboratorios y observó los programas de educación en salud y la participación de la comunidad en Cochabamba, Chuquisaca y Tarija, incluyendo aquellos aspectos regidos por organizaciones voluntarias privadas (PVOs).

Este proyecto piloto, complejo y multifacético, ha hecho un importante progreso durante un año y medio de trabajo. Se han acumulado numerosos datos de base, que detallan la magnitud del mal en las comunidades del proyecto. Se han hecho pruebas sobre esquemas operacionales de bajo costo para la mejora de las casas y del peridomicilio y se han producido algunos manuales para documentar estas actividades. También se ha llevado a cabo el trabajo de laboratorio para probar insecticidas y se han estudiado otros aspectos relacionados con el vector. Asimismo, la organización y la motivación de la comunidad, y los aspectos educativos, han recibido el necesario énfasis.

En términos generales, el grupo evaluador es de la opinión de que el proyecto ha conseguido logros importantes. Muchos de los componentes necesarios para un Programa Nacional de control de la enfermedad de Chagas' han sido eficientemente ensayados. Al revisar los planes futuros del proyecto, junto con su personal, los evaluadores hacen una serie de recomendaciones que aparecen en detalle en el texto de este informe.

El grupo evaluador está convencido de que el proyecto piloto debera extenderse con el propósito de que se pueda obtener toda la información técnica requerida por un Programa Nacional de control.

3. Introduction

USAID/Bolivia is supporting Chagas' disease control activities through the development of a pilot project under the Community and Child Health (CCH) program. This is an integrated effort to evaluate the efficacy of the various program components, including health education, housing modification based on community participation, and vector control, to reduce Chagas' disease transmission and prevalence. The pilot project is designed to develop and field test methods that are practical, cost-effective and sustainable for subsequent use in a national Chagas' disease control program. Technical support for the project is provided by the Vector Biology and Control Project (VBC), a centrally funded project of the U.S. Agency for International Development's (A.I.D.'s) Office of Health, Bureau of Research and Development, and the U.S. Centers for Disease Control (CDC).

A program planning meeting was held in late 1990 to lay the groundwork for the project. Program activities began in early 1991 in four regions of the country: Cochabamba, Tarija, Chuquisaca and Tupiza. Entomological and epidemiological baseline data were collected, program components designed, field manuals produced, and more than 1,000 houses were improved in the pilot zones during the first year. Detailed data on the cost of each component have been collected and will permit an evaluation of the economic feasibility of the project.

This report presents the results of a midterm technical evaluation of project activities, conducted by an interdisciplinary team of international experts to review progress and make recommendations for future project development.

4. Terms of Reference

1. Review overall scope of the project, objectives, approaches and accomplishments to date.

2. Review individual components of the project as they contribute to the overall project objective: epidemiology; entomology; housing improvements and economics of control; and health education and community participation.

3. Considering that this is a pilot project, assess how well current activities are designed and being conducted to produce one or more models that can be developed into a full national Chagas' control program.

4. Based on work completed, make recommendations on the need for, and type of, operational research needed in the next year to provide information important for a national control program.

5. Examine the interactions between the various elements comprising the current pilot project such as the CCH Project/USAID-Bolivia, USAID, MPSSP, PL-480, Habitat, VBC Project, CDC and regional field activities (Cochabamba, Chuquisaca, Tarija, Tupiza), and make recommendations for better coordination and planning, if required.

6. Advise USAID and MPSSP on the steps that should be taken to develop the framework for a national control program that can be presented to a meeting of bilateral and multilateral donors for the required long-term support.

5. Project Review

5.1 Epidemiological Aspects

5.1.1 General considerations

Chagas' disease probably existed in Bolivia centuries before Carlos Chagas, its discoverer, described it in Brazil in 1909. There is evidence that the relationship of the main vector *Triatoma infestans* with man has been longstanding; the insect was present both under wild and domestic conditions in the Cochabamba Valley before the Spaniards arrived. Furthermore, the parasite probably existed in Bolivia before man arrived, in enzootic natural foci where *T. infestans* lived in association mainly with the wild guinea pig (*Galea musteloides*). It is also clear today that the vector became very well adapted to households, becoming almost entirely synanthropic, with some populations still preserving their natural ecotopes.

The socioeconomic conditions prevalent in the human environment in some areas of Bolivia make Chagas' disease a widespread illness, probably involving more than a quarter of the country's population. The disease is also a permanent threat and a serious health problem in some other Latin American countries. Throughout the region, an estimated 16-18 million persons are currently infected, according to the World Health Organization (WHO).

5.1.2 Epidemiological pattern in the country

Before 1990, little epidemiological information about Chagas' disease was available in Bolivia. We know now that endemic areas extend below 3,500 meters above sea level, comprising about half of the country's territory, and that about a half of the population (3 million people) is at risk.

Many factors favor the thriving of the vector in households, or in areas linked to the household environment, making Bolivia a paradise for *T. infestans* and for Chagas' disease. As a consequence, Bolivia now has higher Chagas' morbidity than any other endemic country.

A recent national study[1] indicates that the dispersion indices of the insect range between 75 and 80 percent, and that in the department of Santa Cruz it may reach 96.5 percent. Insect densities within houses are also high; up to 5,000 have been observed in a single house.

Trypanosoma cruzi infection rates in 7,886 triatomines captured in households throughout the country range from 9.5 percent to 58 percent. Previous studies based on 16,481 insects in Cochabamba and 9,132 insects in Santa Cruz produced rates of 67.9 and 40.6 percent, respectively. These rates may reach the astonishing figure of 90 percent in rural areas in the departments of Cochabamba and Chuquisaca. Moreover, rates of 78 percent have been found in insects captured in guinea pig pens in the peridomestic environment.

The role of domestic mammals in the cycle of the parasite has also been studied. A national sample of 17,588 animals revealed a predominance of guinea pigs (35 percent), followed by pigs (27 percent), dogs (25 percent), and cats (13 percent). Guinea pigs and dogs seem to play a very important role as reservoirs, presenting infection rates of up to 61 percent and 23 percent, respectively. Congenital transmission has been documented in guinea pigs.

The seroprevalence rates in humans are about 40 percent for the country, reaching up to 70 percent in some areas. For children younger than 5 years of age, these rates can range from 11 percent in urban areas to 70 percent in rural areas. Overall it has been estimated that about 35 percent of school-age children in endemic areas are infected. In Tarija and Chuquisaca 29.3 percent and 23.5 percent, respectively, of children younger than one year are serologically positive for Chagas' infection.

From a total of 7,696 electrocardiograms taken, 26.2 percent from those of the group with positive serology (3,852 out of 9,547 individuals) presented abnormal patterns compatible with Chagas' disease. Using this estimation, it is concluded that approximately 272,000 persons in Bolivia may have cardiac lesions due to this disease. Most critical is the fact that young persons 15 to 40 years old are the main victims of the chronic

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[1] Data and indices reported herein are derived from the national baseline study conducted at the initiation of this project. Calculations are based on analyses recommended by the recent WHO Expert Committee Report on Control of Chagas' Disease, WHO TRS #811 (1991).

cardiopathy produced by Chagas' infection. This diminishes their working capacities and has enormous impact on the socio-economic development of the country.

Evidence that Chagas' disease also produces pathology of the digestive tract has been observed in Bolivia, although not in a very systematic way. Abnormally prolonged swallowing times were observed in 16 percent of a group of seropositive individuals in the department of Cochabamba. In Tarija, 3.4 percent of a group of 7,000 patients undergoing gastrointestinal surgery presented evidence of pathological changes compatible with Chagas' disease.

In addition to the vectorial mechanism of transmission, which in Bolivia constitutes a very effective method of infection for those living in endemic areas, two other means of acquiring the infection are common. Congenital transmission was confirmed parasitologically in 7.6 percent of newborns in Santa Cruz; moreover, 50.8 percent of 329 mothers were seropositive, suggesting the risk for congenital transmission is about 16 percent. Other seroprevalence surveys have found infection rates between 25 percent and 50 percent in pregnant women, and estimates of congenital transmission rates of 8 percent to 36 percent, with a mortality rate of 32 percent.

Transmission also occurs by blood transfusion. In Santa Cruz it was observed that of 21 seronegative patients who received blood from seropositive donors, 10 (47 percent) became positive for *T. cruzi* 60 days after transfusion. In another study it was observed that about 1,904 new cases were produced from 4,000 blood transfusions made in 1988 in Santa Cruz, Cochabamba and Chuquisaca. This translates to five cases per day, with a risk factor of 48 percent. The seroprevalence rate for blood donors in other studies have ranged from 56 to 70 percent. Blood transfusion is an alarming mechanism of transmission, particularly when we consider that technically competent blood banks are scarce or nonexistent in Bolivia.

These data confirm that Chagas' disease is an extremely serious public health problem in Bolivia. Although no information on death rates is available from autopsies, mortality has been estimated at 13 percent, and about seven children die every day of Chagas' disease in the country.

5.2 Baseline Data from the Pilot Project

5.2.1 Factors related to the house

The baseline studies made in the communities involved in the pilot-project in Cochabamba, Tarija and Chuquisaca confirm the severity of the problem. From the report presented by the group charged with the technical coordination of the project through July 1992, data were selected for secondary analysis to calculate some pertinent indicators that are important for a better understanding of the epidemiological situation in the three pilot-project areas (Table 1). The main conclusion that can be drawn is that the Infestation Index (number of houses infested/number of houses examined x 100) is considerably lower in Cochabamba, suggesting that there is a group of houses without triatomines or with such low populations that they could not be detected. If this is the case, it will be very important to compare the characteristics of those "negative" houses with the ones that contained triatomines. Also, an analytical epidemiological case-control study designed for a locality with similar conditions will be very useful for identifying the principal risk factors associated with *T. infestans* infestation.

In addition, the Crowding Index (number of triatomines captured/number of houses with triatomines x 100) reflects a similar abundance of insects in houses in Cochabamba and Tarija. It will be important to determinate which factor(s) weigh more heavily for each site. The Density Index (number of triatomines captured/number of houses examined x 100) perfectly reflects the observed seroprevalence of the disease in each of the three sites.

Finally, we propose the calculation of two other indicators: the Dispersion Index (Number of localities infested/Number of localities examined x 100) and the Colonization Index (Number of houses with nymphs/Number of houses positive for triatomines x 100), These indices will provide important epidemiological information for a control project. It is evident that the Dispersion Index will be 100.0 for the three sites. The information needed to calculate the Colonization Index is not available in the report but can probably be found in the data gathered from the houses. This index will be very important during the surveillance phase.

TABLE I

Some useful epidemiological indicators for Chagas' disease control programs

AREA	Infestation Index	Crowding Index	Density Index	Dispersion Index	Insect Infection Index (%)	Serologic Prevalence (%)
COCHABAMBA	38.2	25.5	9.7	100.0	27.5	46.0
TARIJA	78.2	14.3	11.2	100.0	31.5	60.5
CHUQUISACA	78.4	25.4	19.9	100.0	33.1	78.1

Colonization Index was not calculated because the information was not immediately available

Tables 2 and 3 show the estimated frequency, in percentages, of some important characteristics associated with households in the three study areas. These may have important epidemiological implications. These different factors, related to this artificial ecotope, should be carefully evaluated for their importance as risk factors in relation to the presence of the vector.

A quantitative exercise, similar to that made by Starr et al. in 1991, will permit ranking the importance of factors that might be associated with the presence of *T. infestans* in households and peridomestic structures. Other factors with important implications that could be also taken into consideration are the number of persons living in the house, the length of habitation and the presence of electric lights. This information will be valuable for the control project.

In relation to the information presented in Table 2, it is not easy at this stage to draw conclusions from the available data. Discrimination of the places where triatomines were originally found would have been useful for this exercise; apparently this information is available from the original survey database. In relation to the internal characteristics of the household (Table 3), it is evident that unplastered or partially plastered internal walls probably constitute the most important factors associated with the presence of the vector.

Nevertheless, it appears that there are factors both indoors and outdoors in each of the three sites that play different roles in facilitating the presence of the vector.

5.2.2 Factors related to domestic animals

It is evident that in Cochabamba there are markedly more *conejeras*, mainly guinea pig pens and in a few cases rabbit pens, than in Tarija and Chuquisaca (Table 2). Nevertheless, we do not know how much they are contributing to the presence of the vector in the peridomestic areas.

There seems to be a coincidence though, between the presence of guinea pigs in Cochabamba houses and the relative abundance of triatomines found around the houses.

TABLE 2

Some important external household characteristics that might be related to the presence of the vector

AREA	No. of houses studied	Household Goods	Chicken Coops	Guinea-pig Pens	Other Type of Corrals	Oven	Fences or Adobe Walls	Houses with Triatomines Outdoors (%)
COCHABAMBA	348	41.1	28.7	27.9	44.5	43.4	56.6	27.3
TARIJA	239	33.9	22.6	4.6	71.5	70.0	51.9	63.2
CHUQUISACA	384	43.8	28.9	1.3	34.6	38.8	47.6	65.9

TABLE 3

Some important internal household characteristic that might be related to the presence of the vector

AREA		External Roof of Mud or Straw	Internal Roof without Ceiling	External Walls without Plastering	Internal Walls without Plastering	Presence of Dirt Floors	Houses with Tiatomines Indoors (%)
COCHABAMBA	Bedroom	83.2 (1)	98.0	78.3	21.7 (4)	98.3	28.4
	Other	87.7	96.8	89.7	45.1	97.8	
TARIJA	Bedroom	8.6 (2)	81.0	73.3	27.8 (5)	54.1	56.9
	Other	13.5	91.0	78.0	51.9	73.0	
CHUQUISACA	Bedroom	60.8 (3)	96.5	76.9	70.4	83.1	71.9
	Other	64.7	98.4	79.0	74.9	92.2	

(1) Predominance of Mud
(2) Predominance of Tiles
(3) Predominance of Straw
(4) 66.1 % parcially Plastered
(5) 42.1 % parcially Plastered

The fact that the infection rates with *T. cruzi* for insects captured indoors is practically double that of insects captured outdoors deserves more attention. It seems possible that a more permanent and effective blood source found inside the house (such as dogs or cats) is responsible for transmission. In Tarija, where this difference in the infection rates is more marked, there are more houses with dogs and cats than in the other two sites. No census was made of the number of domestic animals associated with the household: this could have been important from the epidemiological standpoint. There are plans to establish feeding patterns for the insects captured both indoors and outdoors using an ELISA test. Geographical differences in the main blood sources of *T. infestans* have been reported in the literature. In Chile and Brazil, humans are the principal blood source for insects captured indoors but in Argentina up to 49 percent feed on dogs, which are considered to be the main reservoir for domestic transmission.

