ASSESSMENT OF PROSPECTS FOR FLOOD HAZARD MITIGATION IN THE LA PAZ RIVER WATERSHED AREA

PROJECT EXECUTED BY
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BACKGROUND:

On February 19, 2002, the city of La Paz suffered one of the worst natural disasters of the last decades with a tremendous flood due to a strong hailstorm that fell upon the city in less than an hour. Streets, avenues and houses were flooded, various houses collapsed, the energy supply system collapsed and drain systems got stuck. Avenues and streets in the city center became one big water torrent that dragged along people, vehicles, goods and especially an enormous amount of urban waste and construction debris that was accumulated on the streets.

During the disaster, the full capacity of different underground canals of the city's drainage system was not used. Most drains and sewers, as well as many canals of the system were obstructed with debris and huge amounts of waste and construction debris produced by the urban population.

Sixty-eight people died in the tragedy, hundreds were taken to hospitals, and estimated material damages surpassed 10 million dollars.

Likewise, at a distance of 30 minutes from the city in the Río Abajo region, twenty-one communities on the banks of the La Paz River suffered from severe flooding of their vegetable gardens. Approximately 450 hectares of agricultural cropland on the La Paz riverbanks, belonging to nearly 1,200 families, were affected. Moreover, more than 118 hectares of farmland on the La Paz Riverbanks were lost due to the flood. In the rural area, 80.7% of the affected population owns half a hectare or less of land, which means that recurring flood in the rural area that is the object of this study, has a severe impact.

Natural hazards found in the La Paz River watershed and the surrounding area:

During the assessment, the team did not only organize extensive fieldwork sessions, but it also revised existing documents on conditions in the region. In particular, the team used documents available under the "Urban Development Plan of the City of La Paz" prepared by the consulting firms BRGM – BCEOM, PCA in 1977, and to a certain extent also part of the document of the "Program for Integrated Rural Development, Watershed Management and Torrent Control in Río Abajo", prepared by the Consortium CONSA SERINCO, and kindly put at our disposal by the Infrastructure Department of the Prefecture of La Paz. Furthermore, the team systematized the information contained in event registers of the Emergency Relief Service of the Municipality of La Paz, which was generously provided by that municipal service.

The assessment team set up for this assessment has visited most of the study area to be able to verify data of the studies mentioned above. Nonetheless, a representative sample was determined of tributaries in the La Paz River Sub-watershed, all of which with habitual behaviors or higher risk signals. The following study area was selected:

Three important rivers and 2 mountain streams were selected in the city of La Paz (Apumalla, Panteón, Cotahuma, Melchuco and Venecia) and in the Río Abajo region 4 rivers and 1 mountain stream (Huacullani, Llauchi, Khellkhata, Saytu/Milliri and Petuila/Aleluyani).

Analysis of watercourses in the city of La Paz

The assessment has shown that, in general, all sections with open canals imply flood hazard to a lower or higher extent. In the case of vaulted canalization, especially old sections are at risk of flooding, because of deterioration of the structures. Vaulted structures imply higher risks and require more efforts and attention from the municipality. Especially vaulted sections in narrow streets or sections that run underneath different types of buildings - from houses to multiple-storey buildings - must be focused. An example of such a section is the area where the Panteón and Apumalla Rivers meet in the VITA intersection and the Apumalla River course between the VITA intersection and the Mariscal Santa Cruz Avenue (where it joins the Choqueyapu River). Annex 2 shows the different identified hazard sections in the canalization network of the city of La Paz.

Similar characteristics can be observed in the Zoqueri River, the subterranean canalization of which runs under houses and buildings of the Alto Miraflores neighborhood.

Various areas on the eastern hillside of the city have a weak geology. This is the case of Villa Armonía, Villa Copacabana and Kupini, which are exposed to a constant land movement hazard.

Because of its complex network of tributaries and its geological structure, the Cotahuma River is a potential hazard area with active landslides, both in the headwater section of the micro watershed and the river mouth in Kantutani. The river mouth sector forms part of the geological structure that corresponds to the Llojeta mud torrent. Also in this area, there are mass movement hazard areas in the Los Sargentos avenues, Alto and Bajo Seguencoma, which are considered high-risk areas.

Based on the systematization of the information supplied by the Emergency Relief Service and the analysis of the rivers included in the sample, thematic maps were prepared (floods, underground flooding, landslides, falling walls and a combination of these events) on the location of events registered in the last five years. Based on the maps and the respective analysis, the following conclusions were drawn:

In general, hazard events in the city of La Paz are associated with the geological structure and morphology of every zone.

Subterranean erosion is a risk factor in different places of the city of La Paz, for example on the western hillside, especially between Cotahuma and Llojeta.

Habits and costumes of the urban population and the rural population in the Río Abajo region have a remarkable effect on recurring hazard events.

These events are mainly concentrated in the rainy season and just after the rainy season.

Floods and underground flooding are associated with canalization structures, but also with the geological structure and the presence of subterranean streams.

Landslides and the collapsing of walls are associated with the weak geological structure in some regions of La Paz.

Most events are concentrated in the environs of the Apumalla, Panteón, Cotahuma, Choqueyapu Central Norte, San Pedro and Venecia Rivers.

The following neighborhoods are subject to the highest risks of suffering landslides and the collapse of walls: Kupini, 28 de Marzo, Barrio Lindo, Zarzuela, Challapampa, Apumalla, Munaypata, Villa Armonía, Villa San Antonio, Agua de la Vida, la Merced and the upper zones on the western hillside of the city.

Likewise, it has been verified that debris and garbage are factors that increase hazard along canalizations of the city of La Paz.

Analysis of watercourses in the Río Abajo region

In general, the accumulation of solid waste transported along the La Paz riverbed is remarkable, with a varying thickness of 8 to 10 cm yearly. This has a fundamental impact on behavior of the river, especially in the rainy season.

Solid waste dragged along the river results from erosion in the area where the rivers and mountain streams of the city of La Paz spring up, as well as in the areas where the rivers and tributary mountain streams of the Río Abajo region begin to flow. Landslides also contribute considerable drag materials.

Hydric erosion in the micro watersheds of tributaries in Río Abajo, in rivers and mountain streams with geological formations of lutites that correspond to the Siluric Devonic age and conglomerates of the Aranjuez formation and with regular to steep slopes, gives rise to areas with marginal soils and scarce vegetal coverage. In turn, erosion is a constant characteristic in clearly identified mud torrents, for example in Achocalla and its manifestations along the La Paz River.

Old landslide areas have been identified, as well as areas with probable and also imminent landslides. Fortunately, these areas do not imply any risk for human settlements.

The most important risk for communities in Río Abajo is the periodic presence of hydraulic lava flows (mazamorra) or torrents that form important alluvial plains, such as in the case of the Khellkhata River. This river has been canalized with active participation of the prefecture and the municipality of Mecapaca. However, hydraulic behavior of this structure needs to be monitored.

Besides the Khellkhata River, there are important sectors with recurring considerable mazamorras in rivers in the communities of Avircato, Palomar, Huayhuasi, Huaricana and Peñol. The Llauchi River shows an extensive plain composed of hydraulic lava; in turn, Lipari Bajo, Ananta, Huajchilla and Taypichullo can be catalogued as areas that are less mazamorra-prone.

Width of the La Paz riverbed in Mallasa, Jupapina, Lipari, Taypichullo and Llakasa require special attention because of flood and landslide hazard. These risks are the result of both the weak geological structure, and the attitude of landowners who constantly want to “reclaim land from the river”. These land reclamation practices erode the basis of the natural slope of hills. Hazards become more important if we take into account that reclaimed areas become areas for potential urbanization. In the region of Palomar, Cachapa and Huayhuasi, where the natural riverbed of the La Paz River is wider than in the previous cases, inhabitants are also

adopting the attitude of wanting to reclaim land. However, they risk loosing many working days and money to buy non-local materials as they execute works without any type of technical assistance and without having appropriate hydraulic designs.

We should not forget that in the Río Abajo region, there are approximately ten big urbanization initiatives that have started to occupy land near the rivers or hydraulic lava dejection cones and torrential fans (for example, the Khellkhata, Saytu Rivers, etc.).

Based on the identified risks and the analysis of existing information, the following maps were developed and in some cases updated:

- Hazard map of the city of La Paz, extended toward the Río Abajo region.
- Map on events registered by the Emergency Relief Service of the Municipality of La Paz.
- Maps on flood-prone areas.
- Maps on construction possibilities in the city of La Paz.
- Geotechnical map of the city of La Paz.
- Map on forestry intervention of Río Abajo.
- Edafological map of Río Abajo.

The Base Map was prepared in a georeferenced, digital format, in the WGS84 system, UTM zone 19.

Agro-forestry Component

Vegetation in the study area is seriously degraded, the vegetal population has been severely reduced and some species are at risk of extinction. Native vegetation is confined to small discontinuous spots in inaccessible places and watercourses. Most vegetal coverage is of the shrub type.

Urban expansion has caused the loss of considerable native vegetation. The formation of peri-urban belts has resulted in the population exercising more pressure on the vegetation as an alternative energy source in the first phase of human settlement.

Currently reforested areas are severely contaminated as they are used as construction debris and rubbish dumps. In general, the population's attitude toward trees and shrubs of a native or exotic origin, planted under reforestation or public ornamentation campaigns, is aggressive.

In view of this situation and intense erosion in extensive areas of the study zone, there is a need to implement reforestation and tree planting projects to minimize the dragging of sediments to watercourses, stabilize hillsides and mitigate the possible occurrence of events that imply risks for the population. The hillsides and upper parts of mountain streams must be subject to mass reforestation plans and the promotion of native vegetation.

Socio-cultural Component

This study examines the socio-cultural behavior of the population of La Paz and communities of Río Abajo, as a critical and central factor in the generation of natural disaster hazard. The study identifies and analyzes different habits and costumes regarding management and

disposal of garbage, construction debris, wastewater, based on interviews with neighbors and members of neighborhood councils in the urban area. It also identifies and analyses cultural practices, beliefs and knowledge regarding riverside management for agriculture, landslides, flood defense structures and mazamorras in the rural area, based on interviews with peasants from rural communities. In this sense, the study identifies and analyses the level of awareness of the population on the effects of their behavior on the generation of natural disasters.

The principal conclusions of the study are:

Urban Area

The population of La Paz, regardless of the neighborhood or social class of which it forms part, is used to cohabit with waste and debris. They consider waste is a part of their “normal” environment.

Perceived differences are related to intensity, levels of tolerance and characteristics of provided services.

There are no social sanctions and people do not disapprove of dumping any type of garbage and construction debris on the street.

Municipal authorities do not control this type of behavior.

The population has sanitary habits and costumes that make it difficult for waste collection service providers to keep the city clean.

This situation is not only related to a lack of information and environmental education, but basically to a lack of interest and awareness on having a garbage-free city.

Hence, throwing garbage and construction debris into the rivers and mountain streams of the city is a common and accepted practice. People are unaware of the risk, and resulting damages to the rivers.

On the other hand, social obligations prevail over residential sanitary facilities. Throwing wastewater in the street is not subject to any type of social sanction either.
The urban population does neither respect nor appreciates trees, and rather associates green areas with citizen insecurity.

Rural Area

People in peasant communities have considerable knowledge on local natural characteristics that are risk factors.

The generalized practice in communities to “reclaim land from the river” is an important risk factor, causing loss and flooding of the land in neighboring communities.

Maintenance and construction of defense walls to protect cropland is one of the central activities in rural communities. This activity requires considerable labor force and time from communities.

On the other hand, natural disaster risk factors in communities in the upper parts largely depend on weather conditions and topographical characteristics of their soils.

Traditional practices for hydraulic lava flow and landslide control based on inter-communal coordination or in coordination with neighboring haciendas have been abandoned.

The cultural practice of burning vegetal coverage is still maintained in spite of official information campaigns on the environmental damages this practice causes.

Communities in higher areas use vegetal coverage – trees and shrubs – as fuelwood to prepare food. Overgrazing of sheep is another factor that causes depredation of smaller vegetal coverage, and hence erosion.

Finally, the following project profiles were prepared on flood and inherent event hazard mitigation measures:

- Canalization of Pilot Sections of the La Paz River
- Agro-forestry project in Río Abajo
- Model of an Early Warning System for flood events in the La Paz River watershed
- Forestry Project in the City of La Paz
- Project for Agricultural Support in Río Abajo
- Awareness-raising for a Garbage and Debris Free City

Team:

- Manager
- Agro-forestry Expert, responsible for Geographical Information Systems (GIS)
- Expert Anthropologist, social researcher
- Four research assistants (Geologist, Agronomist and GIS support, Sociologist and Psychologist)
- Assistant for Graphical Aspects - Digitalization.

1 BACKGROUND

Because of its geomorphology, the La Paz area is vulnerable to floods, landslides, intense erosion processes, as well as mass soil movements, which endanger both the structure of the city and livelihoods of the population inhabiting the rural and urban areas. Events demonstrating this occurred on February 19, 2002, at approximately 15:00 pm, when a torrential rain with an average and estimated duration of 45 minutes and a registered precipitation of 39 mm fell upon the city of La Paz. This storm was extraordinarily spectacular because of the resulting damages to inhabitants, their livelihoods, infrastructure, utilities and public and private vehicles.

Hail and electrical discharges accompanied the storm. Because of the watershed's formation, the rainwater quickly drained into its natural watersheds. Hence, the storm also had an impact on the rural area near the city, particularly the Río Abajo area located in the jurisdiction of the Municipality of Mecapaca and to a lesser extent the Municipality of Achocalla.