5.2.3 Factors related to the sylvatic condition of *T. infestans*

Feeding patterns will be also useful in determining blood preferences for *T. infestans* found under sylvatic conditions. The potential epidemiological role of these insects found in natural ecotopes will have to be assessed. This will be discussed in more detail in the entomology section that follows.

5.2.4 Factors related to human beings

House improvement, as is being done effectively in the pilot project, together with proper education and motivation, plus community participation in the permanent surveillance and vector monitoring activities, should be effective tools to avoid recolonization. Furthermore, these actions, and spraying of insecticide when necessary, will guarantee an efficient and sustainable mechanism for control of the disease in the pilot areas. By this token, any control program undertaken at a national level should use the pilot project as a model and utilize the available expertise.

Nevertheless, from the epidemiological standpoint a longer time frame than is currently available will be necessary to evaluate the possible appearance and consequences of renewed infestation of improved houses. Preliminary data from Chuquisaca indicate a marked reduction or disappearance of triatomines from improved households and only very sporadic reinfestation by adult insects that could be easily controlled by effective community action.

In this respect, the periodic evaluation of the prevalence of the disease by serological methods, particularly in recent migrants and young children, will be very useful to demonstrate the interruption of transmission.

5.3 Laboratory and Investigation

5.3.1 National entomology laboratory

Bolivia has a national entomology laboratory in Cochabamba which is now fully functional. The technical staff consists of an entomologist, Dr. Hernan Bermudez, two entomological technicians and two laboratory assistants. The technicians have been trained to identify triatomines captured in the field and to conduct insecticide susceptibility testing of triatomines by the standard WHO procedures. Bioassay tests are performed on sprayed test panels as well as on sprayed surfaces of houses in experimental areas. To facilitate this testing, and for other biological investigations, laboratory colonies of *Triatoma infestans* and *T. sordida* are permanently maintained.

Dissections of triatomines to determinate infections with *Trypanosoma cruzi* are done in the laboratory, but under somewhat crowded conditions in the same space with other laboratory procedures. It would be better, for safety considerations, to carry out these dissections in a separate room or space equipped with a hood and air exhaust system. The technicians seem to the well trained and competent, and all of the dissections of triatomines captured during the baseline survey were done at this laboratory. The national entomology laboratory has also been the base for field trials carried out in nearby study areas, such as the trials of the insecticides RODY, CYPERATOR, POLYTHRIN, TEMPO and ICON.

The laboratory is also serving as a base for the entomological and epidemiological studies of the sylvatic foci of *Triatoma infestans* and *Trypanosoma cruzi* known to exist in the Cochabamba Valley. Some preliminary studies have already been done, but a great deal remains to be discovered about these sylvatic foci and their importance in the transmission of Chagas' disease. These investigations will be discussed in more detail in a following section of this report.

Protocols have been prepared for trials of some alternatives methods of vector control. These methods include the use of insecticide paints and fumigant insecticide dispensers for the control of triatomines in houses. Both of these control methods have promise, but must be field tested under Bolivian conditions. Field areas in the Cochabamba Valley have already been selected, and the trials can start immediately upon receipt of funding from the project headquarters. It is important to begin these trials soon, so that the results will be available to the planners of future Chagas' disease control operations in the country. In addition, field observations are to be carried out this year on alternative entomological evaluation techniques. Examples are the use of the Maria sensors developed in Argentina and the use of sticky tapes for the detection of triatomines in houses.

The National Entomology Laboratory is a well organized unit, fully capable of carrying out the operational research essential for the future development of a Chagas' disease control program. The laboratory is also prepared to collaborate with other research institutions in projects involving the control of triatomines. The entomology laboratory is in a good position to offer this collaboration because of the knowledge staff members have of the distribution and biology of Chagas' disease vectors in the country.

5.3.2 Sylvatic foci of *Triatoma infestans*

Sylvan foci of *Triatoma infestans* in the Cochabamba Valley have been identified and studied by several investigators. These sylvatic foci of the vector could play an important role in the epidemiology of Chagas' disease as a source for reinfestation of houses previously cleared by house improvement and spraying. If sylvatic triatomines are infected with *Trypanosoma cruzi* from wild mammal reservoirs, the epidemiological situation is even more complex. We do know, from investigations carried out to date, that the wild *T. infestans* are associated with wild guinea pigs, which have their nests in rock piles. Both the wild guinea pigs and triatomines have been found infected with *T. cruzi*. Several questions come to mind:

a. Are the wild populations of *T. infestans* morphologically and genetically distinct from the domestic populations?

This question could be studied with available taxonomic and genetic techniques. There may be behavioral differences to be discovered as well.

b. What animals do the wild *T. infestans* feed on?

This question could be investigated by performing ELISA tests on the blood meals of triatomines captured in the wild foci. The serology laboratory is fully equipped to carry out the ELISA tests, and works closely with the entomology laboratory.

c. Do the triatomines of the sylvan populations invade houses?

This question could be studied by placing sentinel chicken coops at varying distances between rock piles and occupied houses. Another approach would be to determine flight range of the adults by a mark-release-recapture experiment.

All of the questions above could be investigated by national entomological laboratory personnel and their scientific collaborators. At this point we have little precise information on the geographic distribution of sylvatic populations of *T. infestans* in Bolivia. There is a recent report from Chuquisaca of the finding of *T. infestans* under tree bark at some distance from houses. There are many unknowns, and we believe that research in this area should receive a high priority.

5.3.3 Current entomological research and future needs

The insecticide testing program carried out in 1992 concentrated on a comparison of the efficacy of several pyrethroid insecticides in the control of *T. infestans*. Five synthetic pyrethroid compounds (RODY, CYMPERATOR, POLYTHRIN, TEMPO and ICON) were tested by bioassay of sprayed wall surfaces. Of the five insecticides tested, TEMPO and ICON demonstrated the best knock-down effect and residual action. Mortalities of the test insects were lower than expected with all of the pyrethroids, and future tests with higher application rates might give valuable information. Evidently the dosages recommended by the manufacturers and the test papers available from WHO are based on trials for mosquito control, and may be too low for good control of *T. infestans*.

It has not been possible to start the field trials of insecticide paint and fumigant insecticide dispensers that were programmed for early 1992 even though all of the preliminary work has been done. We were told that there had been delays in arrival to the project of the necessary in-country funding. It is important that these trials proceed as soon as possible.

Additional operational research is needed on methods of detecting reinfestation of houses by *T. infestans*. The man/hour collection method was the standard technique used during the baseline survey to measure infestation, and will probably continue to be used to detect reinfestation. Different and simpler methods have been described in recent years for this type of evaluation. One is the Maria sensor, a simple box device that can be manufactured locally.

Other workers have used sticky tapes to capture triatomines that have reinfected houses. Another method is to fix a clean sheet of paper over one bed in a bedroom, and to periodically check this paper for fecal stains made by *T. infestans*. All of these methods should be evaluated for future use in the Chagas' disease control program.

A field of investigation that has been neglected in recent years is the biological control of Chagas' disease vectors. There is a body of published work concerning predators and parasites that could help control natural populations of triatomines. The national entomology laboratory is in a good position to enter agreements with other institutions to carry out laboratory and field studies of biological control agents for Chagas' disease vectors.

5.4 Housing Improvement

The housing improvement component of the pilot Chagas' disease control program is comprehensive and integrated with health education, community participation, insecticide spraying and vector reinfestation surveillance.

The housing improvement component is based on several subcomponents:

- Community motivation for house improvement through health education of all family members;
- Establishment of written agreements with each community to conduct its own housing improvement under the guidance of locally selected and trained promoters and project staff;
- Organization of a Chagas' disease control committee in each community;
- The community's selection of promoters, who are trained by the health educators and project staff;
- Gathering and recording baseline data (by the promoter) of the physical conditions of extant houses and their peridomestic environments (corrals, small animal shelters, outdoor ovens, etc.);
- Identification of abandoned and seasonally closed houses, as a part of the baseline;
- Repair or replacement by the family of occupied houses (walls, ceiling, roof, windows, door) and peridomestic structures (corrals, animal shelters, outdoor ovens) that may harbor the vector, using community participation and local materials wherever feasible;
- Residual insecticide spraying to eliminate any remaining vectors after housing improvement is completed;
- Destruction of abandoned houses and unused or unrepairable peridomestic structures;
- Periodic surveillance of housing improvements by the family and the promoter to detect deterioration and reinfestation; and
- Repair and respraying of reinfested houses as needed.

5.4.1 Accomplishments in housing improvement

In 1991, 1,030 houses were improved in 13 different communities in three distinct regions in Bolivia (Cochabamba, Tarija, and Chuquisaca). Housing improvement guided by the project continues apace in these three areas. The very high level of community participation and the large number of improved houses is a remarkable achievement by any standard. Project staff plan to continue housing improvement as funds permit, and hope the improvements will be sustainable.

The project staff has very appropriately focused the housing improvement effort on both intradomiciliary and peridomiciliary environments, including their human and animal residents, which *Triatoma infestans* populations utilize for food (blood meals), shelter and reproduction. Commendably, promoters have given improving animal shelters and outdoor ovens almost as much emphasis as housing improvements. Within the house, the emphasis on improvement of ceilings (a more difficult site to improve) as well as walls is most appropriate. The provision of one standardized door and two standardized windows (one each for bedroom and main room; with two glass panes and a polypropylene or metal screen) for each house is an important, cost-effective vector control measure, and is welcomed by householders.

The emphasis on the use of local building materials for housing improvement is important. There is an intentional preference for the use of locally available building materials. Examples of these materials are: local soils, animal dung and straw for adobe bricks; *Eucalyptus* poles for roof supports; and in some areas, locally-made roof tiles. Their use represents an appropriate technology: it is more cost-effective for both the householder and project, promotes local self-reliance, reduces dependency, supports local artisans, and strengthens local markets and the local economy. Project staff also recognize that not all building materials, particularly cement, lime and plaster, are locally available, or that a better price may be negotiated with a large regional manufacturer or vendor of these materials. Cement in particular is an expensive material, in terms of its street price, transport costs, and the energy-intensive nature of its production; however, a more suitable and equally durable substitute material has not been found in Bolivia, and the project will continue to rely on cement.

The project uses local craftspeople, particularly masons, or trains community members in masonry if these skills are not available in a particular community. Another laudable practice of project staff is its encouragement of community members to use their indigenous knowledge of the local environment to make technological advances in housing improvement. A prime example is the use of the juice of the prickly pear cactus "leaf" to thicken the mixture used to plaster walls (*revoque*) and to thicken and make more adhesive the lime-water paint mixture applied to the external walls of some houses after wall improvement has been completed.

The project's housing improvement efforts do not stop with the completion of construction and repairs. An integral part of the goals of the project is the "raising of consciousness" of householders to keep houses and storeroom interiors (floors, walls, ceilings) and belongings (clothing, beds, furniture, stored foods) in a clean, tidy state. This task falls particularly to women and children, whose traditional role is to maintain the house in good order, but men are educated simultaneously with women. In addition, all householders are educated to participate in surveillance for vector reinfestation and to keep houses and other structures in good repair through the years.

5.4.2 Intersectorial Cooperation: Linkage of Potable Water Provision with Housing Improvement.

The lack of sufficient potable water supplies is one of the greatest felt needs of rural communities throughout Bolivia, from the *altiplano* to the valleys and plains. In housing improvement for Chagas' disease control, water is used for the following important purposes: as the medium in which adobe bricks are made; to mix the *revoque* plaster, cement and limestone-based white plaster used on walls, ceilings and floors; to wet the walls of houses and other structures before *revoque* can be properly applied; to heat and ferment the prickly pear cactus "leaves" that are mixed in the *revoque* and in the limestone-based white "paint" used to decorate some houses after improvement; and, finally, to help householders properly cleanse themselves and their clothing and tools after plastering and other housing improvement tasks.

Several communities visited by the evaluation team strongly expressed a need for improved potable water supply to carry out housing improvement in a timely and effective manner. Most housing improvement is done during the dry season, when the agricultural calendar is slack, but also the time when water is at its scarcest. People from one community in the Cochabamba pilot area had to haul water for housing improvement a long distance by hand or by animal dray. Two communities in the Cochabamba pilot area received drilled wells in 1991-92 as a part of the agreement between the Chagas' disease project staff and the community. The wells were greatly appreciated and widely used by the communities. Though there was no formal evaluation of the effect of the wells, it is probable that provision of wells in the communities acted as a positive incentive to carrying out housing improvement. An ex-post facto survey of these two communities could provide an answer to the question.

The appropriate ministries of the Bolivian Government and NGOs should strongly consider utilizing the prevalence of Chagas' disease as one of the major criteria by which they prioritize which communities in Bolivia will receive new, improved or expanded potable water supplies. Communities with a high prevalence rate for Chagas' disease would be ranked high on a list to receive such potable water systems. Provision of potable water supplies in such a manner will have direct ancillary benefits in helping control Chagas' disease, which is now recognized as one of the major mortality factors for women and children in Bolivia. This type of strategy was successfully used to promote Guinea worm (dracunculiasis) control in West Africa in the 1980s and 1990s during the United Nations Water Decade.

A joint package of potable water supply delivery and Chagas' disease control through housing improvement could be of strong interest to bilateral and international development aid agencies, including the IDB and World Bank.

5.4.3 Intersectorial cooperation: linkage of improved animal husbandry with housing improvement

Another strongly felt need in many rural Bolivian communities appears to be the care of animals and improvement of animal husbandry. Most families in the chagastic areas of Bolivia typically own large animals (burros, horses, cattle) and/or small animals (guinea pigs, chickens, doves, rabbits, pigs, sheep, goats) which are used for animal traction, drayage, wool and fur, or food. Dogs are commonly kept as guards and companion animals, and cats are kept as rodent hunters and for companionship as well. Guinea pigs, doves and pigs are considered a delicacy used primarily for special, holiday meals and festivals, and are sold as a "cash crop" by poorer families when there is a household cash shortage. The rural economy of Bolivia is very much an animal-based economy. Epidemiologically, small animals in particular frequently act as blood-meal hosts for the triatomine vector of Chagas' disease, playing an important part in the epidemiology of the disease in Bolivia.

The linkage of an animal husbandry and improvement project with housing improvement could provide an additional incentive for communities to participate in housing improvement.

In addition, community- and household-oriented education and training in small animal husbandry could provide an opportunity to address one of the challenging parts of housing improvement: how to encourage people to move and keep their small animals away from the house, and to keep corrals and animal housing in good repair. In the Chuquisaca area, where goats are common, project staff found it is difficult to maintain goat corrals once improved because the animals lick and chew the *revoque*. Working with local people, project staff may find alternatives such as the incorporation of bitter-tasting substances into the *revoque* or provision of salt blocks to lick and sticks to chew. The evaluation team understands that CARE/Bolivia has a small animal husbandry project; it would be worthwhile for the project staff to talk with CARE staff to determine whether such a joint effort would be feasible and fruitful.

5.4.4 Models for housing improvement

To date, project staff have not had the opportunity to synthesize all the different approaches to housing improvement used in the three pilot study regions. However, there is a clear need for project staff, NGOs and other groups interested in participating in the project to have a clear "roadmap" in front of them that compares and contrasts the variations in housing improvement resources and methods in each study area. This roadmap could simply be a table detailing all major variables: types of materials used for walls, ceiling and roof, and their sources; roles and responsibilities of promoters, educators and profesores *rurales*; control of building materials distribution; quality control methods; availability of potable water systems, wood poles and fuelwood, clay soils and sand; variations in housing design, size, and function; types of animals and animal housing present; identification of the insecticide applicators (promoters or MPSSP staff) and so forth.

5.4.5 Role of women and children in housing improvement and maintenance

The project staff has developed and used educational materials on housing improvement that are targeted to adult women and men, and children, separately (e.g., school materials) and together (promoters' guides for family-based housing improvement). However the training materials do not address certain latent gender and age issues that underlie housing improvement, maintenance and surveillance. To date, few project health educators and promoters are women. Though it may be argued that promoters are selected by the community, and such selections to date have, happenstance, been primarily men, the project staff could encourage each community to select promoters from each gender to reach the various members of their community more effectively.

The evaluation team has noted that both women and children in the three pilot study areas have the major role in animal husbandry, house and peridomestic cleanliness and tidiness, household maintenance and perhaps household repairs. Maintaining household orderliness is seen by some A.I.D. staff as a major challenge; to address this issue, the experience and ideas of women and children can help project staff determine the most effective means of communicating and sustaining the message of tidiness. There is a need for a carefully developed survey tool to help project staff better understand the division of labor among women, men and children in relation to housing improvement, orderliness, maintenance and vector surveillance, so that education and training can be carried out more effectively and fairly.

5.4.6 Duplication of baseline housing data

The evaluation team noted that the HABITAT/Bolivia office and the Cochabamba-based project director's team have each collected baseline data on houses in Erquis, a community in the Tarija study area. The two groups independently developed housing survey forms that cover much the same material. There is a clear need for the project's administrators to improve communication and coordination between the NGOs and other actors in the pilot project to avoid a costly duplication of effort. For the future, a common set of survey forms that equally serve all the needs of all actors should be cooperatively developed, with the administrative staff taking the lead.

5.4.7 Determination of life span of improved walls and roof

Project staff estimate that the average life span of improved walls is about 4-5 years, based on empirical evidence, with an improved roof made of tiles perhaps lasting longer. The pilot project is only in its second year, thus there are no field data as yet to evaluate this estimate. Since the cost of wall and especially roof improvement is a significant portion of total housing improvement costs, it is important to estimate the life span of the walls and roof in order to evaluate the cost-effectiveness over time of housing improvement.

5.4.8 Determination of life span of improved peridomestic structures (i.e. corrals, small animal housing, ovens)

Domestic animal corrals (for large animals), small animal housing (for guinea pigs, rabbits, chickens, doves), and ovens are frequently built either touching or very near the household dwelling, and are to be torn down and removed to places more distant from the house, as a part of housing improvement. Such peridomestic structures are improved by reconstruction with more suitable material (e.g., replacement of stone corrals with adobe brick, to which plaster adheres better), or simply re-plastering over the existing base material. One may expect that the life span of improved peridomestic structures in Bolivia may be less than for houses, since these structures are more directly exposed to the elements (rain, wind), receive damage from domestic and peridomestic animals, and may receive less maintenance than the house itself.

The life span of house roof and walls and improved or new peridomestic structures should be quantitatively evaluated in each pilot project area over a minimum period of 5-10 years.

5.4.9 Choice of house foundation and foundation life span

House foundations serve two critical functions: prevention of water damage to the base of the walls and floor, and even transfer of the load (weight) from walls and roof to the ground. In the improvement of existing houses and the construction of replacement houses, families have used both large and small stones to construct above-ground house foundations (i.e., foundations without footings below soil level). Experience in the pilot study communities indicates that houses with foundations made of small stones are more prone to rain erosion and the development of cracks in which vectors may be harbored than houses with foundations built with large stones. A comparative study should be made to verify this observation.

The life span of above-ground house foundations, whether made primarily of stone or adobe brick, apparently has not been studied in Bolivia. However, based on experience in Kenya and Tanzania, Schofield et al. (1990:201-202) recommend that traditional earthen-based houses be constructed with foundation footings embedded in the soil layer to a minimum depth of 30 cm for single-story houses, up to one meter for two-story houses. A diagram of such a foundation footing is shown in **Figure 1**. Footings may be compacted stones, compressed earth blocks, baked clay bricks, or soil-cement mortar. It is recommended that experimental houses be constructed in several sites having variable rainfall patterns, using below-ground footings as described. Rainfall data should be recorded locally if possible; alternately, regional meteorological data can be used to estimate local rainfall. The experimental houses with footings should be compared with improved houses built with above-ground foundations semi-annually or annually over at least a 5-10 year period to determine which type of foundation provides the longest life span, least water infiltration into the floor, and best support for the walls and roof.

5.4.10 Use of local building materials

The quantity and quality of available building materials varies from community to community and through time. Currently the project purchases windows and doors under contract with local or regional businesses. In the Cochabamba and Chuquisaca study areas, local residents make their own roof tiles. Communities such as Tarija have independent local artisans who make high quality building materials and who might be contracted to make doors, windows or tiles. HABITAT/ Bolivia proposed to conduct a market survey in Tarija to examine the feasibility of such an approach.

In order to accurately estimate the purchase cost of building materials, project staff should continue to determine the local cost, availability, quantity and quality of building materials that could be purchased locally.

5.4.11 Construction and maintenance norms

The Government of Bolivia has established construction norms for housing, but the norms are targeted and enforced primarily for urban housing, while the Chagas' disease control project targets rural, substandard housing. Project staff have prepared an excellent, well-illustrated draft manual, "Manual de mejoramiento de viviendas dirigido al control de las vinchucas" (May 1992), which provides simple norms for housing improvement for Chagas' disease control to be used by promoters and health educators. No manual of norms for housing maintenance yet exists, but there is a clear need for one using promoters' field experience with the causes of deterioration in the project areas. HABITAT/Bolivia may be selected to prepare a revised, more detailed set of manuals, one each for housing improvement and housing maintenance for Chagas' disease control, under contract with CCH.

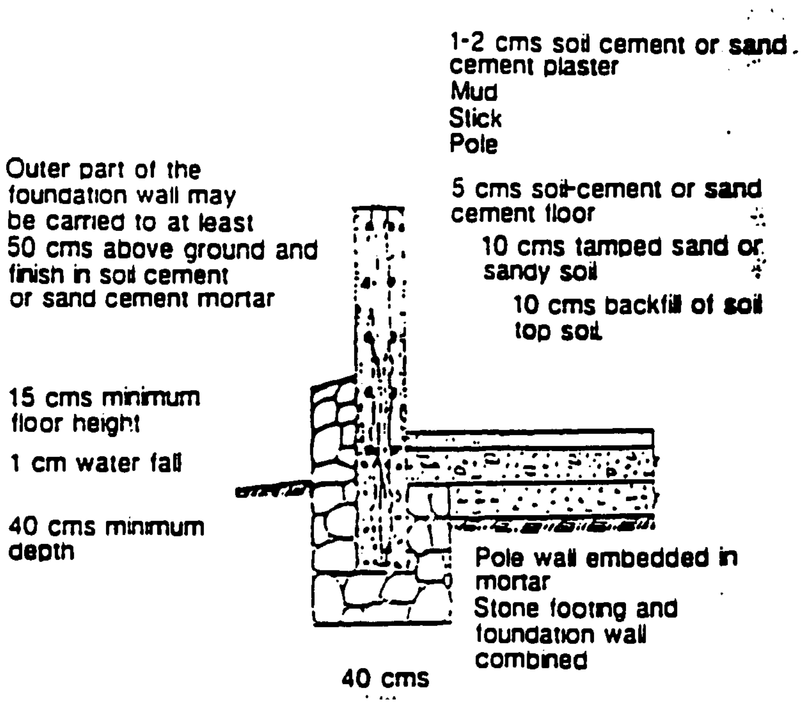
5.4.12 Promoters and quality control

Proper supervision and quality control are keys to effective, sustainable housing improvement for Chagas' disease control. Project staff, reflecting their careful development of the control program, have prepared draft guides for training promoters in housing improvement that include a discussion on quality control of the repairs undertaken by the householders. These guides are: "Guia ilustrada para entrenamiento de promoters" (draft - 1992) and "Guia de entrenamiento de los promoters" (June 1992).

The latter document clearly lists the steps in housing improvement that need direct supervision and quality control by promoters. It also notes that if some people do no respond well to supervision, promoters should communicate these problems to the community's Chagas' Control Commitee for attention.

Figure 1

Design of Foundation for Traditional Houses



Source: Schofield et al., 1991.

5.4.13 Housing improvement: partial or integral?

USAID/La Paz staff members have asked whether effective disease control can be achieved by simply improving certain rooms in houses or certain peridomestic structures, and not the entire house. Such an approach could reduce the costs of control, since material and labor costs would be reduced. It is true that transmission to humans usually occurs only in the rooms where people sleep; however, experimental work in Brazil (Schofield and Marsden 1982) and empirical evidence from other countries show that partial plastering of interior and exterior walls and ceilings does not significantly reduce the number of vectors in the house. Thus the risk of transmission remains high with only partial house improvements. A hungry triatomine vector in an adjacent (unimproved) room or in structures that house animals may move (disperse) 10-20 m in search of a blood meal (Starr et al. 1991). To fully interrupt disease transmission, the entire house and structures in the peridomestic environment need to be improved (and subsequently sprayed). Partial improvements will not reduce risk sufficiently.

5.4.14 Incomplete housing improvement

In some communities (e.g., Cochabamba, Tarija) families may not finish housing improvements, or may not do so in a timely manner. Project staff should determine, using a representative survey tool, why families do not finish housing improvements. A shortage of water to mix adobe bricks and plaster was cited by community leaders in Cochabamba, together with delays in the delivery of doors and windows, but no doubt there are multiple causes in any community. Possible solutions to be examined include provision of potable water supplies where water is a limiting factor, careful timing of housing improvement so as not to coincide with peaks in activities in the agricultural calendar, and the use of communal labor (e.g., "la torna vuelta" as seen in Tarija, and cooperative irrigation works observed in Cochabamba). Food for work programs in Bolivia seem to be generally unsuccessful as an incentive tool, but the provision of potable water to needy communities may act as an incentive to complete work and overcome a limiting factor in completion of housing improvement.

5.4.15 Abandoned, seasonally closed, and rented houses

Numerous houses in the pilot study areas, and presumably elsewhere in Bolivia, have been permanently abandoned as families and their animals relocate, or individuals die without leaving their houses to heirs. Abandoned houses and associated peridomestic structures can remain as habitats for the vector, which can survive for months without a blood meal. Alternately, the human and domestic animal blood hosts that left may be replaced by wild animal blood hosts. Either way, the site remains a potentially important epidemiological factor.

It can be difficult to obtain a family's participation in improving a house that is closed for part of the year when its owner migrates as a laborer to other parts of Bolivia or abroad for seasonal employment. These houses may remain isolated foci of vectors in that community, which may contribute to the reinfestation of adjacent improved houses. Project staff should consider whether such houses should simply be sprayed on the exterior walls and in the peridomestic area to achieve some level of vector control.

The baseline data document, "Resultados del estudio de la linea de base en las areas de trabajo 1991" (July 1992) for the pilot project does not include any enumeration of the number of abandoned or seasonally closed houses in each study site. Another project document, "Conceptualizacion del mejoramiento de las viviendas dirigido al control de triatominos" (not dated), states that the first phase of housing improvement in the pilot project was to include actions to demolish "old houses," implying abandoned houses. However, in the same document no criteria were listed to evaluate the success in destruction of old or abandoned houses as a part of vector control. The project document, "Resultados de la evaluacion de las viviendas despues del proceso de mejoramiento en las areas de trabajo de Cochabamba, Tarija y Chuquisaca" (July 1992), did not quantify the number of abandoned houses destroyed, if any, nor the number of rebuilt houses and peridomestic structures.

The team recommends that the baseline data should be amended to include site-specific data on the number of abandoned and seasonally closed houses in the pilot communities. Collection of qualitative data as to the reasons why houses are seasonally abandoned is also recommended for the pilot area baseline data.

The evaluation team recommends that future regional and national programs should include quantitative information on abandoned and seasonally closed houses as well as qualitative information on the reasons for seasonal house closure in the baseline study. Program implementation should include specific steps to destroy any abandoned houses, evaluate the number of houses that were properly demolished as a part of control efforts, and address how housing improvement could be conducted for seasonally closed houses.

Some families who rent their homes (or are squatters) have little or no incentive to participate in housing improvement. The team can only recommend that the project staff search for answers to this difficult problem by seeking solutions from the families and communities themselves, perhaps through focus-group discussions. Broader and more permanent solutions lie only in changes in the land tenure system in Bolivia.

5.4.16 Housing improvement surveillance

The project's 1992 work plan calls for periodic surveillance of houses and the peridomestic environment for reinfestation with *T. infestans*. The team recommends that surveillance should also include a comprehensive qualitative survey for the apparent causes of deterioration of housing improvement (e.g., damage caused by rain, domestic animals, peridomestic rodents and termites, tree roots), as determined by both the householder and evaluator (promotor). Given the great burden of work being conducted by the Cochabamba-based technical team, the evaluation team recommends that project staff should consider shifting the non-entomological component of house surveillance to another group.

5.5 Economics of Control

The economic component of the pilot Chagas' disease control program to date has included numerous internal and external costs, such as:

- salaries (university faculty, project professional staff, SNEM and Unidad Sanitaria staff) and wages (masons, carpenters);
- equipment and supplies (vehicles, insecticides, building materials);

- rent and facility maintenance (portion of CCH office, office in Cochabamba, entomology lab);
- consultants (national and international);
- community participation (training, donated supplies, equipment and labor);
- health education (training, supplies and equipment, transport);
- medical laboratory (serology, parasitology, treatment, investigation of congenital transmission and blood bank problems);
- entomology laboratory (colony maintenance, field bioassays, evaluation of alternative insecticides, insecticide resistance testing);
- field epidemiology and entomology - operational research (serology, sylvatic cycle research, labor, travel);
- house modification (materials, transport, labor); and
- potable water supply (drilling, pumps and equipment, labor).

Both internal and external costs must be continuously and carefully documented in order to properly evaluate expanding the pilot project into a regional or national level control program. Costs for training, insecticide application, monitoring for reinfestation, serological screening, production of educational materials and so forth vary by region. These regional differences will also need to be reflected in planning for expansion of Chagas' disease control in Bolivia.