The effects of this storm in the urban area gave rise to acts of solidarity from different donors, enabling an immediate and effective response to solve the problems caused by the emergency at the request of the Municipality of La Paz. Various international donors dealt with impacts suffered due to the extraordinary flood in the rural area near the city, effectively contributing to specific actions aimed at providing an effective response to the emergency situation.

With financial support from friendly nations such as England, Holland and the USA, CARE Bolivia participated in emergency relief activities with good results. It also channeled donations in kind to the people affected by the floods in the Río Abajo area, as well as food and agricultural input donated by USAID Bolivia, with the objective of restoring productive conditions of the Rio Abajo region to a certain extent.

Consistent with the action line in the La Paz area, at the request of the US Government Federal Disaster Relief Office, in April CARE Bolivia presented a proposal to conduct an "Assessment of prospects for flood hazard mitigation in the La Paz River watershed area".
On September 16, 2002, CARE Bolivia signed Agreement No. 511-G00-02-00274-00 with USAID Bolivia to assess prospects for flood hazard mitigation in the La Paz River watershed area.

Once flood related issues were known, the assessment team decided not to limit its analysis to aspects strictly related to floods, but also to cover aspects related to natural phenomena in recurring cycles associated with rainfall in the La Paz River watershed area.

Therefore, the purpose of the assessment is to make a diagnostic on existing conditions in the La Paz River basin, particularly focusing the natural causes and other socio-cultural aspects that cause floods and flood inherent effects, such as landslides, soil subsidence, hydraulic lava flows and other rainfall related phenomena.

To comply with this assignment, CARE Bolivia organized a team according to staff proposed in the Statement Of Work. The team started to work on September 30, 2002.

1.1 Geography

The Department of La Paz covers an area of 133,985 Km2; its capital is the city of La Paz, which is also the seat of the Central Government of Bolivia. La Paz is located at an average altitude of 3,600 meters above sea level, bordering in the north on the Department of Pando, in the south on Oruro, in the east on Beni and Cochabamba and in the west on the Republics of Peru and Chile.

It is situated between the latitude of 16°30'00" south and the longitude of 68°08'00" west of the Greenwich Meridian. The department of La Paz is subdivided into 20 provinces and 75 municipalities.

Three geographical zones can be distinguished in the Department of La Paz:

1.1.1 The High plateau (*Altiplano*),

This area covers a lateral extension from the border with Chile and Peru up to the city of El Alto and from the surroundings of the provinces of Camacho and Franz Tamayo in the north to the provinces of Pacajes, Aroma and Villarroel in the south, bordering on the department of Oruro. The presence of the famous Lake Titicaca characterizes this region, which is the most humid region of the Bolivian Andean High plateau (with an annual average rainfall of 650 mm).

1.1.2 The Sub Andean Zone*,*

This zone covers the northeast flank of the Cordillera Real or Eastern mountain chain that descends to the tropical lowlands of the north. This area has a humid climate with exuberant vegetation.

1.1.3 The Amazon Tropics*,*

This tropical zone borders on the departments of Beni and Pando; because of its exuberant vegetation, this region is an adequate place for ecological and adventure tourism.

1.2 Population

The Department of La Paz has a total population of 2,350,466, 1,522,146 of whom live in urban areas and 798,320 in rural areas. The population of the study area in the municipalities of La Paz, Mecapaca and Achocalla totals 820,185 inhabitants in the urban area and 20,231 in the rural area (INE, Census 2001).

1.3 Climate

The climate in the Department of La Paz is varied: cold in the high plateau and puna, with polar cold at an altitude of over 5,000 meters and perpetual snow on the high peaks of the Illimani, Huayna Potosí, Chacaltaya, Illampu and other mountains that form the Cordillera Real range of mountains. The climate is template in the Sub Andean valleys at 2,000 to 3,400 meters above sea level, warm in regions at 500 to 2,000 meters above sea level and tropical in the Amazon lowlands in the northern part of the north of the Department. Average temperatures range from –5 to 18°C in the high plateau and government seat and an average of 20 to 25°C in the Yungas region of La Paz.

1.4 The climatic event of February 19, 2002

1.4.1 Urban Area of the city of La Paz

According to the official report drafted by the National Meteorological and Hydrological Service (SENAMHI), on Tuesday February 19, 2002, at daybreak the La Paz sky was clouded, with a temperature of 6°C. At around 10 o'clock in the morning, cumulus clouds started to develop and at noon cumulonimbus were reported in the north-northwest direction.

Meteorological conditions showed a cold front entering the territory of the city of La Paz with severe atmospheric instability and the resulting formation of cumulus clouds and cumulonimbus. The super convective cell that traveled over the city from north to south caused intense rainfall with electrical storms and hail surpassing the historical record, as no similar event had been registered since 1940. Therefore, this event can be considered an extraordinary event in the century.

It started raining at 14:20 and it stopped raining at 15.50, with total precipitation amounting to 39.4 mm (39.4 liters per m2), and a drop in temperature from 14.6°C at 14:00 pm to 3.5°C at 15:42 pm. The maximum intensity was registered in the Laycakota Meteorological Observatory between 15:00 pm and 15:50 pm with a total volume of 34.0 mm in 50 minutes, i.e. an intensity of 41.0 mm/h. (Source: SENAMHI)

Average intensity in the city of La Paz in the last 50 years amounted to 8 - 10 mm/hour, which means this storm transcended the average value by over 4 times.

According to historical registers of SENAMHI for the city of La Paz, maximum rainfall was 32.0 mm/hour in the year 1976.

The storm on February 19 was registered by 12 pluviometric stations, only one of which – the Laycakota station – is a pluviographic station (with intensity measurement), as well as by four hydrometric stations, three of which are equipped with classic quarterly limnigraphs (float – continuous paper band – clock), and the fourth – the Aranjuez station – is equipped with a satellite telemetric equipment that registers hourly data. Data in the latter are received in the first instance by Brazil and are then retransmitted to our central through the Internet.

Spatial distribution of the rains was as follows, according to the pluviometric network in the urban area of the National Meteorological and Hydrological Service:

Table 1. Rainfall registered in SENAMHI stations

Station	Registered Daily Rainfall (mm)
Vino Tinto.	73.3
San Calixto	59.9
Villa Copacabana	32.2
Chuquiaguillo	20.2
Achumani	10.9
Cota Cota	8.8
Ovejuyo	5.7
Villa Adela	23.0
Río Seco	0.3
El Alto Airport	6.7

Source: SENAMHI

Data processed by the Consulting Firm CONSA SERINCO on annual maximum rainfall, based on information generated by SENAMHI - within the framework of the Program for Comprehensive Rural Development, Watershed and Torrent Management in Río Abajo - show the following results.

Table 2. Return period for maximum rainfall

Station	Return period (years)				
	2	5	10	15	20
	MAXIMUM DAILY RAINFALL (mm)				
CALACOTO	29.6	36.5	40.5	42.6	44.0
Achocalla	22.6	29.3	33.6	36	37.7
MECAPACA	25	31	35	37.2	38.8
PINAYA	26.7	34.4	39.5	42.3	44.3
BOLSA NEGRA	29	35.2	38.6	40.1	41.2
LAMBATE	35.2	42.7	46.7	48.7	50.0
MALLASA	23.1	29.9	34.4	36.9	38.7
ARACA	21.6	31.1	37.5	41	43.5
CARACATO	19.6	23.4	25.4	26.4	27.0
SAPAHAQUI	22	27.4	30.9	32.9	34.3
PALCA	25.7	34.5	40.3	43.5	45.8
COLLANA	28.6	36.1	41	43.8	45.8

Source: Program for Comprehensive Rural Development, Watershed and Torrent Management in Río Abajo

SENAMHI has determined the volumes of water that may have passed through the gauging sections mentioned in the following table, which are compared to average values of the month of February in various years. This information is shown in the table below:

Table 3. Estimated volumes of water in the Choqueyapu and Orkojahuira Rivers on February 19, 2002

Station	River	Estimated volume of water (m3/sec) February 19	Method	Average volume of water (Q) (m3/sec)	Period
Achachicala	Choqueyapu	3,212	Calibration curve	2,040	1981 – 2002
Holguín	Orkojahuira	30,104	Calibration curve	1,166	1981 – 2002
Obrajes	Choqueyapu	268.8	Area – Slope	7,741	1981 – 2002
Aranjuez	Choqueyapu	323.8	Area – Slope	10,890	1990 – 2001

Source: Specific Analysis Report prepared by SENAMHI on the meteorological event of February 19, 2002

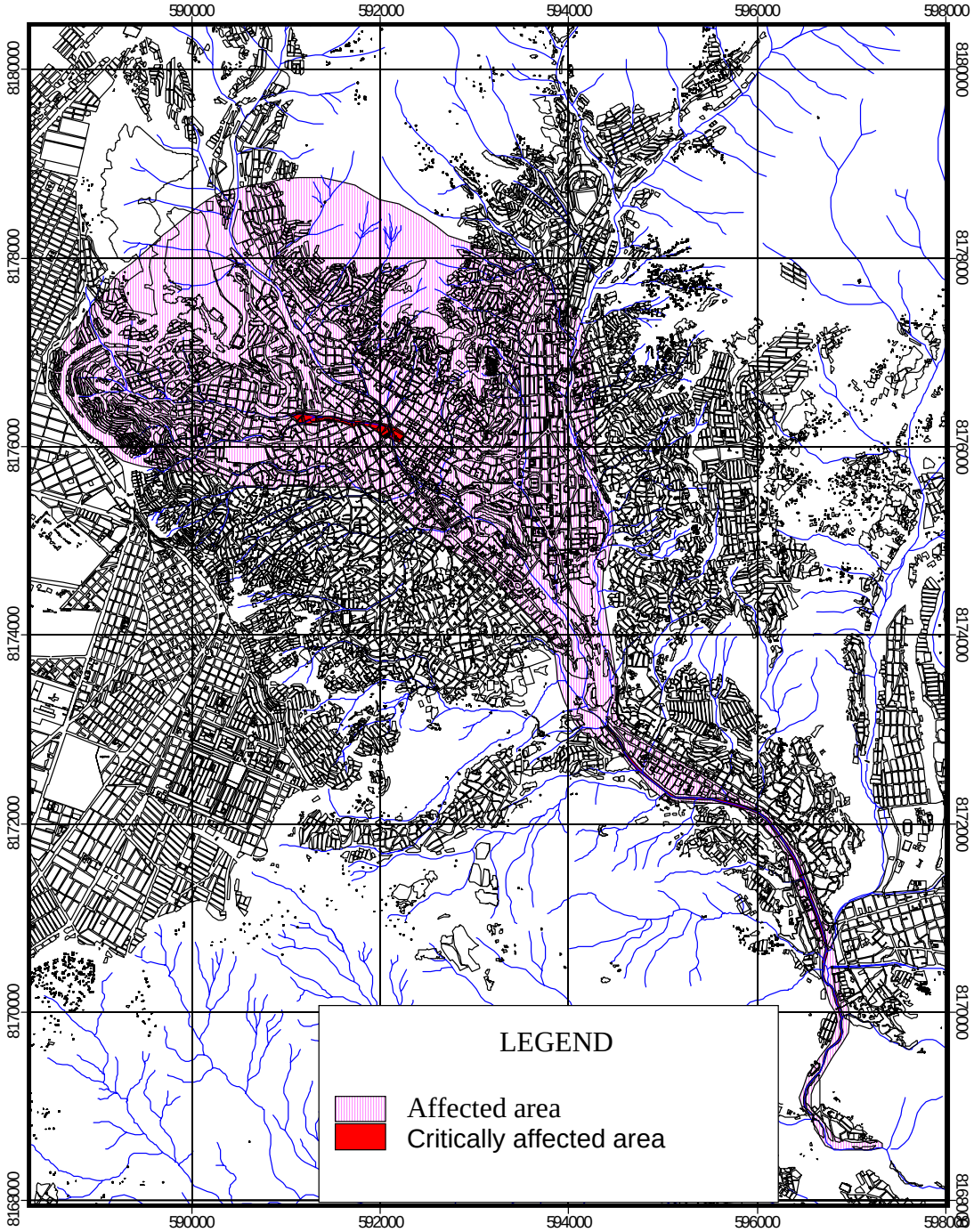
Based on the tables included above and the analysis SENAMHI made, the following conclusions can be drawn:

- Volumes registered in the Choqueyapu River in Achachicala do not show any significant variation. Hence, it is possible to deduce that the storm was concentrated in the urban part of the watershed, not spreading to the northern part of La Paz.
- Volumes registered in the south of the city show a considerable difference in average volumes of various years and the volume that probably passed through these sections during the flood.
- The meteorological event that occurred on February 19 was an extraordinary event, considering the intensity of rainfall and average volumes registered at the gauging sections mentioned in the report.

Maintenance conditions of drainage infrastructure (semi-saturated vaulted canals in some sections, rainwater sewers obstructed with garbage and rubbish or in many cases closed by street vendors) could have caused the true collapse of some parts, which resulted in the water being drained on the surface of sidewalks of the streets and avenues where the rain fell.

Sixty-eight people died in the disaster, hundreds of people had to be hospitalized and many people had to take refuge in the sports coliseum of the city of La Paz.
The urban area suffering the greatest impact of the storm is shown in the fraction of the urban map of graph No. 1, included below:

Graph 1. Zones that suffered the greatest impact of the storm on February 19, 2002.