If expansion to a regional or national control program occurs, one may expect that the first few years will require increased administrative costs to establish and efficiently organize the program. Over time, administrative costs should decline to a stable level, while operational costs should begin to consume a greater portion of the program budget.

5.6 Accomplishments in Economics of Control

5.6.1 Cost savings through community participation

The pilot project has been able to achieve considerable cost savings in housing improvement and insecticide spraying. All communities in the pilot project have contributed a significant amount of labor towards house improvement, on the order of 19 person-days per house. Promoters have been trained to spray residual insecticides, further reducing costs.

Additional cost savings can be obtained through the use of community surveillance for house reinfestation by the vector. This surveillance system uses sensor boxes (e.g., Gomez-Nunez, Maria, or CONICET - Argentina sensor boxes) to detect reinfestation. Householders are given plastic bags or match boxes in which to place any bugs found in the home, and these are delivered to the community promotor. Chuit et al. (1992) found that community-based surveillance using sensor boxes (which were delivered to the local PHC agent) in Argentina was equally as sensitive as the man/hour method of surveillance, and showed a higher sensitivity for detection of low densities of vectors. The cost of the sensor box system was also five times lower than the man/hour method of surveillance.

5.6.2 Cost savings through resource sharing

To date, the project has been able to achieve considerable cost savings because other government agencies have covered salaries of some professional and technical staff of the project. Spraymen have been provided by SNEM at some sites. NGOs such as the Cardenal Maurer Project/Chuquisaca and CARE/Tarija have expended monies (professional and technical staff salaries) and human resources to implement housing improvement, insecticide spraying and production of educational materials. The Cardenal Maurer project obtained further cost savings by training its drivers as promoters.

5.6.3 Development of a costing model

Currently, VBC has contracted with Development Group Inc. of Alexandria, Virginia, to develop a standardized accounting system for the control project and a costing model that should be appropriate for estimating costs of expanded control at the regional or national level. DGI staff have gathered and standardized an extensive set of cost data in the project, including external costs such as volunteer labor provided by the community. The types of cost data collected generally follow the guidelines given in the Report of the WHO Expert Committee on Chagas' Disease Control (1991). The full report of the economic analysis (VBC Report Number 81337) is available in Spanish, as a separate document.

Four cost centers have been identified (La Paz, Cochabamba, Sucre, and Tarija) and their costs separated. Variable, fixed and quasi-fixed costs have been enumerated for each cost center. Recurrent costs have been separated from capital costs, and the model being developed is a full-costing model. Such a model will allow for definition and implementation of control mechanisms.

5.6.4 Cost estimate to protect the nation's entire at-risk population

The costing model developed by DGI staff has been used, together with data from a cost-benefit study in Brazil (Schofield and Dias 1991), to estimate the total costs (in constant 1992 dollars) of an expanded Chagas' disease control program in Bolivia that would reach 50,000 houses per year for a 10-year period. (See **Annex 1**). The estimated total cost is approximately US$14.3 million per year for 10 years. At the end of such an expanded program, the entire Bolivian population currently at risk of the disease (approx. 2.8 million people) would have benefited from the comprehensive disease control effort through improved housing, residual insecticide spraying, surveillance, and treatment of identified acute cases.

5.7 Issues in Economics of Control

5.7.1 Defining and tracking external and internal costs

The internal and external costs of the project have not yet been clearly defined. What is an external cost in one community (e.g., a pre-existing water well used for house improvement) becomes an internal cost in another community (e.g., in Cochabamba, where two communities received new wells as a part of the project).

In the pilot project, typical internal project costs include salaries of La Paz and Cochabamba staff and the costs of vehicles, house improvement materials (cement, lime, roof tiles, windows, screens, doors), insecticides, construction labor (masons), transport, training, preparation of educational materials, serological surveillance and patient treatment. In DGI's costing model, the considerable contributions of participating NGOs are accounted for. It is important to clearly define what the external and internal costs are for each community and region.

5.7.2 Need for permanent staff economists and accountants

In order to properly manage a regional or national level Chagas' disease control program and be successful in obtaining foreign funding, it is strongly recommended that a permanent staff of economists and accountants be hired. The economist(s) should preferably be trained at doctoral level, and be familiar with public agency costing practices and cost-effectiveness analysis. The advisory team does not believe the part-time use of economists and accountants who are assigned other duties will suffice for an expanded control program.

5.7.3 Research on cost recovery methods

In order to effect cost savings in any publicly-funded project, one must develop cost recovery methods wherever possible. In the case of the Chagas' disease control program in Bolivia, the chagastic communities have little if any disposable income or savings to put into a community fund for Chagas' disease control. Any funds spent will likely be on an family basis for the purchase of plaster, extra windows and so forth.

However, cost recovery is obtained from the volunteer labor input from each family, amounting to an average of 19 person-days per house for house improvement.

Cost recovery for certain building materials for house improvement can also be obtained, as in Chuquisaca where some participating communities made their own roof tiles. The Cardenal Maurer Project in Chuquisaca trained its drivers to be promoters. It also trained community members to become professional masons, which enhanced employment and income opportunities for participating families. In Tarija, HABITAT/Bolivia is of the opinion that local, independent artisans will be able to make high-quality doors and windows under contract to the project.

Using the skills learned in housing improvement, participating families and communities may be able to increase their income over time and be able to expend some portion of that future income on house maintenance and repair, thus further reducing the downstream costs of disease control.

It is recommended that a specific study be conducted in the pilot project communities to determine all feasible cost recovery methods for an expanded project. Such a study should intimately involve community members, perhaps using focus groups, to solicit their ideas on cost recovery methods.

5.7.4 Variation in building materials costs

The communities in the pilot project areas vary considerably in terms of language, educational levels, income, distance from urban areas and their surrounding natural environments. These factors and others have created a large variation in the types of housing and corral construction, and the sizes of such structures. Such variations need to be carefully tracked and utilized to plan control activities in similar communities.

5.7.5 Variation in insecticide and spraying costs

The purchase of pyrethroid insecticides currently used in the pilot program constitutes a large percentage (~60%) of the total cost of the household spraying activity. The product currently in use, Cyperator, costs about US$ 55.91/liter. The pyrethroids are relatively new insecticides on the international market, and as such their market price has not yet stabilized.

Compared to malaria control programs, the recurrent costs of spraying improved houses are minimal, since only one spraying just after house improvement is required. In malaria control, there are normally one to two spray cycles per year. However, if house improvements are not maintained through the years (i.e., the house deteriorates naturally or through neglect in maintenance), it may be necessary to repeat a spray every four to five years, after a deteriorated house has been improved or repaired again.

Spraying costs vary according to the size of the house and corrals to be sprayed. For economic reasons, corrals were not sprayed in Chuquisaca, and thus the spray costs were lower there than in Cochabamba and Tarija. Spraying costs/house and corral in Tarija are typically larger because the dimensions of the houses and corrals are much greater than in the other two sites. Such differences should be considered in developing spray operation budgets.

The costs for spray supervision, vehicle purchase and maintenance, transportation to and from communities, insecticides and spray equipment should be detailed in an expanded program budget.

The evaluation team notes that the central entomology laboratory will sustain recurrent, variable costs for reagents and test kits for insecticide resistance. For reasons of staff health and safety, the team recommends a capital expenditure to repair and improve the quality of the Cochabamba entomology laboratory and to increase its size.

5.7.6 Costs to develop regional and central epidemiological surveillance centers

The team recommends the establishment of regional centers to decentralize the serological screening program for Chagas' disease (serological analysis by IHI and IF). A central reference laboratory would verify seropositive tests using ELISA. IHI and IF tests are relatively inexpensive, compared to ELISA, and less specialized equipment is needed at regional facilities (e.g., an IF microscope), while a larger fixed cost would be incurred at the central reference laboratory to purchase and operate an ELISA reader. Additional costs will accrue to pay the salaries and training expenses for professional staff and to rent or purchase the laboratory sites. These fixed and variable costs should be included in the budget for an expanded control program.

5.7.7 Potable water provision: converting an external cost to internal cost

In the discussion of housing improvement, the team argued that potable water supply provision be considered for needy communities to encourage full and timely participation in house improvement for Chagas' disease control. On these grounds, the team further recommends that potable water supplies, typically treated as an external cost, be converted to an internal cost (estimated) for each community in which the control program will operate.

5.7.8 Planning for cost-effectiveness analysis

A TDR expert consultation on standard protocols for testing new control strategies for Chagas' disease was held in Montevideo, Uruguay, in October 1989. The expert panel recommended that control programs be economically evaluated using cost-effectiveness analysis (CEA) (see TDR, 1989).

Based upon the work of DGI, extensive cost data from the pilot project are now available and organized. Though cost data are available, in order to conduct CEA one must also have delineated a specific set of criteria or objectives, that defines "project effectiveness." Project staff have not had the opportunity to do this as yet.

It is recommended that project staff conduct a CEA of the pilot project to date. Generally, to conduct a CEA, project staff must first set a specific, quantifiable objective (NB: it is not necessary to quantify in monetary terms) for each community in the project. An example of a quantifiable, specific objective may be: "to improve all occupied houses in community x, and to observe no more than a 5% house reinfestation rate after 1 (or 2) year(s)."

Simultaneously, project staff should define each combination of health education, community participation, housing improvement and insecticide spraying "tools" used in each community. Once these prerequisite steps are complete, staff would then use the house reinfestation data and the cost data to conduct the CEA.

Details as to how to conduct a CEA for Chagas' disease control may be found in TDR (1989). Such an exercise will require economists trained at the doctoral level and familiar with CEA.

5.8 Education and Community Participation

Education and community participation activities are fundamentally important in Chagas' disease control programs. Effective education of the target population with respect to the disease and its transmission are necessary prerequisites to enlisting and motivating community participation in control activities. Similarly, education and training are required to enable families to make the necessary modifications in their homes, animal corrals and personal behavior in order to reduce vector-host contact and thus reduce the rate of disease transmission. In addition, community-based surveillance for continued vector control will be required following successful community programs, and must be sustained by educated and motivated community members. Effective community participation in all aspects of a community-based vector control program is a *sine qua non* both for successful program implementation and for long term follow-up for sustained vector control.

5.9 Review of Education and Community Participation

The evaluation team reviewed program activities related to education and community participation in villages in three areas. The areas, villages and the number of houses in each village are listed below.

Program activities began in January 1991 with the selection of the villages to be included in the pilot program. Project activities related to education and community participation in the villages in the Cochabamba and Tarija areas were implemented by CCH/Chagas' program staff and the format was similar in all villages.

In contrast, in the villages in the Chuquisaca area the project was implemented by Proyecto Cardinal Maurer, an integrated primary health care/community development program that had been underway for several years. CCH provided financial support to this NGO to implement a Chagas' disease control program in the villages where it was working.

Cochabamba	No. houses	Tarija	No. houses	Chuquisaca	No. houses
Aramasi Grande	110	Lajas	90	Tasapampa	97
Aramasi Linde	132	Erquis Norte	87	Santa Rosa	49
Blanco Rancho	58	Erquis Sur	63	Tiwacan	58
		Erquis Oropeza	54	Jatunckaka	83
				Candelaria	85
				Saruphaya	64
	Total: 300		Total: 294		Total: 436

The program in Chuquisaca is fundamentally different from that developed in Cochabamba and Tarija since the Proyecto Cardinal Maurer staff developed its own educational program and materials and relied on its extant program infrastructure to promote community participation for the control of Chagas' disease.

Unlike the program in Chuquisaca, the villages selected for intervention in the Cochabamba and Tarija areas had no program infrastructure. Accordingly, in order to initiate program activities, project team members visited the villages, identified village leaders and collaborated in the formation of village committees. The local power structure (e.g., the church and other village organizations) was also enlisted in this activity. The village committees then selected the community promoters, who in turn were trained and subsequently supervised by a CCH staff education specialist. The ratio of community promoters to houses is approximately 1:50 during the initial stage of the project, and promoters receive B10.00/day (US $2.50/day).

Unlike the initial work for other project components (e.g., entomology and epidemiology), systematic baseline data on knowledge, attitudes and practices (KAP) related to Chagas' disease, housing, community structure, values and organization were not collected prior to the development of program activities. Rather, the education, training and community mobilization activities were designed by project staff, based on an intimate knowledge of the community.

Following the organization of village committees and the selection and training of the community promoters, the village-level education, training and promotional activities begin. The staff education specialist trains and supervises the village promoters and uses project manuals for planning and executing activities in the village. Promoters motivate community residents through group meetings and individual family visits.

Educational activities are conducted by the staff education specialist and reinforced by promoters at community meetings and through visits to individual families. Information is provided about Chagas' disease, including symptoms, impact on health, the role of the *vinchuca* in transmission, vector habitat and vector control. Visual aids and other educational material are developed by the staff education specialist.

The educational materials developed by the project and the nonformal participatory activities employed in the education program appeared to be generally excellent and very creative. This was particularly the case with the Proyecto Cardinal Maurer. Careful observation had convinced the program staff that important and enduring behavior changes had occurred. Nevertheless, no systematic evaluation of the education program has been carried out, making it impossible to estimate its effectiveness in improving knowledge and changing behavior.

Village committees are the functional units where plans and priorities for house improvements are decided and where all participatory activities are coordinated. Training is provided in basic construction skills and use of local materials for home improvement. Villagers participate in the program by donating time and providing locally available materials. The village committee designates a community member who is responsible for control of all construction materials. Materials are provided in small amounts as needed.

Animal corrals are given first priority in the home improvement program. These are moved away from the house (up to 10 meters where possible) and are designed for improved vector control. Home improvement is the next project focus, followed by promotion of behaviors related to orderliness in the storage of personal effects and household goods.

Following completion of the home improvement program, plans call for the reduction of the promotors to a household ratio of 1:200 for spraying activities. The need for continued long-term surveillance for ongoing vector control is foreseen. Current plans call for incorporation of this activity into the primary health care activities of the regional sanitary unit of the Ministry of Social Prevention and Public Health.

This pilot program, as carried out in the villages in Cochabamba and Tarija, appears to have been very effective in enlisting community participation in housing improvement during its initial phase. Significant progress has been made in a brief period of time. Manuals describing program activities have been produced for most program components, permitting replication and extension of these aspects of the program by other organizations. An indicator of the effectiveness of the program in promoting community participation is reflected in compliance rates for house improvement. These are reported to range from 94 to 98 percent.

The program implemented by Projecto Cardinal Maurer in the Chuquisaca region was also very successful. Although no systematic evaluation was conducted, the evaluation team members were uniformly impressed by the quality of the educational activities and materials. Similarly, the house improvement component of the program was extremely effective. Since in Chuquisaca, the Chagas' disease control program was "inserted" into an ongoing integrated primary health care/community development program, it is not directly replicable. Nevertheless, with proper field testing and appropriate modification, the educational material and non-formal educational techniques will be useful in similar projects in other areas.