The principal affected public roads were the Av. América (Kennedy), and the Av. Manco Kapac, the violent water streams in which came together on the Av. Mcal. Santa Cruz. Emergencies with fatalities occurred in the Vita intersection, the end of the Mercado street and the underground passage of the Av. Mcal. Santa Cruz.

The General Medical Center of the National Health Fund (CNS) in Av. Manco Kapac provided emergency assistance. However, its services collapsed when one of the center's walls fell as a consequence of the natural disaster. In the central zone, the catastrophe occurred in the San Francisco tunnel and the Mercado street, where water and hail flows came together from three water receiving areas: from the north through the Av. Montes, from the east through the Yanacocha and Socabaya streets and from the northwest through the Santa Cruz, Evaristo Valle and Figueroa streets.

In the south area of the city, the Hernando Siles, Roma, Kantutani and Costanera avenues on both sides of the Choqueyapu River suffered considerable water flows with incidents affecting many persons, street stalls and inhabitants in these zones of the city.

All watercourses coming from the urban center of the city of La Paz flow into the Choqueyapu River, which as from the "Amor de Dios" neighborhood takes all tributary flows of the city to the Lipari area in Río Abajo, where the river is called the La Paz River.
After the registration point in Aranjuez, there are still other tributaries that contribute considerable water to the accumulative volume of the La Paz River, such as the Huacullani, Achocalla, Llauchi, Khellkhata, Petuila / Aleluyani, Milliri, Huanuni rivers, as well as about twenty other tributary mountain streams that drag along hydraulic lava.

As representatives of the National Meteorological and Hydrological Service say, the storm on day 19 has shown that the available hydro-meteorological network is deficient in terms of the density and quality of equipment; the upper parts of the watershed are not subject to observation, adversely affecting knowledge on the watershed's hydrological behavior.

Because of the considerable slope of the watershed along the 34 Km of the principal riverbed, the concentration time is very short, approximately 3 hours. In this sense, it is necessary to install an early warning system that enables immediate identification of possible anomalous situations in the La Paz River watershed area. This early warning system could be equipped with satellite transmission systems that are fit for the watershed's particular conditions, as well as communication systems that enable the dissemination of early warning messages.

1.4.2 The rural area of the La Paz River Sub-Watershed, from Jupapina to Tahuapalca

Just like the city of La Paz, as a consequence of the storm on February 19 and subsequent rainfall, the rural area was affected by flooding of the La Paz River, causing landslides, destruction and floods in the Río Abajo area (Municipality of Mecapaca), which was also declared a disaster area.

In this region, located between 15 to 48 kilometers south of the city of La Paz, cropping areas were seriously affected, with a severe adverse impact on the Río Abajo rural population's economy, as 21 communities located on the La Paz riverside lost land prepared for sowing.

Official data (prepared with active participation of CARE) on damages sustained in the Río Abajo area show that 450 Ha of productive land located on the banks of the La Paz River were affected due to flooding in 21 rural communities that belong to the Municipality of Mecapaca. This situation impacted 1,134 households. Furthermore, hydraulic lava flows affected large work zones of the peasant population in this region. And 118.12 Ha owned by over 300 households suffered permanent losses due to hydric soil erosion and hydraulic lava (mazamorra).

Impacts of the floods caused by the torrential rains on February 19 and subsequent days are summarized in the following table:

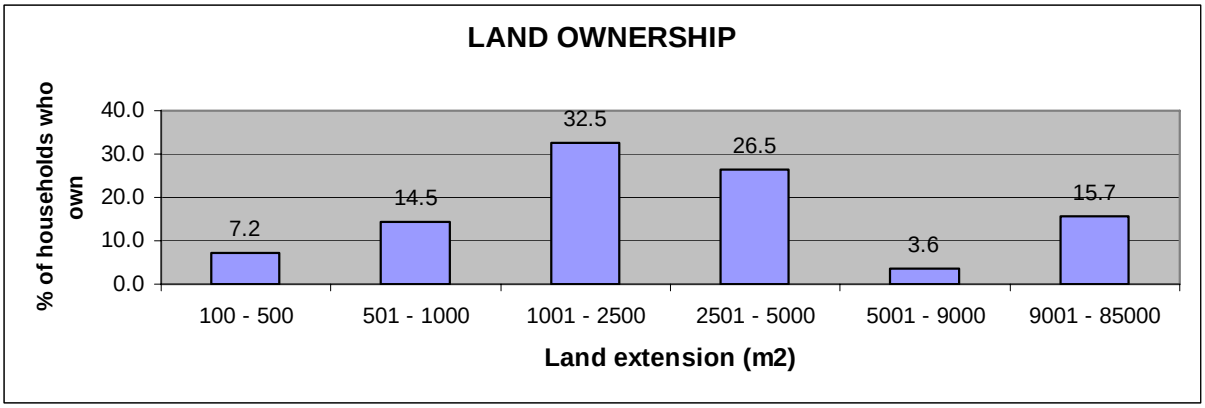
Table 4. Communities and number of households affected by the storm of February 2002

	Community	No. of households	No. of affected households	Total land that suffered losses (m2)
1	Mallasa	*86*	56	*7,800*
2	Jupapina	*58*	47	*69,400*
3	Ananta	*25*	22	*5,790*
4	Lipari	*44*	40	*40,000*
5	Huajchilla	*74*	44	*17,420*
6	Taypichullo	*42*	42	*34,450*
7	Carreras	*112*	47	*40,540*
8	Valencia	*27*	14	*20,200*
9	Llackasa	*54*	22	*32,200*
10	Yupampa	*123*	10	*18,100*
11	Calicanto	*18*	10	*15,500*
12	Mamaniri	*10*	10	*3,000*
13	Mecapaca	*63*	54	*22,650*
14	Huancarani	*35*	30	*22,250*
15	Avircato	*59*	42	*85,560*
16	Palomar	*147*	147	*14,700*
17	Cachapa	*16*	16	*25,500*
18	Huayhuasi	*164*	100	*490,269*
18	Huaricana A.	*150*	150	*248,900*
19	Huaricana B.	*97*	97	*123,000*
20	Millucato	*95*	95	*178,000*
21	Peñol	*39*	39	*116,000*
	Total	**1,258**	**1,134**	**1,181,229**

Source: CARE Bolivia

In order to adequately perceive the impact of the storm, the following graph includes statistical data on land ownership in the Río Abajo area, i.e. from Lipari to Millucato. Based on this information, we can conclude that 80.7% of the population owns less than half a hectare of land; therefore, the impact of floods in the Río Abajo area is high.

Graph 2. Distribution of households, in percentage, with respect to the land they own in the Rio Abajo area.



Source: CONSA SERINCO

Flood impact indicators show that on average, 72% of the families are vulnerable to being affected. The housing infrastructure of 44% of the households was affected, as well as 73% of their farmland. Estimates are that 10 – 15% of existing livestock is affected by floods, either due to a lack of feed or due to direct effects.

2 OBJECTIVES OF THE ASSESSMENT

- Identification and mapping of areas and communities affected by the storm on February 19, 2002, and other recurrent events identified in the study conducted by CONSA SERINCO and other important initiatives on the La Paz River sub-watershed.
- Identification and mapping of areas with the greatest flood hazard vulnerability.
- Identification and mapping of areas for possible future project activities that are useful as mitigation measures in most of the flood-prone areas in the La Paz River watershed.
- Identification of the causes that generate or contribute to increased flood hazard vulnerability.
- Identification of practices and habits of the population that generate or contribute to increased flood hazard vulnerability.

3 THE STUDY AREA

The city of La Paz as the seat of the Bolivian government is located at the foot of the Andes mountain chain, bordering on the high plateau in the west, on the high plateau and the La Paz mountain chain in the north, on the La Paz mountain chain in the east and on the semi-confined valleys of the Río Abajo region in the south.

The area studied in the present evaluation covers a geographical area of 983 Km2, including morpho-structural sectors of the end of the high plateau and the Cordillera Oriental mountain range.

3.1 Selection of micro-watersheds to be analyzed

With the objective of having a clear idea of the causes and effects of floods in the studied area, a representative sample of effluents of the La Paz River sub-watershed was defined. This sample shows habitual behavioral patterns that somehow represent the other micro-watersheds both at the rural and urban levels or that imply higher hazard in the region. In this sense, the following study areas were selected:

3.1.1 In the city of La Paz:

3.1.1.1 Apumalla River - Panteón River

These rivers cover an area of 4.1 Km2. According to subsequent analyses and hydro-meteorological references, as well as specific reports on the event on February 19, 2002, these rivers and their respective micro-watersheds seem to have contributed considerably to the formation of extraordinary surface flows that caused the catastrophe in the city of La Paz. Alongside the course of these rivers, there are different human groups with garbage and waste disposal habits and practices that also contribute to the deterioration of urban environmental conditions and operation and operability of the existing drainage infrastructure.

3.1.1.2 Cotahuma – Melchuco Rivers

These rivers, tributaries to the Choqueyapu River, cover an area of 6.8 Km2. Although the micro-basins of these rivers did not directly contribute to the most relevant disaster areas of the central zone of La Paz, they did contribute at the point where they flow into the Choqueyapu River, in the Kantutani sector, at the beginning of the Mario Mercado or Max Fernandez avenue. These rivers are located in zones where the topography, geology and soils imply high risks, as is evident from different events occurred in recent years. Moreover, these areas show considerable slopes and a high population density.

3.1.1.3 Venecia Mountain Stream

This tributary to the Orkojahuira River covers an area of 1 Km2. Its micro-watershed is located in the area of Villa Copacabana and Valle Hermoso. The stream is characterized by its steep slope and flow through areas with a high-risk geology and soils, as well as by recurring underground flooding along the river's canalization.

3.1.2 In the Río Abajo area:

3.1.2.1 Huacullani River

This river covers an area of 21.3 Km2. The headwater section of the watershed is wide, but a long section of the river is very narrow like a canyon with steep slopes.

The point where the river flows into the La Paz River at the Lipari Bridge shows a regular slope. At that point, material in suspension is dragged along, coming from soil subsidence and/or landslides in the middle area of the watershed. The river is very hazardous for the communities of Lipari Bajo, including the Lipari Bridge, Ananta and Jupapina Bajo. It is located halfway the studied area. It is an area of current and potential landslides.

3.1.2.2 Llauchi River

This river covers an area of 9.6 Km2. The watershed area of this river is wide at the headwater section, with considerable erosion and landslides, causing severe hydraulic lava flows that will be analyzed separately. This river implies high risks for the communities of Taypichullo and Carreras.

3.1.2.3 Khellkhata River

The river covers an area of 33.3 Km2. This river with a considerable slope shows a wide watershed area at the headwater section, with long canyons in other sections. The river drags along a lot of materials because of landslides and severe soil erosion. In the area where the river flows into the La Paz River, risks are considerable for the communities of Valencia - Yupampa, Avircato, Carreras and Mecapaca.

3.1.2.4 Petuila / Aleluyani River

The river covers an area of 45.3 Km2. The river shows a regular slope, the watershed headwater area shows highly eroded parts and areas exposed to landslides. The area where the river flows into the La Paz River shows clearly visible signs of the dragging of solid materials, which represent considerable hazard to the communities of Avircato, Mecapaca and Cachapa

3.1.2.5 Milliri River

This river covers an area of 37.4 Km2. It is a river with a steep slope, with landslide-prone areas on the riversides. In the area where the river flows into the La Paz River, there is a considerable dejection cone where dragged along materials from hydraulic lava flows are deposited. This could adversely affect the communities of Avircato, Mecapaca, Cachapa and also agricultural production areas in Palomar.

4 REFERENTIAL FRAMEWORK OF THE STUDY AREA GEOLOGY

4.1 Stratigraphic Synthesis of the region

Below, a summarized description is included of the most representative formations of the La Paz River sub-watershed, which is based on information extracted from documents prepared by BRGM-BCEOM, CONSA – SERINCO and other specialized publications available in the country. Moreover, this information was updated with results of fieldwork within the framework of this study.

Clayey and sandy sediments deposited in seabeds during the Paleozoic can be observed in the Belén and Sica Sica formations that are subsequently described as parts that outcrop in some sectors of the study area.

4.2 Sica Sica Formation (Siluric - Devonic)

The rocks of this formation outcrop in the southeast in the regions of Mallasa – Lipari – Mecapaca, on both sides of the La Paz River. We can also find rocks of this formation in the Florida area. In terms of lithology, it is composed of a monotonous succession of black, dark grey and micaceous lutites, whereby sandstone horizons are rare.

This type of lithology, mainly the result of erosion, gives rise to the formation of extremely unstable vertical slopes. The destruction of lutites by salts produce residual soils that tend to be saturated quickly, giving rise to the downward flow of hydraulic lava. In the case of outcropping, scarps with foot-of-slope deposits are visible, which are inadequate for the growth of vegetation.

4.3 Aranjuez Formation

This formation is found in the range of mountains bearing the same name, covering the northeast area of the Valley of the Moon up to Mecapaca, even up to Peñol. Cretaceous strata in the Aranjuez mountain chain are clearly exposed. They consist of banks of red – violet polymictic conglomerates and red-rose sandstones of a continental, fluvial origin and alluvial cone.

The age of this formation is still under discussion. Although it supposedly dates from the Oligocene epoch, according to GEOBOL mapping, it corresponds to the Jurassic era.

4.4 Vila Vila Formation

This is a potent series of reddish, grey-violet and whitish, very siliceous micaceous sandstones, of medium-sized particles, interbedded and intercalated with thin layers of greenish lutites.