5.10 Plans for Future Education Activities

The systematic evaluation of community knowledge, attitudes and behaviors related to Chagas' disease, housing, community participation and other fundamental program components has not been conducted. Recommendations for the systematic evaluation of education and community participation activities and suggestions for appropriate methods were developed by consultants who visited the Tupiza project site in August 1991. Plans to initiate activities along this line are underway. CCH will contract the services of the United Nations Agency for Human Settlements (HABITAT) to conduct field research in the Tarija area.

HABITAT has been active in community-based housing programs in Bolivia since 1989. This group has experience in developing "bottom-up" community programs, identifying constraints to program implementation, and developing, pretesting, refining and employing educational materials in development programs. It also has both the technical equipment and human resources to produce professional quality educational material.

Current plans call for HABITAT to develop a conceptual framework for community participation based on community values, beliefs and attitudes. This group will develop, implement and field test a nonformal, participatory educational model that will be broadly applicable for diverse socio-economic and ethnic groups. In addition, HABITAT will produce and pretest a series of educational materials appropriate for use in this and other Chagas' control programs. Operational research will be carried out to determine the feasibility of food-for-work programs to support housing improvement, and to test formats for project financing, including village-based rotating funds and cost recovery mechanisms.

A central consideration in the effort by HABITAT will be program replicability. The basic program modules related to education and training, community motivation and participation, and program financing schemes will be designed to be appropriate for use in other areas of the country.

In addition to the program development activities described above, which will be undertaken by HABITAT in the Tarija area, there are also plans to extend the program in the Cochabamba area. Using the methodology developed during the first year of the program, the CCH team in Cochabamba will implement control activities in a yet to be determined number of villages. Detailed plans for program extension and evaluation are currently being developed.

6. Project Administration and Coordination

The operational and administrative aspects of the pilot project are complex. Multiple field sites and participating organizations create administrative demands beyond those of other projects of similar size Although a management analysis was not part of the scope of work for this evaluation, the following observations are presented.

Centralization of the operational authority in Cochabamba for the initial phase of the project was an excellent decision. As additional organizations become involved, however, the administrative structure of the project will need to be reviewed and perhaps revised to ensure effective coordination and communication.

The appointment of Lic. Jaime Burgoa as project coordinator will strengthen project administration and coordination significantly. Nevertheless, there remains the need to develop an operational plan that will guide project efforts and permit effective use of resources, enhance coordination among project sites and other collaborating organizations, and ensure agile communication among all parties. Such coordination, at a minimum, should facilitate regular exchange of program formats, materials, methods and results in order to avoid wasteful duplication.

Toward this end, it would be useful to develop an operational plan, perhaps using a formal project planning format (e.g. Log Frame, Pert, Gant) to guide project planning and implementation activities. Moreover, the use of such a format will facilitate ongoing process evaluation for management purposes and facilitate opportune management intervention to ensure effective project performance.

7. Recommendations

1. Communication and coordination between project sites should be strengthened and methodologies and results should be shared on a regular basis. With the entry of HABITAT, there is an increased possibility of wasteful duplication of effort unless regular and effective communication among project sites can be established.

2. Project management should develop an integrated operational plan for the projected life of the project. Such a plan, cast in an operational format (e.g. Logical Framework, Gant, Pert), will facilitate project management.

3. Estimation of important epidemiological indicators, such as Density Index, Dispersion Index and Colonization Index, is recommended for the evaluation of the effectiveness of the control measures and for monitoring the extension of the disease.

4. Available data on house features and characteristics should be submitted to a careful quantitative analysis in order to identify and rank risk factors related to house infestation by *T. infestans*.

5. Special attention should be given to domestic animal quarters in order to guarantee that the walls or corrals do not have cracks, and in the case of guinea pig pens a mechanism that will facilitate inspection, such as lids, should be incorporated.

6. Since triatomines were not detected in some houses, it would be valuable to design a case-control study to determine the Odds Ratios of the risk factors related to this phenomenon.

7. A seroprevalence follow-up survey is recommended as a mechanism for monitoring active transmission during the surveillance phase. In order to classify a person as serologically positive, at least two of the three tests used in the central laboratory must be positive.

8. A well-designed national control program should be initiated to establish a blood bank network to prevent transmission of Chagas' disease by blood transfusion.

9. The National Entomology Laboratory needs a "clean" space, separate from other laboratory operations, for carrying out dissections of triatomines to determine infection rates with *T. cruzi*. This space should be equipped with a hood and an air exhaust system.

10. In the future, insecticide testing should be done with the same pyrethroid compounds tested in early 1992, but at higher dosage rates.

11. The field trials of the alternative vector control methodologies — insecticidal paint and fumigant insecticide dispensers — should proceed as soon as the transfer of funds can be arranged.

12. Future operational research projects should include testing of new methodologies for the evaluation of house reinfestation by Chagas' vectors. Active collaboration with other research institutions should be encouraged.

13. As the project in the Cochabamba area expands into new villages, baseline data should be collected on knowledge, attitudes and practices related to Chagas' disease, housing, community values, aspirations, organization and structure. This will permit evaluation of the effectiveness of program efforts in education and community participation.

14. The evaluation team has established a clear need to link potable water supply to the housing improvement component of the Chagas' disease control project. Therefore, a) one of the main criteria for the provision of new or expanded potable water supplies in Bolivia should be the prevalence of Chagas' disease, i.e., communities with a high prevalence of Chagas' disease should be among the first to receive new or expanded potable water systems, and b) all communities at risk of Chagas' disease that also have a clear need for new or expanded potable water supplies should be provided potable water as a part of the housing improvement component.

15. The housing improvement component should be linked to improved animal husbandry in order to encourage and assist families to simultaneously improve the health of their animals and the condition of animal housing (corrals and small animal shelters) for the purpose of reducing the populations of *T. infestans* that feed and shelter in animal housing.

16. Models need to be developed that clearly delineate all the variables in housing improvement in the three study areas, including: variations in education, community participation (in labor and materials provision, construction, quality control, reinfestation surveillance), house design and size, house and corral improvement methods, human resources and locally available building materials.

17. Systematic surveillance and evaluation of the life span of improved walls, ceiling, roofs, foundations, floors, windows, doors, corrals and small animal shelters is needed, with emphasis on determining why and when particular structures deteriorate.

18. Housing improvements for Chagas' disease control need to be integral, covering all parts of the house, corrals and other peri-domestic structures, in order to reduce vector populations and risk of disease transmission. Partial housing improvements will not reduce risk.

19. The problems of incomplete housing improvement and abandoned, seasonally closed and rented houses need to be systematically evaluated, with the participation of the affected communities, to determine the barriers and limiting factors to improving (or demolishing) these houses. Options include spraying of abandoned, seasonally closed, or rented houses.

20. External and internal costs need to be clearly defined and desegregated by community and regions in the accounting system.

21. An expanded control program will need a permanent, full-time staff of at least one PhD-level economist and two accountants in order to separate the complex accounts in the control program, effect cost control measures, and conduct periodic cost-effectiveness analyses.

22. Research on cost recovery methods is needed to determine all the different community-based methods of cost recovery available to a control program, including family- and community-based provision of labor, supplies, and equipment.

23. Plans for an expanded control program will need to include means to account for strong regional variations in the costs of building materials for house improvement, and the costs of insecticides and their application.

24. Potable water supplies, typically treated as an external cost in the project, should be converted to an internal cost to the project and any expanded control program to reflect the recommendation that potable water supply provision be linked to Chagas' disease control activities

25. Specific objectives for the pilot control project need to be defined; for example: "The project will improve all occupied houses in the community "x" by date "y", and will observe no more than a 5% house reinfestation rate by year "z." Next, the objectives should be linked to the costing data to effect a cost-effectiveness analysis of the project.

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Annex 1

People Contacted

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2. **CCH Project/La Paz**

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3. **CCH Project/Chagas' Component**

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Dr. Julio Pizarro, Director, Sanitary Unit, Tarija
Dr. Guillermo Quinteros, Director, Sanitary Unit, Chuquisaca

5. **HABITAT (U.N. Commission for Human Settlements)**

   Dra. Irene Vance, Coordinator, Bolivia Office

6. **Social Investment Fund**

   Dr. Luis Alberto Valle, Minister/Director

7. **Vector Biology and Control Project (VBC)**

   Dr. Andrew A. Arata, Deputy Director

8. **World Food Program (Programa Mundial de Alimentos)**

   Dr. Praveen K. Agrawal

Annex 2

Tables and Graphs

This annex includes graphs and tables that were generated based on costing data compiled and adjusted by DGI, economic consultants to the Chagas' disease control project through the VBC Project (see page 35).

Graph 5-11 is a projection of estimated costs to extend the current control program (education, community participation, training, research, house improvement, residual insecticide spraying, case treatment and reinfestation surveillance) to the entire population at risk of Chagas' disease in Bolivia (approx. 2.8 million people). The projection is based upon a cost of approximately US$ 14.3 million each year for 10 years, to protect 50,000 houses and their residents each year.

Graph 5-10 summarizes the unit costs of control (house improvement and spraying) for the three regions served by the pilot project (Tarija, Cochabamba, Chuquisaca).

Graphs 5-7 through 5-9 detail the structure of costs (administration, materials for house improvement, transport, and salaries) for housing improvement for the three areas.

Tables 5.1 through 5.3 show the unit costs of residual insecticide spraying for each of the three areas and each community therein. Tables 5.4 through 5.6 show the unit costs for housing improvement.

Graph 5-4A shows the total expenditures for the entire project, desegregating the expenditures for spraying, house improvement, education, research and administration. Graphs 5-4 through 5-6 detail the structure of expenditures for each of the three field sites.

Graphs 5-1 through 5-3 display the evolution of costs over time (trimesters) for La Paz, Cochabamba and Chuquisaca, including capital and recurrent costs. Data for Tarija is not shown.

Unit Costs of Insecticide Spraying in Tarija, Cochabamba, Chuquisaca

COSTOS UNITARIOS DE ROCIAMIENTO

CENTRO DE COSTO: TARIJA

COMUNIDAD	NUMERO DE VIVIENDAS	REMUNERACIONES	VIATICOS Y TRANSPORTE	INSECTICIDA	GASTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
Oropeza	52	35.41	17.70	3,075.80	570.47	3,699.38	71.14
Erquis N.	87	60.29	31.06	5,146.05	954.44	6,191.84	71.17
Erquis S.	67	44.22	22.78	3,962.16	735.03	4,764.19	71.11
Total	206	139.92	71.54	12,184.01	2,259.94	14,655.41	71.14

COSTOS UNITARIOS DE ROCIAMIENTO

CENTRO DE COSTO: COCHABAMBA

COMUNIDAD	No. VIVIEND	REMUNERACIONES	VIATICOS Y TRANSPORTE	INSECTICIDA	GASTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
ARAMASI G.	173	340.81	992.57	6,134.58	4,759.18	12,227.14	70.68
ARAMASI L.	152	299.44	870.96	5,389.92	4,181.48	10,741.80	70.67
Blanco Rancho	64	126.35	366.72	2,272.77	1,760.62	4,526.46	70.73
Total	389	766.60	2,230.25	13,797.27	10,701.28	27,495.40	70.68

COSTOS UNITARIOS DE ROCIAMIENTO

CENTRO DE COSTO: CHUQUISACA

COMUNIDAD	No. VIVIEND	REMUNERACIONES	VIATICOS Y TRANSPORTE	INSECTICIDA	GASTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
SANTA ROSA	48	102.54	410.82	1,151.04	210.70	1,875.10	39.06
TASA PAMPA	100	123.89	633.50	2,398.00	438.96	3,594.35	35.94
TIHUACANA	65	130.70	672.31	1,558.70	285.32	2,647.03	40.72
JATUN CKACKA	91	190.96	875.56	2,182.18	399.45	3,648.15	40.09
SARUPHAYA	73	144.34	797.10	1,750.54	320.44	3,012.42	41.27
CANDELARIA	83	182.07	834.02	1,990.34	364.34	3,370.77	40.61
Total	460	874.50	4,223.31	11,030.80	2,019.22	18,147.83	39.45

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Unit Costs — Housing Improvement in Tarija, Cochabamba, Chuquisaca

COSTOS UNITARIOS - MEJORAMIENTO DE VIVIENDA

CENTRO DE COSTO: TARIJA

COMUNIDAD	No. VIVIEND	REMUNERACIONES	TRANSPORTE	MATERIAL DE CONSTRUCCION	COSTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
Oropeza	46	9,155.89	2,005.41	21,972.14	6,248.11	39,381.54	856.12
Erquis N.	81	16,122.32	3,531.26	38,690.07	11,002.11	69,345.76	856.12
Erquis S.	67	13,335.75	2,920.92	32,002.90	9,100.51	57,360.07	856.12
Lajas	90	17,913.69	3,923.62	42,988.97	12,224.56	77,050.84	856.12
Total	284	56,527.64	12,381.20	135,654.09	38,575.29	243,138.22	856.12

COSTOS UNITARIOS - MEJORAMIENTO DE VIVIENDA

CENTRO DE COSTO: COCHABAMBA

COMUNIDAD	No. VIVIEN	REMUNERACIONE	TRANSPORTE	MATERIAL DE CONSTRUCCION	GASTOS ADMINISTRATIV	COSTO TOTAL	COSTO UNITARIO
ARAMASI G.	152	23,799.12	5,514.75	77,668.20	42,294.00	149,276.07	982.08
ARAMASI L.	110	17,223.05	3,990.94	56,207.25	30,607.50	108,028.73	982.08
Blanco Rancho	58	9,081.24	2,104.31	29,636.55	16,138.50	56,960.61	982.08
Total	320	50,103.41	11,610.00	163,512.00	89,040.00	314,265.41	982.08

NOTA.- Los componentes de transportes y materiales de construccion fueron incrementados con el aporte del PMA en tejas por Bs 74.120.- y transporte por Bs. 11.610.- llegando a un total de Bs. 85.730.-

COSTOS UNITARIOS - MEJORAMIENTO DE VIVIENDA

CENTRO DE COSTO: CHUQUISACA

COMUNIDAD	No. VIVIEND	REMUNERACIONES	TRANSPORTE	MATERIAL DE CONSTRUCCION	GASTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
SANTA ROSA	44	3,398.49	2,120.61	21,106.31	3,168.39	29,793.79	677.13
TASA PAMPA	93	7,183.17	4,482.19	44,611.06	6,696.82	62,973.24	677.13
TIHUACANA	55	4,248.11	2,650.76	26,382.88	3,960.48	37,242.24	677.13
JATUN CKACK	86	6,642.50	4,144.82	41,253.24	6,192.76	58,233.31	677.13
SARUPHAYA	66	5,097.73	3,180.91	31,659.46	4,752.58	44,690.68	677.13
CANDELARIA	60	4,634.30	2,891.74	28,781.33	4,320.53	40,627.89	677.13
Total	404	31,204.30	19,471.02	193,794.27	29,091.56	273,561.15	677.13