This formation finds its origin in a coastal marine environment. The morphology is strong because of its high resistance to erosion. Generally, it occupies topographical heights, with the development of dip slops.

4.5 Catavi Formation

This formation is composed of an alternation of banks of micaceous sandstones and lutites, the former grey-greenish and the latter dark grey.

The formation is of a proximal platform marine origin.

Its morphological expression is intermediate to strong, its resistance to erosion high to medium, and it is frequently covered with colluvia that enable growth of vegetation.

4.6 Belén Formation

This is a lithological formation composed of grey – greenish lutites, micaceous grey limolites with brown sandstones belonging to an internal platform environment.

Its morphological expression is intermediate to strong, its resistance to erosion high to medium, and it is frequently covered with colluvia that enable growth of vegetation.

4.7 Luribay Formation

This formation often shows in the upper parts of verticals walls. It is located in the Valle Escondido Canyon and the Huacullani area acquiring the shape of a conglomerate with upward transformation into violet - dark grayish sandstones containing two levels of whitish tufa.

The conglomerate of the Luribay formation outcrops in the Zapatuni hill where it is mixed with tufa material, acquiring a whitish shade. It is also found south of the Muella del Diablo peak (Devil’s Tooth), intermingled with clay.

4.8 La Paz Formation

This formation is located on the eastern edge of the northern high plateau with a thickness of more than 600 meters. (Dobrovolny, 1955)

This formation is characteristic north of the Aranjuez mountain range and it is composed of discontinuous, lenticular, little consolidated layers of sand, mud, gravel and clay and some thin lignite seams. The individual layers range from a minimum thickness to a thickness of 20 meters.
Most layers are light – dark grey, with lenticular strata of light brown sand. They are located in the surroundings of Obrajes and San Jorge.
In outcrops located west of Pampajasi, the upper strata of the La Paz formation are thick in the west side in the Irpavi valley. Contact between the Tertiary and Pleistocene ages is gradual.
It is also found in sectors such as Alpacoma, Mallasilla, in the mud torrent of Achocalla, Lagunas de Achocalla and in the Lipari sectors.
The Paleozoic rocks in the sector were identified by Dobrovolny in 1961 as a substructure. They are composed of lutites and dark grey slates, intercalated with sandstone deposits that are siluric and devonic formations intercalated with cretaceous or tertiary conglomerates.

In the highland deposits, they can be differentiated from the tertiary Ulloma formation (Ahlfeld, 1946), composed of clay, limolites, sand and gravel.
In the quaternary stratigraphic sequence, sediments of the La Paz formation crop out (Gregory, 1913), composed of layers of clay, mud, sand and gravel of a light grey color with tufa levels (Chijini cinerite).

Alluvial deposits correspond to the Pleistocene and Holocene and are composed of gravel, sand, mud and clay of a very varied composition and granulometry.

The formation of the La Paz River sub-watershed in the study area is the result of a process of retrocession and descent of the Beni River base level, causing gradual erosion and modeling of the watershed. Eroded materials were transported to the Amazonas River watershed and finally to the Atlantic Ocean. As from capture of the Beni River, base levels of the tributaries gradually changed towards the La Paz River watershed, which in the high plateau approximately corresponded to the base level of the Titicaca Lake. (E. Dobrovolny)

An important document for preparing the hazard map of the La Paz River watershed is the geological report on geomorphologic characteristics of the La Paz Watershed and its surroundings, developed by the consulting firms B.R.G.M. – B.C.E.O.M Prudencio Claros y Asociados, a summary of which is contained in Annex No. 1.

5 NATURAL HAZARDS IDENTIFIED IN THE LA PAZ RIVER WATERSHED AND ITS SURROUNDINGS

As is clearly stated in the technical reports prepared by the consulting firm BRGM – BCEOM, PCA, the La Paz watershed and its surroundings show natural conditions that on the one hand are peculiar and on the other hand unfavorable. Maps on restrictions and natural hazards show these conditions.

Different manifestations of nature, such as floods, and events inherent to rainfall (landslides, hydraulic lava, soil subsidence, etc.) occur unforeseen, they are surprises that imply a hazard for the population.

Mapping of restrictions and natural hazards enables a better understanding of trends in the transformation of slopes and geomorphologic ruggedness of the La Paz region. The existence of a danger is clear evidence of hazards in these zones (for example, the presence of hydraulic lava at the exit of a mountain stream or river).

The following section summarizes the natural hazards associated with floods that affect soils in the study area, on the basis of revisions and analyses of the micro watersheds that were proposed as samples of the behavior of the rest. We will deal with factors on topography, slopes, climate, vegetation, surface and subterranean water, geological structures and formations and the morphological evolution of slopes.

Consequently, this document on restrictions and hazards is a synthesis, the purpose of which is to provide orientation on problems that might occur and interfere with the normal development of human and economic activities in the region.

5.1 Natural restrictions and hazards in the La Paz watershed area

The BRGM – BCEOM Consortium concluded that there are many natural factors mankind must confront, which can be classified into two large groups.

- **Restrictions:** these are fixed or continuous factors in time that can influence urban expansion and/or human activity, as is the case of topography, ruggedness, etc.
- **Hazards** for mankind are factors that are variable or discontinuous in time of an untimely presence. For example: falling blocks or hydraulic lava flows.
  Hazards are closely linked to situations of obvious danger (hydraulic lava) or potential danger that something might occur (landslides or soil subsidence).

5.1.1 Natural restrictions

The following paragraphs summarize these determinants in the study area:

5.1.1.1 Typography and slopes

In the high plateau and some sectors located in the lower part of the watershed area, slopes are weak. However, the highest percentage of slopes surpasses 50% and constitutes a characteristic restriction of the region.

This restriction, besides the loose structure of geological formations in the La Paz watershed area, causes different problems on the hillsides of the city and the Río Abajo area: streets and access roads with steep slopes, instability for constructions, hydric erosion hazard, etc.

We can find a series of problems connected with erosion, such as landslides, soil subsidence and falling blocks.

In these circumstances, civil works are very expensive because they require the implementation of complex infrastructure works.

Within the watershed, we can find many sectors with abrupt relief patterns that are segmented by deep ravines where erosion is very intense. This is the case in for example

Mallasa, Mallasilla, Achocalla, Alpacoma and to a certain extent the watershed headwater areas of the Milliri River. These areas have to cope with many difficulties both for town planning purposes and for the construction of access roads to areas with productive potential. In chaotic relief areas, such as Mallasa (Valley of the Moon), no urbanizations should be established because of the hazard of suffering differential subsidence and because of the considerable investment this would involve.

At the mouth of the micro-watersheds, we can find important dejection cones composed of dragged along materials, which represent a permanent threat to the areas the population chose for urban expansion. This is the case of the dejection cones of the Llauchi, Khellkhata, Saytu-Petuila and Milliri Rivers.

5.1.1.2 Altitude and Climate

In general, the La Paz watershed area presents acceptable climatic conditions, which are pleasant in certain sectors of the city, such as the south area and the Río Abajo region. On the contrary, the climate in the high plateau is cold, with strong winds. The upper parts of the confined valleys situated in the north (Achachicala, Kaluyo and Chuquiaguillo) are cold because they are located at an altitude of more than 3,800 meters above sea level. Moreover, they are affected by winds from the high plateau and the Cordillera Real chain.

5.1.1.3 Nature and structure of the geological formations

As is explained in geological descriptions and Annex 1, most pieces of land in the La Paz River basin are little consolidated. This means that they are erosion-prone and highly vulnerable, especially in the case of the presence of water.
There are two basic types of formations: 1) Gravel formations such as ancient terraces (Miraflores and Irpavi gravel areas), which are usually not troublesome for the implementation of urbanizations and infrastructure, except for topographical considerations. 2) Alluvial plains (bottom of valleys), highland plains, alluvial fans (Villa Salomé) and formations with considerable fine material, or severe lithological heterogeneity: these formations often show flood problems, they have a medium to weak carrying capacity, they show differential subsidence patterns, vulnerability to erosion, instable slopes, etc. When these formations are dry, they can produce relief patterns with very strong changes, with the presence of crests and very deep cliffs (for example, in Bolognia), which can be very instable if the understructure is eroded. On the other hand, when saturated with water, their consistency reduces and instability increases, causing landslides, collapses, soil flows, etc., which influence the proliferation of fissured constructions, damaged or cut off roads, broken canals, etc. This soil condition is frequently found in the urban zones of La Paz and in the Río Abajo area.
There are two types of geological structures

Structures linked to deposits

Structures linked to tectonics

Deposits often acquire the shape of intercalated strata (for example, sandy gravel areas alternating with clayey muddy horizons in the La Paz formation). This heterogeneity influences the permeability, physical and mechanic characteristics and vulnerability to erosion of the land.

Structures linked to tectonics are mainly found in the Aranjuez mountain chain, causing a deep dislocation and influencing surface instability of the area. Faults in the heart of the massifs give rise to the formation of flat areas with a weak resistance to erosion, encouraging instability (for example, Alpacoma). In these cases, torrential erosion and collapses can occur.

5.1.1.4 Historical evolution of slopes

The watershed has acquired its current morphology after many changes that need to be analyzed to understand current phenomena.

These phenomena involve all big, mass soil remotions (land flows) covering large extensions of the watershed (Achocalla, Llojeta, Tembladerani, etc.), which seem to be stabilized but show particularly bad characteristics for constructions (weak carrying capacity to saturation, subsidence, potential instability and extremely erosion-prone).

5.1.1.5 Erosion

There are two types of erosion:

Erosion caused by surface water (rain, drainage, streams, rivers). This erosion gives rise to abrupt relief patterns, such as in Bolognia, Llojeta, Achumani, Auquisamaña, Mallasa and important zones of the Milliri watershed.

On little consolidated soils, violent rains cause the superficial washing of fine materials.

The “washing of slopes” caused by rainfall gives rise to the loosening of blocks in gravel formations (for example Miraflores gravel formations on the road to Obrajes, and urbanizations of the La Barqueta zone in Achumani).

The erosion of rivers and streams in flood periods is mainly caused by the hollowing out of the riversides, which in turn causes landslides, collapses, falling blocks, etc. These processes enable the generation of hydraulic lava flows.

Erosion caused by surface water (interstice circulations on permeable land, or localized in more or less important natural conduits).

This erosion is the consequence of the slow dragging along of fine particles of profound strata or the dragging of materials in subterranean canals. Effects on the surface are: funneling, deep pools, flooding of tunnels and cavities. The Valley of the Moon is the result of intense subterranean erosion, which can be observed also - but to a lesser extent - in the neighboring areas of Jupapina, Lipari and Achocalla and some sectors between the communities of Saytu and Avircato, and also in Uncura. Outgoing surface water can also cause hydraulic lava streams.

In general, subterranean water flows are a higher risk for land stability, they facilitate mass remotions, collapses, landslides and mud torrents on the riversides.

5.1.2 Natural hazards

There are different natural hazards in the city of La Paz and its environs, which result from particular natural conditions that characterize a region: they represent a threat to the population or human activity.

In general, we can affirm that various sectors of the watershed are exposed to a series of combined hazards of a different nature, such as, falling blocks and floods, erosion and floods. Below, we will separately analyze each of these hazards.

5.1.2.1 Mass remotion

Mass remotion is defined as all land displacements of a variable nature caused by their own weight. In this context, there is a certain difference between old and long stabilized mud torrents, such as Achocalla, Ovejuyo, Barrio del Periodista etc. and recent displacements.

In mass remotion processes, the soil structure is dissociated; displaced materials absorb water, giving rise to a strong variation of geotechnical characteristics, such as for example decreased resistance to landslides, increased water contents and thus increased weight, which may affect soil stability.

Mass remotion is a hazard for the population, as at ill-timed moments, it may take the shape of a mud torrent, landslides and collapses.

5.1.2.2 Hydraulic lava flows ("*mazamorra*")

Mazamorras are natural phenomena that frequently occur in the La Paz watershed area, where they are a well-known and progressive phenomenon. Hydraulic lava flows mainly come from important mountain streams that dominate the city and from the micro-watersheds of the tributaries of the La Paz River and existing mountain streams in the region. **These flows are a hazard to the population**, as they appear all of a sudden often causing expensive repairs to houses, streets, canals, as is the case of the **communities of Huaricana, Avircato, Palomar, Huayhuasi and Peñol.** In those communities, they can be identified because of the remarkable presence of their dejection cones on the banks of the La Paz River, which cross the road that unites those communities. **Urbanizations in hydraulic lava flow dejection cones are at risk of being directly affected by these flows.**

Water flows on slopes play an essential role in the movement and displacement of materials along the beds of the mountain streams that are connected to the La Paz River.

5.1.2.3 Floods

Floods occur in the rainy season, and in periods with snow fusion or hailstorms. This was the case in the storms in February 1979 in the center of the city, in March 1995 in the south area of the city of La Paz and on February 19, 2002, affecting large urban areas, especially near the most important rivers (Irpavi, Achumani, Choqueyapu).

It is difficult to clearly identify flood-prone areas in La Paz only on the basis of meteorological and topographical information, and information on the existing infrastructure, as there is a series of other determining factors typical of the sub-watershed and its respective micro-watersheds. CARE prepared a map on the location of events (floods, flooded underground chambers, house collapses and landslides), in an attempt to build a georeferenced database on flood hazard and important inherent occurrences, which are registered in the Emergency

Relief Service of the Municipality of La Paz. Likewise, it has been possible to obtain existing non-systematic information in the Río Abajo communities. All this has been useful to elaborate the flood hazard component in the Hazard Map.

In some places of the city of La Paz, the risk of the discharge of considerable levels of water requires the construction of drainage infrastructure or other systems to control the water table, in order to ensure stability of the slopes and banks. This type of structures must be generally implemented in the construction of canals, and must be contained in norms on the compulsory incorporation of barbicans in the walls of energy dissipaters to enable freatic water to flow into drainage canals.

5.1.2.4 Tremors

The presence of some protruding soil structures in the high plateau (from Ciudad Satélite to Amachumapampa) shows that faults have played a preponderant role in relatively recent times in terms of the geological scale (less than 10,000 years ago). A new seismic event of that magnitude is not very probable. In the course of history, there have been minor seismic movements, repetition of which is probable to a certain extent.

5.1.2.5 Hazards linked to human activity

Urbanization activities have gone hand in hand with modification of the natural environment, sometimes with serious consequences, for example: subterranean water pollution, landslides, erosion, etc.

These risks are often the result of non-compliance with basic precautions, both in the design and execution of infrastructure works for urbanizations. Below, the principal risks related to human activity are mentioned:

- **Erosion**

Erosion is a process that generally results from causes that are similar to the risks of soil instability such as the cutting of slopes, and modifications in the circulation of subterranean and surface water. Today, in the city of La Paz, we see erosion has not yet been controlled, in spite of efforts of municipal divisions responsible for erosion control plans.

It cannot be denied that erosion has been controlled to a certain extent through the adequate collection of rainwater, the channeling of rivers, drainage in slopes, etc. On the other hand, some sectors are exposed to a severe erosion process, causing the digression of rivers (Irpavi and Choqueyapu Rivers in the Amor de Dios sector) due to the irrational exploitation of sand and gravel, the lack of protection for important slopes causing the undermining of blocks in the Miraflores gravel area, etc.

Modifications in the topography cause important erosive processes. We should not forget to mention localized wastewater infiltrations, broken canalizations, etc., which can expedite subterranean erosion and in turn cause soil subsidence and collapses (Villa Armonía, Llojeta, Cotahuma, Mallasa, etc)

- **The instability of slopes and hillsides**

Although in the city of La Paz, most urbanized sectors show a good level of adaptation to the topography, in some cases the natural equilibrium of slopes has been disturbed by considerable cuts to form urbanization platforms with steeper slopes. The most remarkable

and recent cases are: the Holguín Curve in the Obrajes area, where hillsides are at higher risk of landslides and the upper part of the Virgen de Copacabana neighborhood of Bajo Seguencoma.

Photograph 1. Cuts to create platforms in the Holguin Curve in Obrajes

The Río Abajo area confronts this type of hazards because of an urbanization initiative in Lipari, on the right-hand bank of the Huacullani River.

Filtrations (bursts) in water networks of zones located on the slopes of the upper part of the city (Tacagua, Villa Nuevo Potosí, Alto Chijini, Kupini, Agua de la Vida, Cotahuma) have caused increased soil filtration, which in turn gives rise to landslides, collapses and hydraulic lava flows.
Slopes at risk of suffering landslides because of the presence of clay layers and slopes undermined by torrential erosion, etc., are vulnerable to a broken equilibrium, for example the landslide of the Capitán Ravelo street in February 1969, or of Villa San Antonio - Pasos Kanqui in February 1974, collapse of the highway to El Alto in the Ciudadela Ferroviaria area in March 1979 and other cases such as Cotahuma, Seguencoma, Final Bolivar, 23 de Marzo, etc.

In areas such as Villa Armonía or Cota Cota, which are located on top of old mud torrents, the lack of drainage systems to drain freatic water have caused soil subsidence (subterranean erosion), as well as landslides due to lubrication of clay layers located at a limited depth.

- Pollution

Pollution is defined as the alteration of the environment (water, air, soil) by highly concentrated chemical or microbial agents, which are harmful to the health of inhabitants in the region. Contamination can be of a household or industrial origin.

- **Surface water contamination**

Drained surface water drags along garbage and other contaminants. This is a frequently observed phenomenon in the streets of the city. Furthermore, contamination is caused by the wastewater coming from the sewage, sanitary and pluvial systems of the city of La Paz. This wastewater chiefly affects fruit-tree and vegetable plantations in the Río Abajo farming area, which sells these products to the population of the city of La Paz.

Photograph 2. Energy dissipaters in the course of the Choqueyapu River and contamination of the river water.

- **Subterranean water contamination**

The water that recharges aquifers drags along certain contaminants exposed on the surface, which can contaminate the aquifers, for example through the transportation of lixiviated materials.

Some organic products pass through a degradation or filtration process in the infiltration phase. In the sense, the thicker the means of filtration, the lower the inherent risk.

It is possible that subterranean water is contaminated by wastewater coming from broken pipes in sewage systems or the use of septic chambers or cesspools with direct discharge into the soil.

- **Soil contamination**

This is the result of contaminants of a household or industrial origin infiltrating into the soil. To a certain extent, elements that are harmful to human beings can be absorbed by vegetal species through their roots. In the case of leaved horticultural varieties that are irrigated using flooding methods, risks are higher.

- Atmospheric contamination

Generally, the industrial sector causes atmospheric contamination.

In the case of the city of La Paz, this contamination chiefly affects the surroundings of the riverbed of the Choqueyapu River, which transports discharges of the sewers of the city of La Paz. Other important atmospheric contaminants are the open wastewater collection networks as is the case of most surface water courses crossing the urban area of La Paz (Choqueyapu, Orkojahuira, Irpavi, Achumani, etc.) and the rubbish dump area of Mallasa, which causes many inconveniences to the population residing in the surroundings, besides the hazard of illnesses due to the environmental contamination.

6 WORK METHODOLOGY, INFORMATION GATHERING AND CONSULTED DOCUMENTS

This chapter contains a very short description of the process that was followed to gather information, as well as a list of consulted documents and other work instruments used to update and extend the hazard map of the region.

Work methodology:

In order to draft the Thematic Maps and Hazard Map and to carry out the Socio-cultural Study, the following methodology was followed:

- Relations and contacts with institutions, organizations, companies linked to the management of information on hazards and disasters in the La Paz area were established, with the objective of ensuring participation of these institutional divisions, especially at the municipal and prefectural level, as well as with specialized entities and/or companies and officers responsible for sectoral aspects at the national and regional levels. (See Annex 8 List of interviewed persons and institutions).
- Search for and collection of information and bibliography specialized in flood hazard and general hazards in the study area, such as the Urban Development Plan of the city of La Paz (B.R.G.M. – B.C.E.O.M. – P.C.A.), the Program for Comprehensive Rural Development, Watershed Management and Torrent Control in Río Abajo (CONSA - SERINCO), Assessment Report on the “El Niño” Phenomenon (SENAMHI), Official Report of SENAMHI on the meteorological event on February 19, thematic maps supplied by P.C.A., air photos of the study area and other information.
- Search for and collection of existing information on the waste management system. In this sense, the Municipal Sanitary Authority kindly provided different documents.
- Analysis of existing and available bibliography, in order to check whether the documents have current validity. These documents were also compared to the field experience of the CARE Bolivia assessment team.
- Purchase of electronic base maps elaborated by the IGM (Military Geographical Institute).
- Complete reconnaissance of the study area, both the urban area and the rural area of the Río Abajo region.
- Selection of specific areas to be studied, based on criteria that were previously determined by the assessment team.
- Programming of fieldwork and coordination with contact persons in the city and rural communities.

- Data collection and analyses of micro-watersheds through field visits, with complete visits of all selected micro-watersheds.
- Identification and localization of characteristic points of the risk zones, using GPS.
- Elaboration and updating of thematic maps and hazard maps, by means of the digitalization thereof with verification of specific details in the selected micro-watersheds.

In order to comply with the purposes of the present Assessment of Prospects for Flood Hazard Mitigation, the following equipment was used:

- Three vehicles
- Five computers
- One GPS
- Three printers
- Furniture for the team of consultants
- Digital camera

Moreover, the team had access to map digitalization and plotting services.

6.1 Used documents

Documents and publications available on the La Paz region.

6.1.1 Maps

- Digital topographical maps at a 1:50.000 scale
- Hydrographical, Geomorphologic maps and maps on canal infrastructure of La Paz at a 1:5000 scale
- Thematic maps developed by the Consulting Firm BRGM BCEOM.(1:25000)
- Map on construction possibilities and geotechnical characteristics of the watershed (urban area), (1:25000)
- Hazard Map prepared by the Consulting Firm CONSA SERINCO, Río Abajo area
- Soil study maps prepared by CONSA SERINCO, Río Abajo area
- Maps on environmental units prepared by CONSA SERINCO, Río Abajo area.

6.1.2 Air photographs and satellite images

- Air photographs at a scale of 1:20.000 (year 1996)
- Satellite image of the LANDSAT TM tracker taken in 2000
- Satellite image of the LANDSAT TM tracker taken in 1998
- Satellite image of the LANDSAT TM tracker panchromatic band taken in 2000

6.1.3 Consulted bibliography

- Some volumes of the Final Report “Urban Development Plan” drafted by B.R.G.M. – B.C.E.O.M. –P.C.A.
- Some parts of the Final Report of the Program for comprehensive rural development, watershed management and torrent control.
- Revision of archives: climatic information obtained from SENAMHI, Assessment Report on the climatic event on February 19, 2002, published by SENAMHI.

6.2 Analyses

Field observations: With support from inhabitants of the visited neighborhoods, as well as community inhabitants and communal leaders in the analyzed micro-watersheds, in order to get acquainted with geological, geomorphologic aspects and hazard areas in each of the sample micro-watersheds.

6.3 Mapping

In order to prepare the hazard map, the air photogrammetric restitution prepared by the IGM in 1996 was used as a base map. The Base Map is developed in a digital format, UTM zone 19, Datum and ellipsoid WGS 84.

A fundamental map was elaborated called the “Hazard Map”, in which information on Flood Hazard Areas and other associated risks (landslides, soil movement, hydraulic lava flows, etc.) was included.

We must underline that the hazard map is a graphical representation based on existing and updated information, in which some of the most recent events can be observed. Georeferences enable the verification of locations.

Obviously, this localization of events or hazards only in the sample watersheds can be perfectly georeferenced using field data. Other events in other micro-watersheds are subject to the transcription of available information.

Besides the hazard map that corresponds to the city of La Paz with extended coverage towards the Río Abajo region, digitalized versions of the following maps were prepared:

- Maps on Events registered and dealt with by the Emergency Relief Service of the Municipality of La Paz, which correspond to the following types of events:
    - Map on floods dealt with by the Emergency Relief Service.
    - Map on flooded underground streams dealt with by the Emergency Relief Service.
    - Map on landslides dealt with by the Emergency Relief Service.
    - Map on falling walls and collapsed houses dealt with by the Emergency Relief Service.
- Map on flood-prone areas.
- Map on building potential in the city of La Paz. CARE Bolivia digitalized this map.
- Geotechnical map of the city of La Paz, digitalized by CARE Bolivia.
- Hazard Map (Río Abajo), developed by CONSA SERINCO, digitalized by CARE Bolivia.
- Map on Forestry Intervention (Río Abajo), prepared by CONSA SERINCO, digitalized by CARE Bolivia.
- Edafological Map (Río Abajo), prepared by CONSA SERINCO, digitalized by CARE Bolivia.

7 SPECIFIC HAZARDS PER ZONE

The map on natural restrictions and hazards is a consultative instrument that must be considered a reference, not a document containing absolute truths. It does however contain a series of elements that make it possible to assume attitudes towards the principal problems that might represent a potential risk of occurrences that hamper the normal development of people's activities.

Below, the natural conditions in each of the micro-watersheds selected as part of the sample for the purpose of this study are analyzed, from north to south in the La Paz River Sub-Watershed.

A separate section summarizes findings of the Database on floods, underground floods, landslides and collapsing walls that were identified as events inherent to floods or rainfall in the city of La Paz. Furthermore, comments will be made on recent events that are not exactly located in the selected micro-watersheds inspected by the assessment team.

8.1 City of La Paz

7.1.1 Description of Elected Watercourses in the City of La Paz

7.1.1.1 Apumalla and Panteón Rivers in the Macro-district 2 Max Paredes

In the northwest sector of the city, the following neighborhoods are considered: Villa Antofagasta, La Portada, Rincón La Portada, Munaypata, Alto Santiago de Munaypata, Cusi Cancha, El Tejar, Mariscal Santa Cruz (drainage into the Apumalla River), Chualluma, Bartolina Sisa, Unión Alto Tejar, 14 de Septiembre and Los Andes (drainage into the Panteón river).

The following mountain streams are the principal tributaries to the Apumalla River: Carhuacunca, Apumallita, Italaque and Boquerón, as well as about ten other small streams. Likewise, the Panteón River has the following tributaries: the Coa Coa, Utapulpera, Loza, Salazar and Soliz mountain streams.

The micro-basin of both rivers was directly affected by the storm on February 19, 2002.

Apumalla River:

a) The Apumalla River and its tributaries: Steep slopes in the headwater section, in the past this area has been little benefited with forestation initiatives, because of its abrupt relief; there are underground flood hazards in the upper sectors, where the river is vaulted. Instability is considerable because of possible landslides. Fortunately, the Municipality has ordered the construction of canals and energy dissipating structures upstream in the natural riverbed that somewhat avoid violent torrents in these streams.