Total Expenses by Technical Area

COSTOS UNITARIOS DE ROCIAMIENTO

CENTRO DE COSTO: TARIJA

COMUNIDAD	NUMERO DE VIVIENDAS	REMUNERACIONES	VIATICOS Y TRANSPORTE	INSECTICIDA	GASTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
Oropeza	52	35.41	17.70	3,075.80	570.47	3,699.38	71.14
Erquis N.	87	60.29	31.06	5,146.05	954.44	6,191.84	71.17
Erquis S.	67	44.22	22.78	3,962.16	735.03	4,764.19	71.11
Total	206	139.92	71.54	12,184.01	2,259.94	14,655.41	71.14

COSTOS UNITARIOS DE ROCIAMIENTO

CENTRO DE COSTO: COCHABAMBA

COMUNIDAD	No. VIVIEND	REMUNERACIONES	VIATICOS Y TRANSPORTE	INSECTICIDA	GASTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
ARAMASI G.	173	340.81	992.57	6,134.58	4,759.18	12,227.14	70.68
ARAMASI L.	152	299.44	870.96	5,389.92	4,181.48	10,741.80	70.67
Blanco Rancho	64	126.35	366.72	2,272.77	1,760.62	4,526.46	70.73
Total	389	766.60	2,230.25	13,797.27	10,701.28	27,495.40	70.68

COSTOS UNITARIOS DE ROCIAMIENTO

CENTRO DE COSTO: CHUQUISACA

COMUNIDAD	No. VIVIEND	REMUNERACIONES	VIATICOS Y TRANSPORTE	INSECTICIDA	GASTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
SANTA ROSA	48	102.54	410.82	1,151.04	210.70	1,875.10	39.06
TASA PAMPA	100	123.89	633.50	2,398.00	438.96	3,594.35	35.94
TIHUACANA	65	130.70	672.31	1,558.70	285.32	2,647.03	40.72
JATUN CKACKA	91	190.96	875.56	2,182.18	399.45	3,648.15	40.09
SARUPHAYA	73	144.34	797.10	1,750.54	320.44	3,012.42	41.27
CANDELARIA	83	182.07	834.02	1,990.34	364.34	3,370.77	40.61
Total	460	874.50	4,223.31	11,030.80	2,019.22	18,147.83	39.45

COSTOS UNITARIOS MEJORAMIENTO DE VIVIENDA

CENTRO DE COSTO: TARIJA

COMUNIDAD	No. VIVIEND	REMUNERACIONES	TRANSPORTE	MATERIAL DE CONSTRUCCION	COSTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
Oropeza	46	9,155.89	2,005.41	21,972.14	6,248.11	39,381.54	856.12
Erquis N.	81	16,122.32	3,531.26	38,690.07	11,002.11	69,345.76	856.12
Erquis S.	67	13,335.75	2,920.92	32,002.90	9,100.51	57,360.07	856.12
Lajas	90	17,913.69	3,922.52	42,988.97	12,224.56	77,050.84	856.12
Total	284	56,527.64	12,381.20	135,654.09	38,575.29	243,138.22	856.12

COSTOS UNITARIOS - MEJORAMIENTO DE VIVIENDA

CENTRO DE COSTO: COCHABAMBA

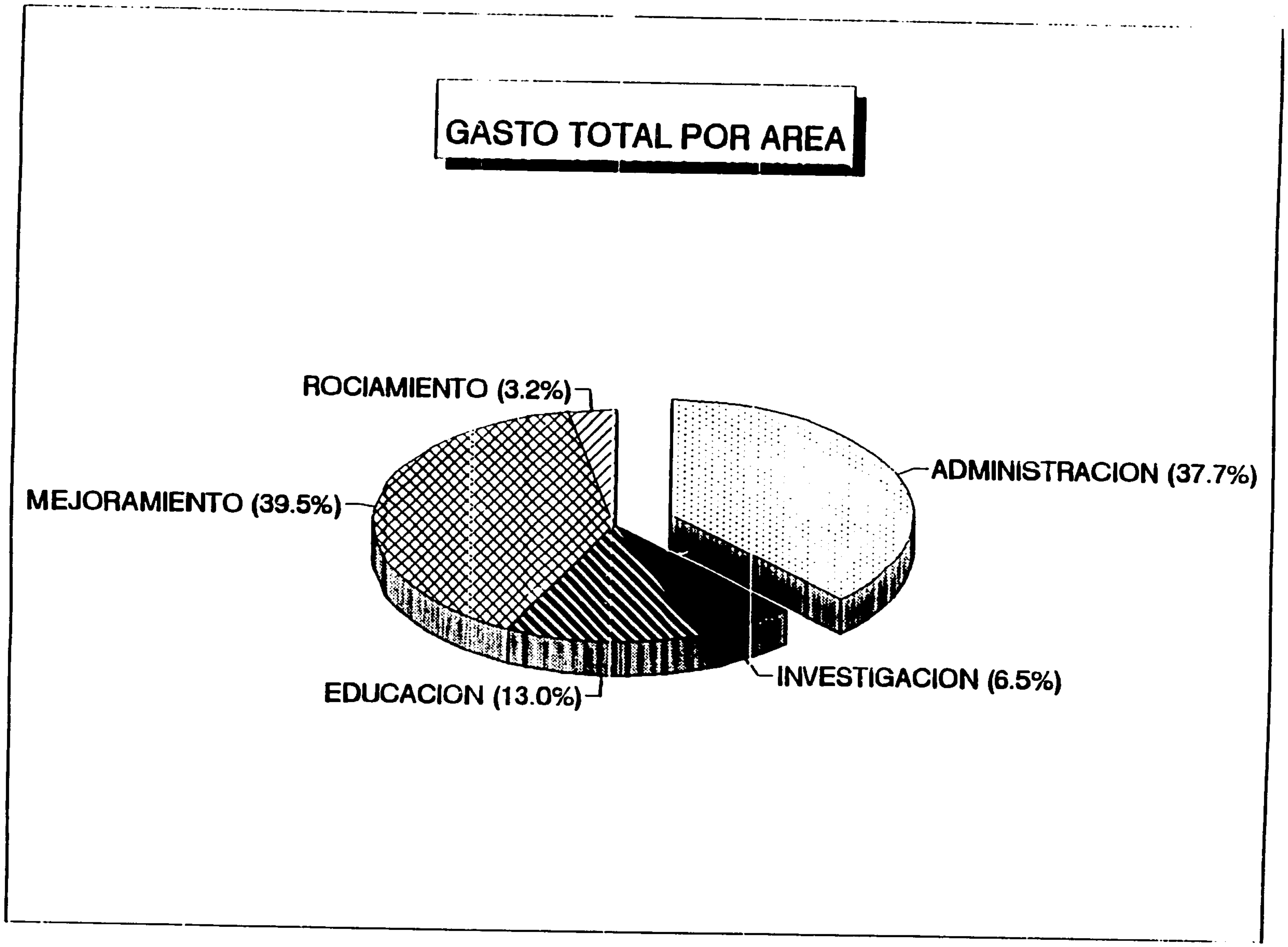
COMUNIDAD	No. VIVIEN	REMUNERACIONE	TRANSPORTE	MATERIAL DE CONSTRUCCION	GASTOS ADMINISTRATIV	COSTO TOTAL	COSTO UNITARIO
ARAMASI G.	152	23,799.12	5,514.75	77,668.20	42,294.00	149,276.07	982.08
ARAMASI L.	110	17,223.05	3,990.94	56,207.25	30,607.50	108,028.73	982.08
Blanco Rancho	58	9,081.24	2,104.31	29,636.55	16,138.50	56,960.61	982.08
Total	320	50,103.41	11,610.00	163,512.00	89,040.00	314,265.41	982.08

NOTA.- Los componentes de transportes y materiales de construccion fueron incrementados con el aporte del PMA en tejas por Bs 74.120.- y transporte por Bs. 11.610.- llegando a un total de Bs. 85.730.-

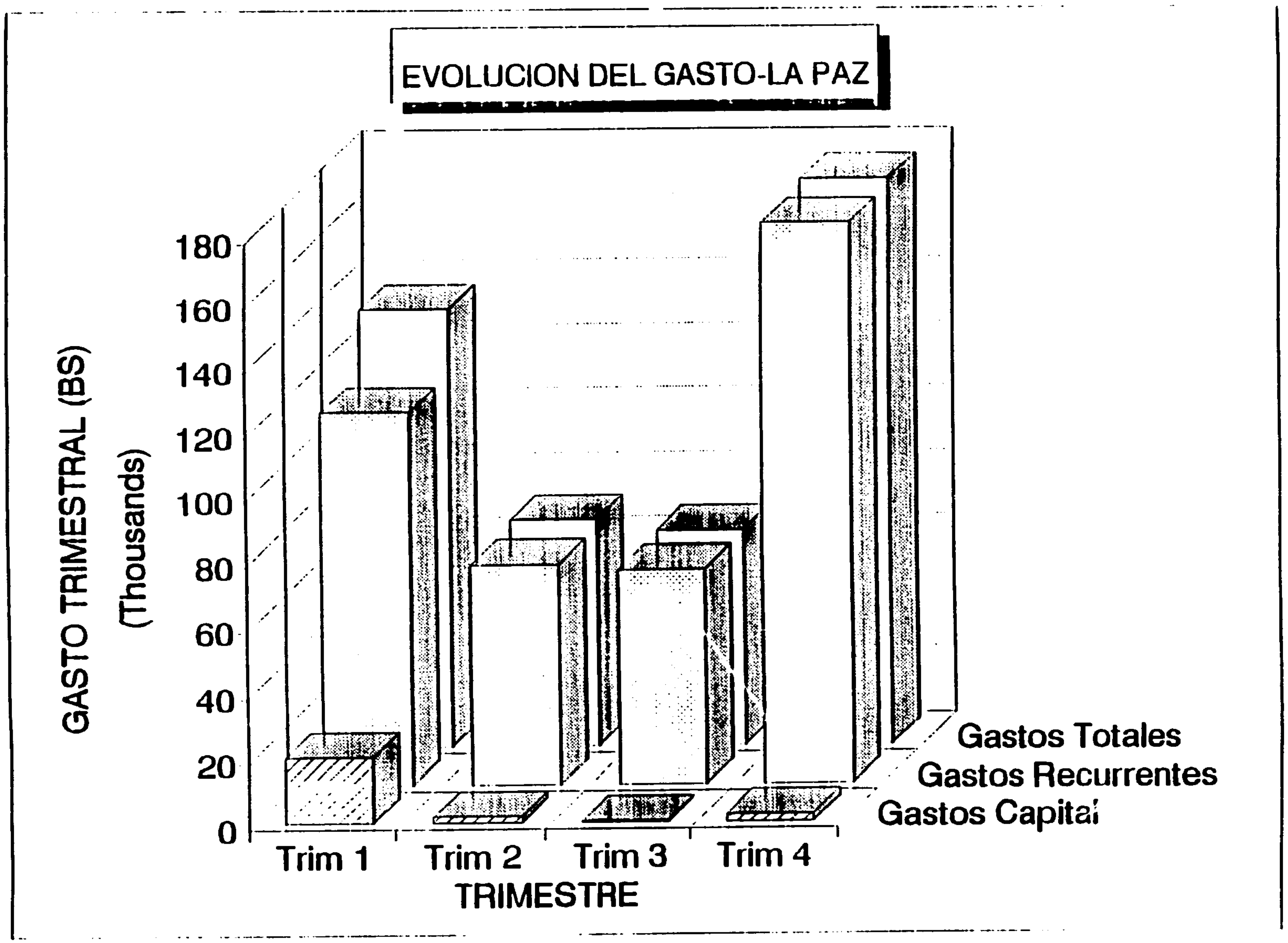
COSTOS UNITARIOS - MEJORAMIENTO DE VIVIENDA

CENTRO DE COSTO: CHUQUISACA

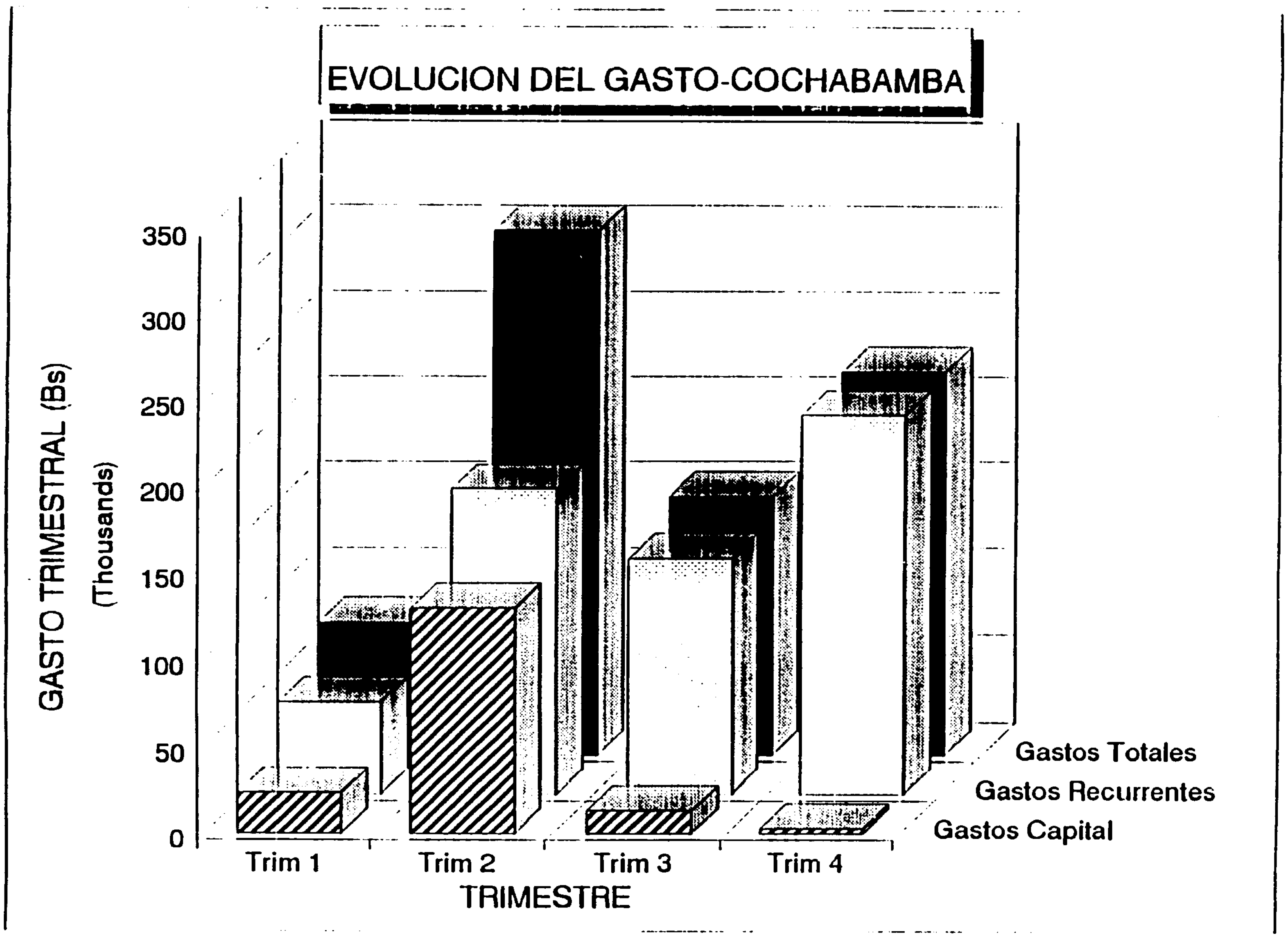
COMUNIDAD	No. VIVIEND	REMUNERACIONES	TRANSPORTE	MATERIAL DE CONSTRUCCION	GASTOS ADMINISTRATIVOS	COSTO TOTAL	COSTO UNITARIO
SANTA ROSA	44	3,398.49	2,120.61	21,106.31	3,168.39	29,793.79	677.13
TASA PAMPA	93	7,183.17	4,482.19	44,611.06	6,696.82	62,973.24	677.13
TIHUACANA	55	4,248.11	2,650.76	26,382.88	3,960.48	37,242.24	677.13
JATUN CKACK	86	6,642.50	4,144.82	41,253.24	6,192.76	58,233.31	677.13
SARUPHAYA	66	5,097.73	3,180.91	31,659.46	4,752.58	44,690.68	677.13
CANDELARIA	60	4,634.30	2,891.74	28,781.33	4,320.53	40,627.89	677.13
Total	404	31,204.30	19,471.02	193,794.27	29,091.56	273,561.15	677.13