Photograph 3. Apumalla River, vaulted sections

b) In the starting sections of the tributary streams and the Amupalla River itself, where the river crosses the La Paz – El Alto highway (currently, the Amupalla River is being vaulted at that place, works were commissioned by the Municipality of La Paz), the watercourses could be subject to silting or blockage with dredge materials, both granular and vegetal materials, resulting from erosion in the headwater part of the micro-watershed. The Apumalla River section and the Apumallita and Carhuacunca mountain streams that converge at the junction of the Cristo Vencedor and Subteniente Peñaloza streets, are not yet vaulted. Neighbors and builders use them as waste disposal areas (without authorization from the Municipality of La Paz), implying high risks of obstruction of the Apumalla River's principal canal.

c) At the point where the mentioned rivers come together, there is a certain accumulation of dry materials, as well as water springs in the course near the Apumallita mountain stream. Below, some cases of landslides can be seen, as well as scarps of landslides occurred in previous years. These are probably the main reason why these sections have not been vaulted.

Photograph 4. Rubbish accumulation in tributaries to the Apumalla River

Photograph 5. Sidewalk damages due to underground flooding in the Juariste Eguino Square

The Apumalla River section between the Genoveva Ríos and the 29 de Enero streets shows underground flooding at present, which is recurrent in this section. It is one of the more than fifteen underground floods of the Apumalla avenue, which are considered in the events database and which are also included in the events map of the Municipal Emergency Relief Service. Moreover, more than ten flood events have been registered in this area. In fact, along the Apumalla River, there is flood hazard in the sections where the river is canalized, and underground flood hazard where the river is vaulted. While this study was being prepared, the most recent underground flooding occurred in the Juariste Eguino Square.

The Apumalla River section of the Manco Kapac avenue between the República avenue and the Juariste Eguino square passes underneath premises of the VITA Laboratories, the General Medical Center Manco Kapac, different housing buildings of 3 to 4 floors and the courtyard of the Hotel Italia. Then, from the Murillo street at the junction with the Cardozo – Figueroa – Tiquina – Pasaje Lanza streets it passes straight through private premises, in some parts underneath buildings of up to 5 floors. Because of the comments made in the previous point, we can affirm that the underground flood hazard and hence, the possible collapse of edifications is an obvious risk, which should be seriously taken into account in the future. During the February 19 event, a wall fell down in the General Medical Center Manco Kapac, as well as underground flooding in the courtyard. The following photographs show the current state of the medical center.

Photograph 6. Flood damages in the Manco Kapac Medical Center

Panteón River:

a) The Panteón River and its tributaries: there are important topographical ruptures in the headwater sections. In the past, the areas adjacent to the topographical ruptures have been benefited with forestation initiatives. The steep slopes in combination with a rugged relief pattern show that there are landslide hazards. In the highest sectors, the municipality has built canals and upstream in the natural riverbed energy dissipating structures, which somewhat mitigate though do not avoid hollowing out hazards at the bottom of the slopes in the streams.

b) In the starting sections of the Utapulpera mountain stream and the smaller streams that flow into it underneath the a Paz – El Alto highway, there are silting or blockage risks with dredge materials, both granular and vegetal materials, resulting from erosion in the headwater part of the micro-watershed. Another risk is duct blockage due to the dredging of waste and debris discharged into the tributary streams although there are garbage collection services in these parts of the city.

Photograph 7. Debris, waste and rubbish in canalizations (Apumalla River)

Photograph 8. Flooded underground streams, Apumalla River

c) The El Tejar sports ground is built on the vaults of this river. The section that passes in front of the cemetery has suffered different underground stream floods with considerable soil subsidence. Six flooded underground stream events and nearly ten floods have been registered along the Panteón River course in the events map of the Emergency Relief Service. This suggests there are flood and underground flood hazards.

d) In the year 2000, the Panteón River suffered an important underground flood in the central section of the trade fair in the Huyustus street, which required immediate intervention of municipal officials until complete repair with participation of a private contractor. In general, we can affirm there are underground flood hazards along the river's entire course.

Photograph 9. Headwater section of the Panteón River

Photograph 10. Inner part of the Panteón River vaulted section and damages caused by the river on February 19, 2002

e) In general, the Panteón and Apumalla Rivers have few drains, which may increase flood hazard in case of rainfall with only half the intensity of the event on February 19, 2002.

At the end of its course, between the Huyustus street, the former railway line and the Vita intersection where the Panteón River joins the Apumalla River, the former passes underneath a two-storey building and the control chamber is located in the courtyard of this building (difficult access). During the storm on February 19, the chamber was completely flooded. Moreover, underground flooding inundated the room located next to the entrance. Furthermore, in order to expedite construction of the Vita intersection, the course of this river was redirected with a forced section to connect to the Apumalla River.

Actually, the Vita Intersection is a high-risk area regarding underground floods and slides because of the geometric characteristics of the connection between the vaulted rivers and the topography of the area that causes the concentration of surface draining of rainwater through the Apumalla and Manco Kapac avenues. There are also potential landslide hazards in sections with steep slopes that were cut off to implement the mentioned avenue.

7.1.1.2 Melchuco - Cotahuma Rivers in Macro-district 1 Cotahuma

Located in the west sector of the city, this river passes through the following neighborhoods: Tembladerani Obispo Bosque, Alto Obispo Bosque, V. Ernesto Torrez, Kenani Pata, Hinchupata, Cancha Fígaro, Sopocachi Bajo, Lurituni and Las Lomas.

The Melchuco River (stream) is one of the tributaries to the Cotahuma River, which receives water from the Pasankeri I and Pasankeri II mountain streams. Together with the Las Lomas, Guindal, Lorituni and Durasnani mountain streams and the Arco Puncu and Sehuencani mountain streams, they flow directly into the Cotahuma River.

Photograph 11. Landslide on a Cotahuma Slope

The Cotahuma River is a tributary to the Choqueyapu River, it flows through an open riverbed from Alto Tacagua to Avenida Buenos Aires. Next, it flows through a covered canal with energy dissipating structures up to the point where it comes together with the Jinchupalla mountain stream in Cancha Fígaro, which then flows into the Choqueyapu River in Kantutani.

As from the point where the Cotahuma River joins the Jinchupalla mountain stream, the river flows through its natural riverbed equipped with energy dissipaters and some parts with defense walls, generally built with gabions. It flows through extremely wild areas formed by mud torrents, with remarkable signs of subterranean erosion.

Photograph 12. Gabions and energy dissipaters in the Cotahuma River

Photograph 13. Landslide in the Cotahuma area

The area is characterized by the presence of a great many springs at the source end of the mountain streams. These watercourses are located in zones with a high-risk topography, geology and soils, as these zones often have heterogeneous formations (topographical ruptures, landslides, very old flows as is shown on the photograph). Slopes in the source areas are medium to steep (30º to 60º). Most source areas show topographical ruptures and/or landslides and stability of the mountain streams or streamlets is doubtful.

a) These conditions gave rise to a succession of events that created the current topography, characterized by over fifty old landslides, with scarps and paleo-landslides.
b) Some of these areas have not yet stabilized, and some landslides are still active, as is the case of the “Cotahuma” landslide, located at the source of the Cotahuma and Sewencani Rivers, where a landslide occurred in 1998, affecting nearly 180 persons and destroying approximately 30 houses. This means this area is extremely landslide prone.
c) Another landslide occurred during execution of this study, at the intersection of the Melchuco River and the Avenida Buenos Aires. This was a characteristic event of this micro-watershed in an area with urban settlement activity, by reason of the Melchuco River having the respective sewage canal that crosses the platform of the Buenos Aires avenue extension. Small slope slides in the Pasankeri I mountain stream caused the dragging of granular material that ended up in the sewage system that crosses the avenues. In turn, this gave rise to undermining of the pipes, and hence, the breakdown of the downstream part of the sewage system

Photograph 14. Landslide at the intersection of the Melchuco River and the Avenida Buenos Aires

d) The source areas of the different mountain streams as well as the riverbeds that take the water to the Cotahuma River and even the Cotahuma River itself are equipped with energy dissipating structures in both natural river areas and canalized areas. At the same time, canalization infrastructure in this micro-watershed is very limited. This is because of the area's topographical, geological and soil complexity and because of the presence of dragged materials resulting from frequent surface hydric erosion in these watercourses and a certain degree of subterranean erosion. In the end, these are translated in landslide and hydraulic lava flow hazards.

Photograph 15. Engineering works in the Cotahuma River watercourse

Photograph 16. Active landslide area near the Jinchupalla River

e) In the lower middle part of the micro-watershed, under the point where the Cotahuma River and the Jinchupalla mountain stream come together, we find a combination of subterranean erosion and drain sewers. This is causing riverbed movements in the micro-watershed in the form of hydraulic lava flows, which intensify hazard. A landslide is also in process, as can be seen on the photograph, near the Jinchupalla River, classifying this zone as a high-risk area.

f) More than ten events of flooded underground streams and fifteen floods have been registered in the neighborhood of the tributary mountain streams and the Cotahuma River itself, as can be observed in the event map of the Emergency Relief Service.

g) It is remarkable that these mountain streams are generally used as rubbish dumps, and in some cases as debris disposal areas.

Photograph 17. Cotahuma and the Jinchupalla mountain stream

h) In short, we can conclude that the Cotahuma River micro-watershed is one of the highest-risk areas in the city of La Paz.

7.1.1.3 Venecia mountain stream in Macro-district 4 San Antonio

It is located in the east sector of the city of La Paz, covering the following neighborhoods: Valle Hermoso, Escobar Uría, San José and Villa Copacabana. This mountain stream area shows steep slopes, and flows through areas with a high-risk topography, geology and soils. Underground floods are recurrent along the canalized sections of the stream.

a) In general, the tributary mountain streams do not represent a permanent flow because at the headwater section of the micro-watershed, the number of water springs is limited. An important forested area surrounds the areas where the mountain streams spring up. Two of the tributary mountain streams in the northeast end spring up in areas where the topography shows small landslides that may become more important.
b) Both the tributary mountain streams and the principal vaulted conduit are equipped with energy dissipaters, thus avoiding the formation of detrimental torrents.
c) The vaulted areas are at risk of getting stuck with materials dragged along from the source area of all tributary mountain streams, in spite of forest coverage.
d) In a short section, the vaulted area tends to suffer recurring underground floods and floods, calling inhabitants' attention. Precisely during field observations for this evaluation, an underground flood was verified in the Rafael Ballivián street, as well as two other more recent underground floods at the intersection of the Avenida Tito Yupanqui and the Rafael Ballivián street.
e) Recurrent events of flooded underground streams can be attributed to the design of the canals and soil characteristics in Valle Hermoso and Villa Copacabana.
f) As is the case in the other analyzed micro-watersheds, the streets through which the Valle Hermoso mountain stream passes are characterized by the frequent dragging along of garbage. This garbage is dumped at hours different from programmed hours for garbage collection in the Valle Hermoso zone by the micro company Illimani.

Photograph 18. Area where the Venecia River springs up

g) Underground flood events are more recurrent at the intersection of the Rafael Ballivián street and the Avenida Pasos Kanki (Carrington Motel), and at the intersection of the Rafael Ballivián street and the Avenida Tito Yupanqui. In these areas, the slope of the vaulting suddenly changes, which is probably one of the causes contributing to underground floods.

7.1.2 Summary of results of mapping of floods, underground flooding, landslides and falling walls registered by the Emergency Relief Service of the Municipality of La Paz.

Based on information supplied by the Central Office of the Emergency Relief Service, a database in Excel was prepared, which was organized through dynamic tables and linked to georeferenced geographical attributes that represent floods, flooded underground streams, landslides, falling walls, etc. that are usually related to the rainy season. The digital maps can be can be viewed using the software Arc View™ version 3.2.

Based on the analysis of thematic maps registering events during the last five years, the following preliminary conclusions can be drawn:

7.1.2.1 On the flood map:

In general, these events occur in the rainy season and the period following the rainy season. These events area usually related to the deficient operation of canalizations, obstructions of canals with rubbish and debris and deficient connections between rivers and mountain streams (with angles of about 90o).

Floods usually occur in areas near the rivers that cross the city of La Paz.

Although floods occur in different neighborhoods of the city of La Paz, a certain concentration can be seen in areas near the following rivers: Apumalla, Panteón, Cotahuma, Zoqueri and Choqueyapu or the central and north sectors.

Photograph 19. Flood in Achachicala (water treatment plant of the company Aguas del Illimani)

7.1.2.2 On the underground flood map:

In general, these events occur in the rainy season and the period following the rainy season. These events are usually related to the deficient operation of canalizations, obstructions of canals with rubbish and debris and deficient connections between rivers and mountain streams (with angles of about 90o) .

Underground floods are generally related to deficient canalizations and also occur in areas with subterranean erosion resulting from water flows in erosion and collapse-prone areas. These events are concentrated in the areas near the Apumalla, Panteón, Cotahuma, San Pedro Rivers and the lower part of the Venecia River.

Photograph 20. Underground flood along the Apumalla River

Photograph 21. Fallen wall due to geological instability

7.1.2.3 On the map on fallen walls:

Necessarily, these events occur in the rainy season, and immediately afterwards.
Up to a certain extent, these events are concentrated in areas with a weak geological structure.

These events occur most frequently and are concentrated in the following neighborhoods: Kupini, 28 de Marzo, Barrio Lindo, Zarzuela, Challapampa, Apumalla and Munaypata.

7.1.2.4 On the landslide map:

Necessarily, these events occur in the rainy season, and immediately afterwards.
Up to a certain extent, these events are concentrated in areas with a weak geological structure.

Landslides occur most frequently and are concentrated in the following neighborhoods: Villa Armonía, Villa San Antonio, Kupini, Agua de la Vida, La Merced and the upper parts of the western hillside of the city.

Photograph 22. Landslides caused by water infiltration in the extension of the Avenida Buenos Aires

7.1.2.5 On the map showing a combination of floods, underground floods, fallen walls and landslides:

The purpose of this analysis is to see which zones require more attention from the Emergency Relief Service, based on which work strategies could be proposed that adequately respond to emergency situations that require intervention of the said municipal service department.

- Events are highly concentrated in the rainy season.
- The zones with most emergency events are the areas under the influence of the Apumalla, Panteón Rivers and the neighborhoods of Kupini and Cotahuma.
- Events are associated with river courses and vaulting.

7.1.3 Conclusions and recommendations regarding risk analysis in the micro-catchments of the city of La Paz.

The population of the city of La Paz and each of the micro-watersheds must be adequately informed and oriented on the existing risks inherent to rivers and mountain streams in the neighborhood where they live. They must be informed also on the attitudes that are detrimental to the normal functioning of the drainage infrastructure, the provision of public services for the benefit of the population – e.g. garbage collection – and the importance of citizen participation in appropriate practices, conservation and maintenance of a healthy environment.

The information – awareness-raising methodology must be applied adequately and in a differentiated manner according to the type of population and cultural characteristics of the population groups. This means communication processes between the municipality and the population should be improved.

Radio and television spots are not always the most adequate means to change attitudes in a population with deeply rooted habits. Tests on dynamics of a dialectic type show that the population receives messages on environmental issues as a propagandistic type of messages, which do therefore not always attain the communication objectives intended by those who broadcast the messages.

The Municipality should assume policies in closer coordination with neighborhood councils. This would enable implementation of an extensive awareness-raising program on the effects of the population's attitudes regarding the irregular operation of drainage infrastructure.

Attempts should be made to establish a social control system on operation of the existing infrastructure and attitudes of the population regarding irregular waste and debris disposal. If the population is aware of the abovementioned problems, it could positively impose a social sanction on infringing parties.

Once the population is organized and aware, the municipality could officially exercise control and sanction actions that are detrimental to the normal functioning of rivers, drainage facilities, etc. Then, the population could accept and even support this type of official measures.

A participatory integrated watershed management program should be implemented, enabling awareness raising of the population on the current condition of the micro-watershed where they live. The purpose would be for the population to then commit to participate in improvement of the micro-watershed's environmental conditions.

A program must be undertaken to reinforce canalization and vaulting structures, specially focusing those that pass underneath or through buildings. In this case, relocation thereof should be programmed to ensure these watercourses rather pass through streets and avenues.

7.2 Río Abajo.

7.2.1 Description of the micro-watersheds

7.2.1.1 Huacullani River (21.3 Km2) in the mountain chain composed of the Muela del Diablo, and the Pachajaya, Cuñamani and Cañaviri hills.

This river shows a torrential type of behavior, dragging along materials resulting from landslides that frequently occur in the middle of the watercourse. The riverbanks are composed of sandstone conglomerates of a dark grey – violet color that contain two levels of whitish tufa. Structures are similar to those south of the Muela del Diablo intermingled with clay.

The upper part of the micro watershed shows large areas with strong erosion processes. In the lower part of the community of Huacullani, there is an area with soil reptation, affecting cropland and rendering unfit large extensions of land.

Photograph 23. Upper part of the Huacullani River

Photograph 24. Area with soil reptation, near the community of Huacullani

The dominant vegetation in the watershed are shrubs. At the bottom of the ravines and slopes, there is an abundance of grass species.

a) The micro-watershed of the Huacullani River is characterized by its constant flows, resulting from the bottom of the micro-watershed. There are some water springs that can be observed dispersed over the area that is being subject to a remotion process due to reptation.
b) The Huacullani River does not form part of the Río Abajo Integrated Development Plan. Hence, no canalizations have been designed to regulate torrents in this micro-watershed.
c) Because of the extension of the micro-watershed and assuming the calculation hypothesis of CONSA SERINCO, the volume of water in the micro-watershed amounts to 132 m3/sec. In other words, the sum of water flows and dragged along solid materials, resulting in a canal with a base or bottom width of 35 m. At the point where the two tributary mountain streams join the river, there is a risk of landslides, which could cause flooding and subsequent deterioration of the weak riverbanks of the Huacullani River.
d) In the community and surroundings of Huacullani, erosion and soil reptation are intense, which is seriously affecting the “La Gótica” urbanization, where recently built infrastructure is being destroyed.

e) As a result of the prevailing geo-morphological structure and the erosion process in this micro-watershed, we have verified a solid transportation process at the mouth of the river, forming torrential fans that in their almost perpendicular mouth area violently meet the last section of the Choqueyapu River, just before the Lipari Bridge. At this point, there are clear signs of deposited dragged along materials, the evolution of which can be observed in the increased bottom level of the Choqueyapu River (La Paz), where annual solid deposits probably represent 8 to 12 cm yearly.

7.2.1.2 Llauchi mountain stream (9.6 Km2) in the mountain range composed of the Chijo, Millumarca, Vilaque and Llauchi hills

The headwater section of this mountain stream shows steep slopes, considerable erosion and landslides. It is an important watercourse with flood and hydraulic lava flow hazards for the communities of Carreras, Taypichullo and Mamaniri. The area is not considered a productive area because of the agro-ecological conditions that dominate the micro-watershed (marginal soils with scarce vegetal coverage).

The presence of black lutites corresponding to the Siluric Devonic ages of the Sica Sica formation is notorious in this micro-watershed, especially in the Llauchi, Chojo, Mullumarca and Vilaque hills (which constitute the micro-watershed). It is a weak geological formation with limited resistance to erosion. In the middle of this formation, there are some incrusted conglomerates that correspond to the Aranjuez formation.

a) The micro-watershed of the Llauchi mountain stream is characterized by its untimely flow in case of rainfall. Deposited sediments of a colluvial alluvium type (caused by erosion in most of the micro-watershed hillsides with scarce vegetal coverage) along the river have formed a platform that is currently being prepared to build a second urbanization in the micro-watershed. This urbanization is exposed to flood hazard and more or less intense hydraulic lava flows.

Photograph 25. Materials dragged along the Huacullani River

Photograph 26. Land prepared for an urbanization in the high-risk area in the Llauchi riverbed

b) According to calculations of CONSA SERINCO, the volume that passes through the bottom of the micro-watershed amounts to 84.18 m3/sec (this volume includes 32.48 m3/sec of transported solid material) for which a canal with a width of 25 m was designed with a critical brace of 1.05 m.

c) Following the watercourse in the mountain stream, the canalization in the right-hand bank of the riverbed was taken advantage of, which has the function of a hydraulic lava evacuation canal. Its section (sometimes up to 3.20 m and an average height of 2.10 m), is very limited as compared to the design of CONSA SERINCO. Hence, there could be floods and hydraulic lava flows.

Photograph 27. Current course of the Llauchi River

Photograph 28. Magnitude of materials dragged along the Llauchi River at the point where it meets the La Paz River

d) Scarce shrubs are the surface vegetation in the micro-watershed. During fieldwork, urbanizations were verified at the shore of the mountain stream, which already show some signs of obvious instability due to the quality of the soils, which are unfit for simple constructions, unless the structural design is adequate.

e) The east and west banks of the micro-watershed show signs of two landslides that occurred in previous years and that are still active with successive events that mainly occur in the rainy season. In the middle of the watershed, there is also an area where landslides of a considerable magnitude may occur. In these cases, the hazard is that there could be cases in which additional solid material is dragged along, causing erosion during the severe floods that sometimes occur in this micro-watershed.

f) Because the deposited material along the streambed is erosion-prone and while the canalization works designed by CONSA SERINCO are not carried out (this does not imply a tacit adhesion to the design criteria adopted by the Consortium), the flood and hydraulic lava flow hazard is considerable. This risk is concentrated in a strip with a width that varies between 25 and 60 m, as the course of this mountain stream can be classified as torrential. This mountain stream must be subject to close monitoring to find solutions for the different parts of the micro-watershed, i.e. the collection area, the gorge and the dejection bed.

g) At the point where it flows into the La Paz River, crossing the frontal tongue of the Achocalla mud torrent, there are landslides due to the hollowing out at the bottom of the slope from dejection.

7.2.1.3 Khellkhata River (33.3 Km2 in the mountain range composed of the Llauchi, Vilaque, Cupini and Collana hills)

This river with a steep slope (between 8 and 12%) has a wide headwater section. Long sections of the river flow through canyons with considerable dragging of material due to landslides and severe soil erosion. The principal tributaries are the Llutujahuira and

Ñuñujahuira mountain streams. This river is an important watercourse that implies flood and hydraulic lava flow risks for the communities of Carreras, Valencia. Mecapaca and Yupampa in the area where it flows into the La Paz River, although a section of approximately 2 Km was canalized through a canal of 30 m wide where the river flows between defense walls that consist of a combination of gabions and stone walls.

Although the micro-watershed of the Khellkhata River is located next to the Llauchi mountain stream, its geological formation differs from that of the Llauchi stream. It shows a remarkable presence of black to grey lutites that correspond to the Siluric Devonic age of the Sica Sica formation (weak geological formation, erosion prone), conglomerates of the Aranjuez formation, sandy levels of the Vila Vila formation and deposits of the La Paz formation. In the hills and lower part, this panorama is alternated with sandstones and lutites of the Belén formation.

a) The area of the Khellkhata River basin is an area vulnerable to storms, with hills and abrupt rocky mountains dissected by rocks of the Cenozoic era. Hence, vegetation is scarce, mainly shrubs, especially because of ecological conditions of the zone, characterized by lower average rainfall, as is registered in meteorological registers of the Mecapaca station.

Photograph 29. Upper part of the Khellkhata River micro-watershed

b) Throughout the riverbed, alluvial plains have developed due to sediments and detritus (decomposed solid mass) transported through the river. These terraces were used as farmland, but because canalizations were built, the use of soils is being changed for urbanizations.

c) According to calculations by CONSA SERINCO, the projected volume for the canal is 202.2 m3/sec, 60% representing the transportation of solid material. In these conditions, expectations are that some storms will give rise to the flooding of certain parts of the canal, undoubtedly implying a risk for the communities of Yupampa, Carreras, Valencia and Mecapaca because of possible flooding of the Khellkhata River.

d) With regard to risks associated with rainfall, we can mention two landslides that occurred in recent years, which have not yet stabilized on the east bank of the Llutujahuira mountain stream.

e) In turn, at the point where the tributary mountain streams flow into the Khellkhata River, we can find enormous zones where landslides may occur; the north, east an south banks of the Ñuñujahuira mountain stream contain important areas with these characteristics. The south bank shows signs of a landslide that occurred in the past and that may expand considerably, as is shown on the hazard map of the area.

Photograph 30. Overall view of the canalized section of the Khellkhata River

f) As the hills of the micro-watershed show a weak geological formation that is erosion-prone, the proportion of solids transported through the Khellkhata River calculated by CONSA SERINCO can correspond to the reality of its torrential features. However, its hydraulic behavior must be monitored regularly to define specific solutions for each part of the micro-watershed.

g) Considering the topological characteristics of the canyon and geological conditions of the Llauchi, Villaque Cañaviri hills, the Pijchu mountain range and the Cupi Cupini, Cori Corini and Sankapata hills that form part of the Khellkhata River micro-watershed it is obvious that there is a risk of the damming of rainwater. This is due to landslides that may occur at the point where the Llutujahuira and Ñuñujahuira mountain streams come together.

7.2.1.4 Petuila - Aleluyani River (45.3 Km2) in the mountain range composed of the llakasa, Kharaloma, Achumapampa, Quellimaraloma, Partiloma, Muyunpataloma, and Capurita hills.

The headwater section of this river is called Petuila, and as from the middle of the watercourse it is called Aleluyani. The slopes vary between 2% and 3% where the river flows into the La Paz River, 3% - 8% in the middle sector and slopes over 50% in the cliffy headwater sector.

This micro-watershed is characterized by Devonic formations, quartz sandstones of the Vila Vila formation in the lower part, alternated with lutites and sandstones of the Belén formation and the Sica Sica formation that includes black lutites.

a) In the area where the river flows into the La Paz River, there are signs of dragged along solids resulting from ongoing erosion in this river's watershed area, representing considerable flood hazard for the community of Avircato, and to a lesser extent for the riverside areas of Mecapaca and Cachapa.

Photograph 31. Degraded zones on the Petuila Riverbanks

b) With regard to risks associated with rainfall, we can mention that in the headwater section of the micro-watershed there are areas with imminent and ongoing landslides (sectors: north of the Pocollita mountain stream. northeast of the Amachuma mountain stream, east of the Puchachina mountain stream and southeast of the Aleluyani River). There are various areas where landslides will probably occur on both banks of the tributary mountain streams Pocollita, Amachuma, Chune Chahua, Pucha China and the Petuila River itself. Although these risks have not yet resulted in concrete events, the soil degradation process may effectively contribute to a hazard situation in the short term.

c) The small plain of the micro-watershed of the Petuila River does not show any signs of dragged along material of the hydraulic lava type, which makes us suggest that in case there were hydraulic lava flows, the corresponding material was dissolved and washed away. On the other hand, in the upper part, there are indications of decomposed formations of a Devonic origin. These obviously resulted in hydraulic lava flows that transported material to the area where the river first meets the Milliri River and then the La Paz River, as the area occupied

by this formation is weak and erosion-prone. Finally, we found a dejection cone resulting from hydraulic lava flows that occurred many years ago and that have currently assumed a considerable size.

d) In the area between the Chunechahua, Pocollita Amachuma and Puchachina mountain streams, there is a large area with evident signs of erosion, especially on the northern hillside of the Huichun Chullpa hill, which contributes to the dragging along of materials during the rainy season. Vegetal coverage consists of shrubs intercalated with cacti.