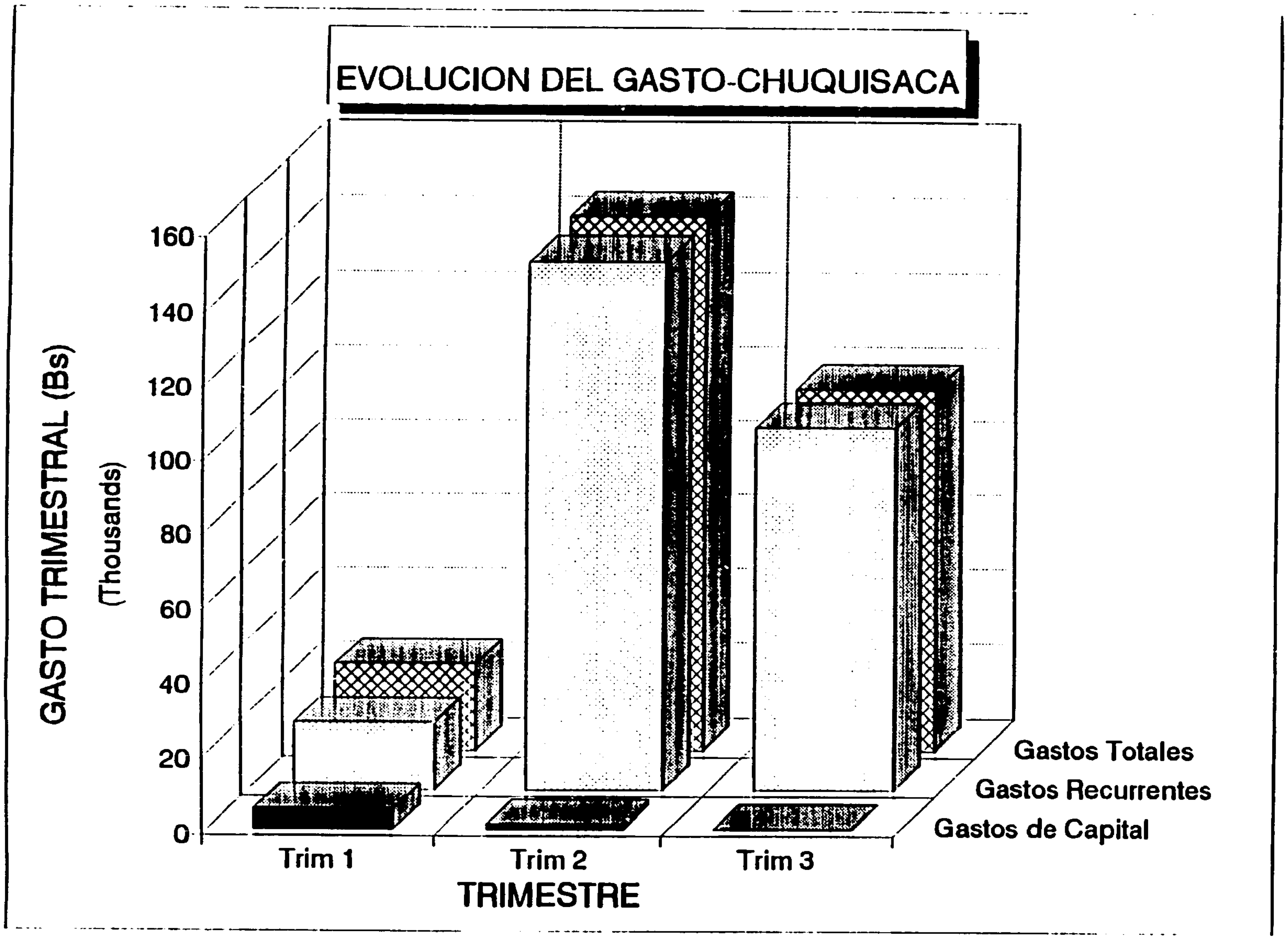

GASTO TOTAL POR AREA
ROCIAMIENTO (3.2%)
ADMINISTRACION (37.7%)
MEJORAMIENTO (39.5%)
INVESTIGACION (6.5%)
EDUCACION (13.0%)

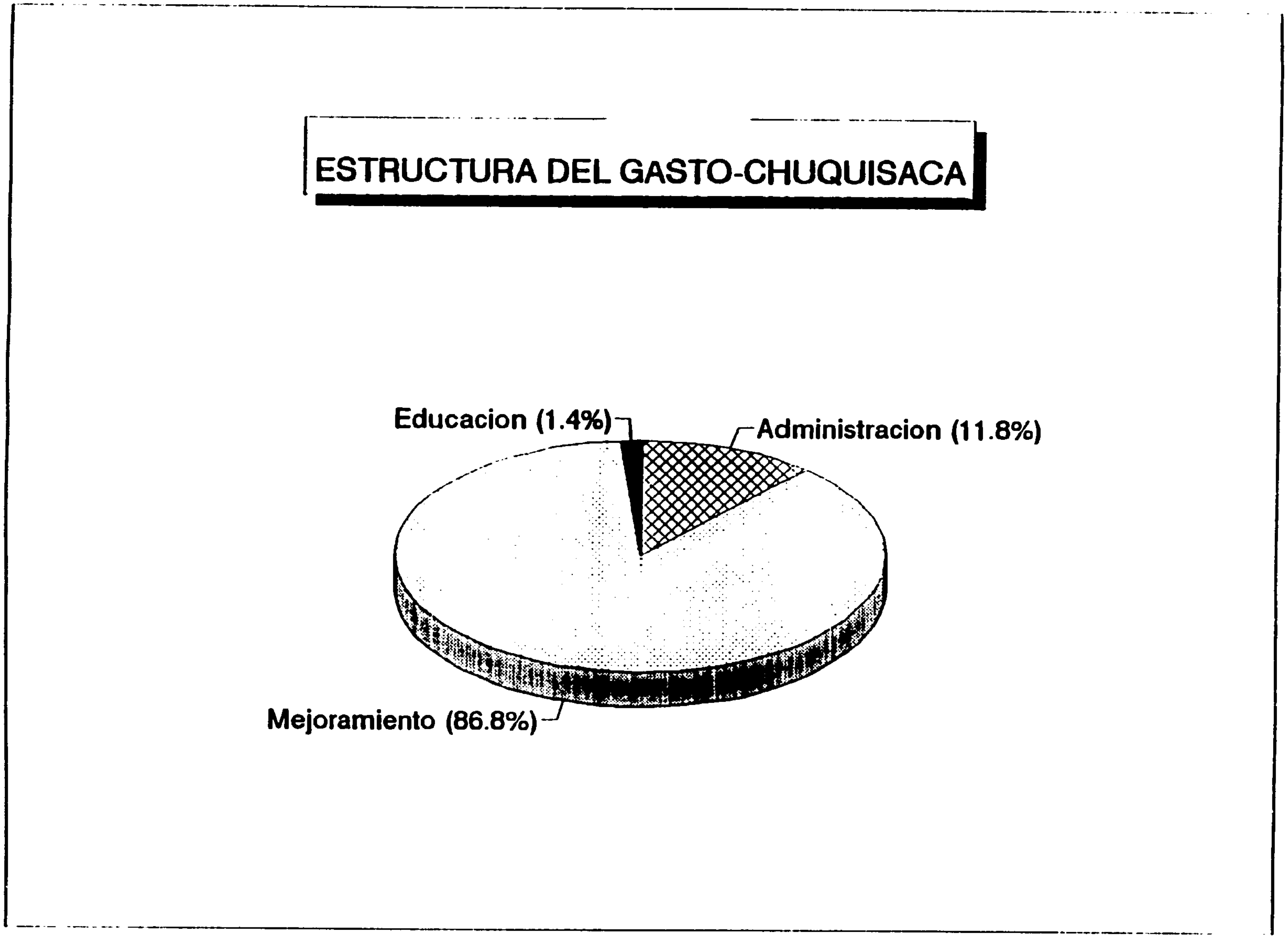
62.


EVOLUCION DEL GASTO-LA PAZ
GASTO TRIMESTRAL (BS)
(Thousands)
180
160
140
120
100
80
60
40
20
0
Trim 1
Trim 2
Trim 3
Trim 4
TRIMESTRE
Gastos Totales
Gastos Recurrentes
Gastos Capital

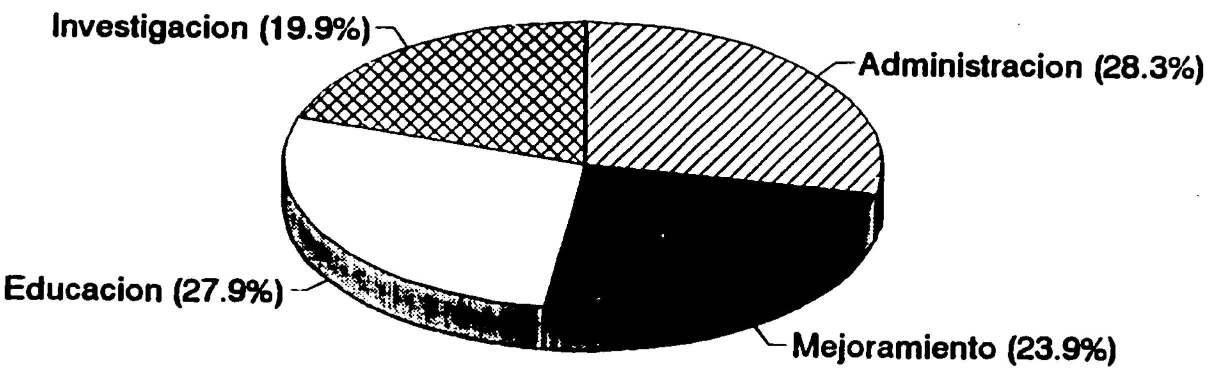
63


EVOLUCION DEL GASTO-COCHABAMBA
GASTO TRIMESTRAL (Bs)
(Thousands)
350
300
250
200
150
100
50
0
Trim 1
Trim 2
Trim 3
Trim 4
TRIMESTRE
Gastos Totales
Gastos Recurrentes
Gastos Capital

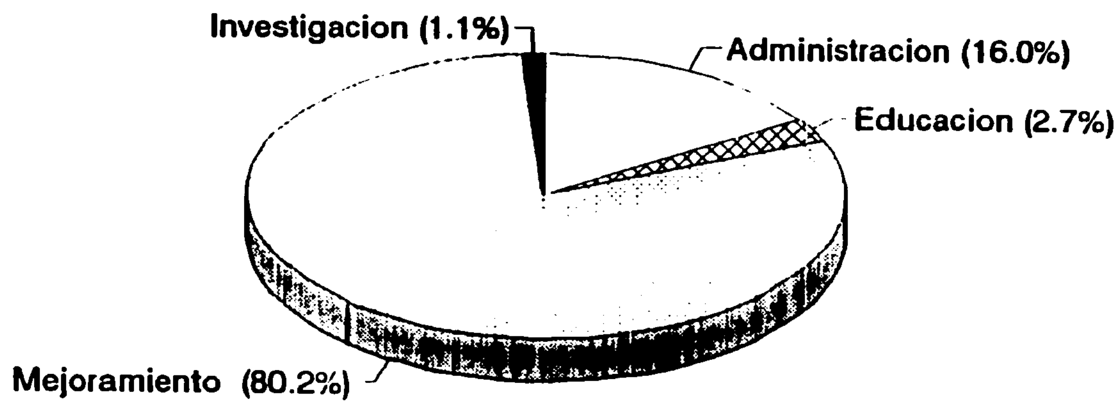

EVOLUCION DEL GASTO-CHUQUISACA
GASTO TRIMESTRAL (Bs)
(Thousands)
160
140
120
100
80
60
40
20
0
Trim 1
Trim 2
Trim 3
TRIMESTRE
Gastos Totales
Gastos Recurrentes
Gastos de Capital


ESTRUCTURA DEL GASTO-CHUQUISACA
Educacion (1.4%)
Administracion (11.8%)
Mejoramiento (86.8%)

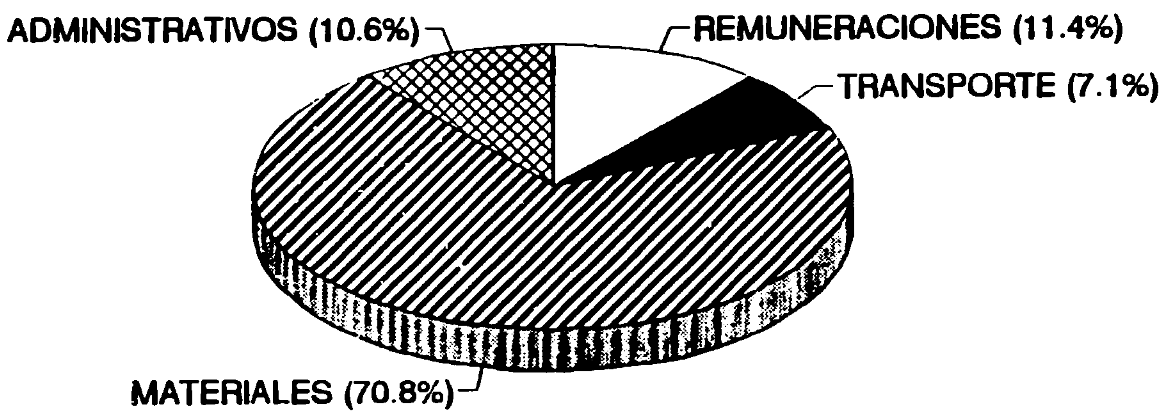
ESTRUCTURA DEL GASTO-COCHABAMBA



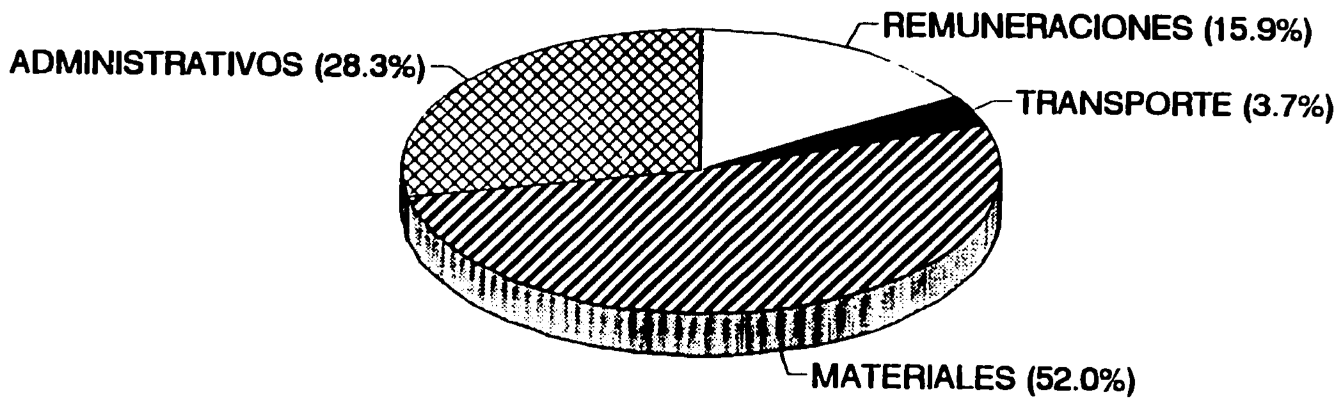
ESTRUCTURA DEL GASTO-TARIJA

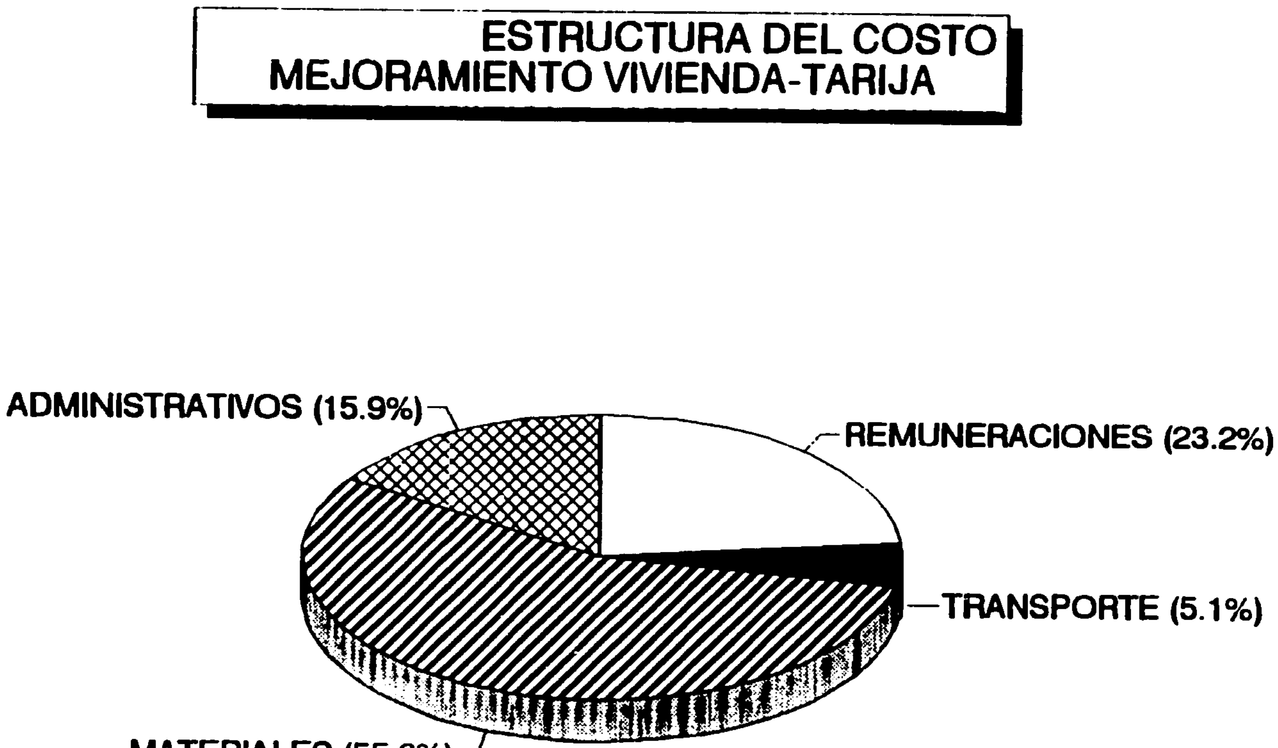


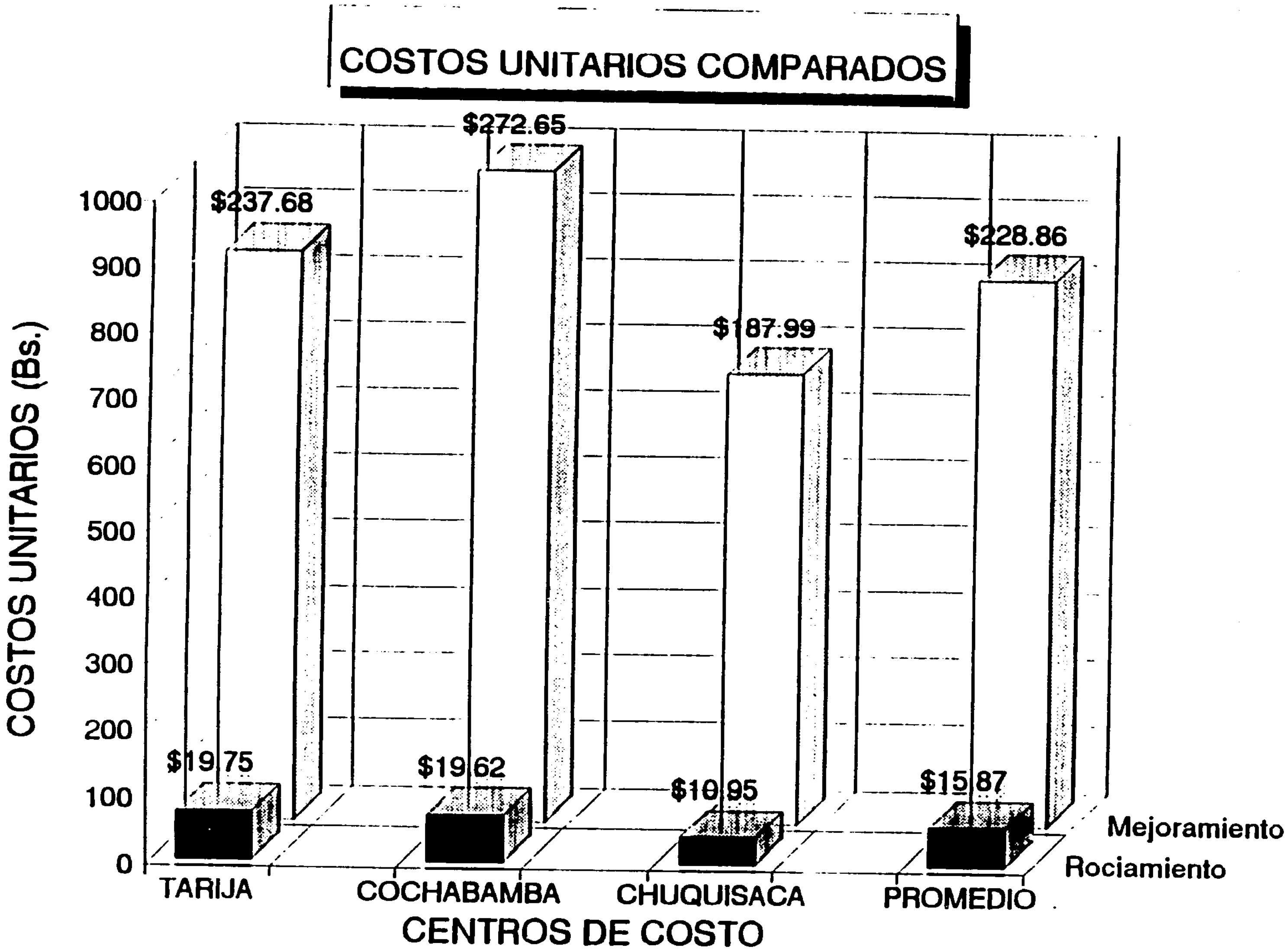
ESTRUCTURA DEL COSTO
MEJORAMIENTO VIVIENDA-CHUQUISACA



ESTRUCTURA DEL COSTO
MEJORAMIENTO VIVIENDA-COCHABAMBA

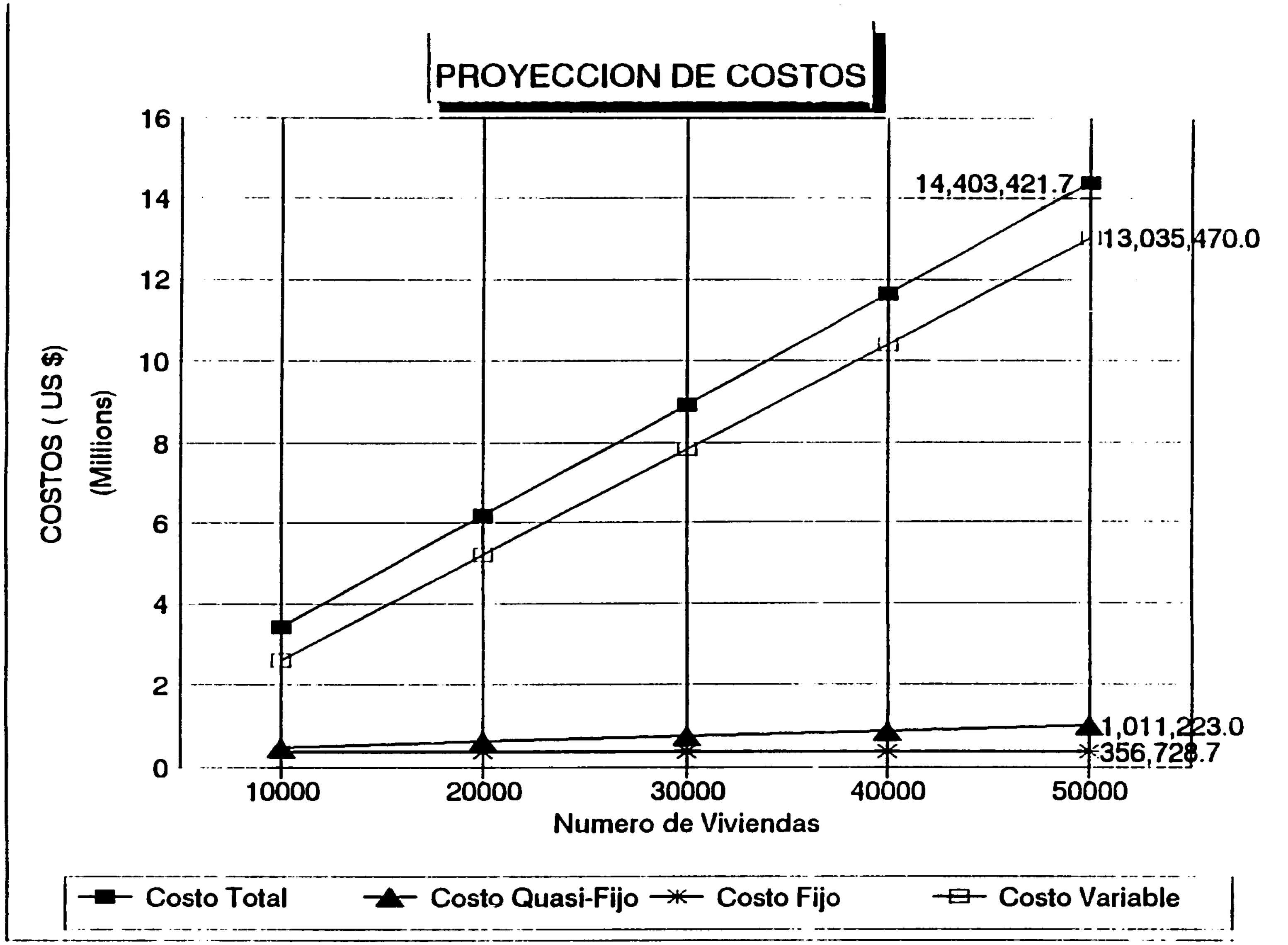



ESTRUCTURA DEL COSTO
MEJORAMIENTO VIVIENDA-TARIJA
ADMINISTRATIVOS (15.9%)
REMUNERACIONES (23.2%)
TRANSPORTE (5.1%)
MATERIALES (55.8%)



COSTOS UNITARIOS COMPARADOS
COSTOS UNITARIOS (Bs.)
1000
900
800
700
600
500
400
300
200
100
0
$237.68
$272.65
$187.99
$228.86
$19.75
$19.62
$10.95
$15.87
TARIJA
COCHABAMBA
CHUQUISACA
PROMEDIO
CENTROS DE COSTO
Mejoramiento
Rociamiento

72


PROYECCION DE COSTOS
COSTOS (US $)
(Millions)
16
14
12
10
8
6
4
2
0
14,403,421.7
13,035,470.0
1,011,223.0
356,728.7
10000
20000
30000
40000
50000
Numero de Viviendas
Costo Total
Costo Quasi-Fijo
Costo Fijo
Costo Variable