Photograph 32. Extensive areas with intense erosion processes. Petuila River

e) These areas show considerable limitations for the planting of forest species because the soils are severely degraded and have been abandoned. However, pilot activities could be started to try to plant some shrub and cacti (prickly pear) species for commercial purposes, especially taking into account that this zone forms part of the region with limited rainfall, as we said in the analysis of the Khellkhata River.

f) According to calculations of CONSA SERINCO the transit volume planned to pass through the projected canal with a bottom width of 25 m is 102.05 m3/sec. In the section where the river joins the Milliri River, and the point where it comes together with the La Paz River (called the Saytu River), the canal has a bottom width of 50 m for a total water volume of 413.41 m3/sec.

7.2.1.5 Milliri River: (37.4 Km2) in the mountain range composed of the Conchamarca, Huichunchullpa, Capurita, Nazacara, Huarisanani Loma and Cruz Pata hills.

In its headwater section, this river is called the Milliri River and as from the point where it meets the Petuila River the name changes to Saytu. Slopes vary from 2% in the dejection cone area, to 9% in intermediate areas and over 55% in the headwater section.

This micro-watershed contains formations that correspond to the Devonic era, with quartz sandstones of the Vila Vila formation in the lower part, alternating with lutites and sandstones of the Belén formation and in some parts with black lutites of the Sica Sica formation.

a) The Milliri River is a micro-watershed with highly degraded soils, which is why it also contains mass remotion deposits corresponding to a mud torrent known as Saytu, which represent a latent hazard in the micro-watershed area.
b) In the upper part, there are areas with imminent landslides and past landslides that have given rise to important erosion processes. Because of the micro-watershed's geological conformation, the area generates hydraulic lava streams that are evident in the section where the river flows into the La Paz River. This implies serious flood and hydraulic lava hazards for the community of Avircato, and to a lesser extent the riverside areas of the communities of Mecapaca, Palomar and Cachapa.
c) Regarding rainfall related risks, it is important to mention that there is a large variety of old, recent, imminent and probable landslides along the Saytu Milliri River, which are generally activated in case of persistent and intense rainfall. These hazards can be identified in for example the following sectors:
    - **Old and/or active landslides:** predominantly on the south bank of the Milliri River and with some similar characteristics on the north bank between 1,000 and 2,000 m upstream from the point where the river meets the Petuila River.
    - **Imminent landslides:** on the north bank of the Milliri River, just before the section called Saytu.
    - **Probable landslides:** on the south bank of the Milliri section and on the north and south banks near the point where the Milliri and Petuila Rivers meet.
d) Because of the considerable number of landslide-prone areas found in this micro-watershed and the geological features thereof, this micro-watershed is vulnerable to erosion. Hence, we can conclude that the Milliri River is an important tributary that drags along material of the hydraulic lava type. Although these risks have never had serious consequences, the soil degradation process could contribute to an event with high-risk consequences in the short or medium term.
e) The highest risk are those landslides that may give rise to more or less significant damming, the collapse of which may result in extraordinary flooding with an impact in the dejection cone, where important urbanization initiatives are already being undertaken.
f) In the Milliri Riverbed, we can see the presence of deposited dragged along material of the hydraulic lava type, which is taken to the dejection cone in case of considerable rainfall, as the watershed area's constitution is weak and erosion-prone. Finally, we found a dejection cone composed of hydraulic lava flows of many years and that find their origin chiefly in the micro–watershed of the Milliri River. The current size is significant.

Photograph 33. Urbanizations in high-risk areas. Dejection cone of the Milliri River

g) The land in this micro-watershed shows limitations regarding the planting of arboreal species. Nonetheless, pilot activities could be started planting native arboreal and cactus species, which could be attractive for inhabitants of communities in this watershed area.

h) According to calculations of CONSA SERINCO, the volume transported during important floods is of 301.36 m3/sec through a canal with a bottom width of 35 m. In the section where it joins the Saytu – Milliri River, the point where the river flows into the La Paz River has a canal with a base width of 50 m, which responds to a total volume of 413.41 m3/sec.

7.2.2 Conclusions and recommendations on the hazard analysis in the Río Abajo micro-watershed area

Inhabitants of communities in Río Abajo are used to hazards associated with floods and other inherent hazards such as landslides, farmland erosion, hydraulic lava torrents, etc. Therefore, they know and they are organized for prevention, mitigation and rehabilitation in case of disasters.

The municipalities of Achocalla and Mecapaca should adequately follow up urbanization processes and implement the required infrastructure in areas identified as risk areas for human settlements. It is neither sufficient nor appropriate to authorize or approve urbanizations plans, as viability of these urbanizations must be determined from a social and communal point of view.

Municipalities must implement programs to increase vegetal soil coverage and reforestation in the areas affected by the micro-watersheds where communities in their respective jurisdictions are located. In this sense, it is recommended to assume mixed strategies that take into account more efficient processes for the natural reproduction of species, in combination with reproduction in greenhouses and also taking into account integrated watershed management processes.

Pilot infrastructure works must be undertaken regarding canalization at the mouth of the La Paz River, thus complementing canalization works in the Khellkhata River. This would be an opportunity to adequately follow up behavior of the works for connection of both watercourses. These works will enable follow-up of the hydraulic behavior of the canalization in the case of considerable floods and its solid material dragging behavior.

8 AREAS THAT ARE MOST VULNERABLE TO FLOODS AND INHERENT HAZARDS

Watersheds included in the sample, as well as the existing and drafted documents and maps were revised, and the zones that were most severely affected by events registered in the Emergency Relief Service of the Municipality were analyzed. Moreover, field visits were carried out in the entire region that is being studied. Based thereon, it has been possible to determine the following areas as the areas that are most vulnerable to floods and inherent risks, both in the city of La Paz and the Río Abajo rural area.

8.1 Most vulnerable areas in the City of La Paz:

In general, we can affirm that flood-prone areas are areas under the influence of all existing watercourses in the city of La Paz, both canalized and non-canalized ones. Habits and practices of the population regarding waste and debris disposal are aggressive for the city's existing drainage facilities. Because of these habits, the canalization infrastructure is exposed to different dangers: silting, overflowing and underground flooding. In turn, the areas that are most vulnerable to underground flooding are vaulted canals, as can be seen in the hazard map.

Below, an overview is presented on the most important hazard-prone locations in the city of La Paz:

Areas under the influence of vaulted canalizations in the entire network of La Paz. This is because of the risk of underground flooding, which may cause damages to constructions near the canalization areas. On the other hand, recurring underground flooding along the canalizations underneath buildings can affect the structures of the vaults and the buildings themselves, for example in the sections described in Annex 2 "*Zones identified as hazardous because of subterranean canalizations".*

Cotahuma River and its tributaries*.* Because of its geological structures and complexity of the tributary network in this micro-watershed area. In the headwater section of this micro-watershed, there are many possibilities of blockage due to waste and debris. Canalizations of the river are exposed to underground flooding and floods in different sections.

One section that has been vulnerable for a long time is the old rubbish dump in Sopocachi, called the Figaro field. This area is vulnerable because cohesion of the soil is limited, composed of a mud torrent that is the result of the Llojeta soil flow extension.

The Cotahuma River watershed gives rise to severe erosion, which in turn results in frequent hydraulic lava flows from the different tributary mountain streams and landslides on the riverbanks. This situation implies severe risks for human activity and canalization structures.

Apumalla and Panteón Rivers*:* Because of the complexity of the tributary network and the respective canalizations, in some cases sections where tributaries flow into the principal watercourse show inconvenient angles. The Amupalla River section between the Vita Intersection and the Choqueyapu River passes underneath a considerable number of buildings. This implies constant hazard related also to the possibility of damages to the vaulting structures with a current useful life of over 40 years. As any other section of the canalizations, vaulted areas can collapse, especially if the required carrying capacity increases with the weight of the constructions.

Zoqueri River*.* This river passes underneath a considerable number of private and public buildings, which are at risk of collapse in case of underground flooding. Moreover, the vault structures may be affected as they do not only carry the weight of the earth on top of them, but also of the buildings. One of the tributary streams, Zoqueri II, passes underneath two blocks of private houses between the Barbados and Diego de Peralta streets. The course of this river between the Haití street and the Tejada Sorzano square (Stadium) passes underneath various consolidated buildings. The middle and end sections (Díaz Romero – end of Juan de Vargas) pass underneath different houses, the Dora Schmidt School, the Obrero stadium, the II° Felipe Guzmán school and the Instituto Bancario school (neighborhood of Miraflores)

Landslide area of Villa Armonía. Soils in this neighborhood have been instable for a long time. Today, there is a remarkable landslide between the Héroes del Chaco street and the Av. Del Maestro. Constructions, drinking water and sewage facilities and other public works are a constant problem that worries inhabitants of this neighborhood. It seems the solution is to implement drainage systems, in combination with support structures opposite to the displacement direction. In this region, no urbanizations should be authorized; the area should be rather used as a green area.

Photograph 34. Landslide in Villa Armonía

Landslide area of Kupini. Some sectors of this neighborhood are remarkably instable, as this area is a large landslide area with periodic activation in case of the presence of the following factors: persistent rainfall, imperfections in water and drainage systems or a lack of regular maintenance of the road platform that crosses the landslide area. The last important event took place in March 1999. Because of these conditions, the population must be adequately informed on future risks in this area, so they would no longer occupy these hazardous areas with buildings, the consistency of which is not appropriate for the existing conditions.

Villa Copacabana. This neighborhood is exposed to underground flood hazards during the rainy season. Width of the canalizations is too limited to avoid these dangers. The same is true for many mountain streams in the city.

Collpa Jahuira mountain stream. This mountain stream is confined between the little consolidated soils of the La Paz formation over an extensive area. In the rainy season, water concentration in the exit canal in Obrajes (street 17) usually causes flooding or hydraulic lava streams. This section has been repaired on different occasions in recent years. Use of the stream as a waste, debris and rabbis dump is a severe risk for the canalization structure.

Ex rubbish dump of Sopocachi. Located near the Sopocachi and Kantutani neighborhoods, the former rubbish dump can contribute to instability of the Cotahuma riverbanks. There are landslide hazards in various places of the area, which are a threat to constructions and banks of the Cotahuma River in the Kantutani area because of hydraulic lava movements.

Photograph 35. Hillsides of the Cotahuma River, former rubbish dump of the municipality of La Paz, in the Sopocachi and Kantutani neighborhoods

Flood-prone sectors. The most extensive flood-prone sectors are located in the alluvial plains of Irpavi, where, in spite of many defense walls, different houses are built in hazard areas without any type of riverside protective walls. The exploitation of sand for construction purposes may cause erratic flowing of the Irpavi River, resulting in floods in various sectors throughout the left-hand riverbank.

In Achumani, existing canalizations are exposed to the transportation of considerable amounts of dragged along materials that may cause obstruction, and hence overflowing of the river, especially in lower areas of the Achumani urbanization. Likewise, there are various flood-prone areas along the Choqueyapu Riverbed, especially in Obrajes, between street 2 and the Bajo Seguencoma Bridge where the Choqueyapu River suffers floods on both sides. Another sector with problems is the main street of the principal access road to Koaní, as well as the exit areas of some important mountain streams (Caiconi, Los Andes, Achachicala, Villa Copacabana, etc. neighborhoods).

The Amupalla River still shows flood hazard because of the limited absorption capacity of sewers and sidewalk grates alongside the river.

Landslide of Alto Seguencoma. The municipality of La Paz has worked in this area, building a contention wall based on gabions. However, the landslide is sill active with constant soil movements that affect houses and infrastructure on the edge of Alto Seguencoma, near the access road from street 16 in Obrajes. This landslide shows a rupture surface that even crosses the base of the slope near the flyover of street 16. This landslide affected a construction that seemed consolidated once. Today, it seems the owners are merely waiting for the construction to completely collapse. The house next door is also at risk in case the active landslide is extended.

Photograph 36. Damages to houses caused by soil displacement, Alto Seguencoma

8.2 Most vulnerable areas in the Río Abajo and Achocalla region:

The vulnerability context of the Río Abajo region is different from that in the city of La Paz. In the city of La Paz, aspects inherent to safety of the population, housing, services and economic activity as a means of subsistence of households and the city dwelling community in general are taken into account. Whereas, in the rural area, the most important factor is the farmland, which represents a means of subsistence for the rural population inhabiting the Río Abajo area.

8.2.1 Achocalla River Micro-watershed

a) The north region of the Achocalla River shows steep slopes and abrupt relief patterns, which are affected by severe erosion and varied and extensive soil movement. Internal erosion is active. There are many active soil movement processes (landslides, flows, hydraulic lava, subsidence).

b) Villa Exaltación is located in the jurisdiction of Achocalla, where a new landslide was registered at the moment of this study, as part of the mass movement process that characterizes this region.

Photograph 37. Landslide in Alpacoma, in the jurisdiction of the municipality of Achocalla

c) The area that is being prepared for urban expansion is located in a hazard zone because of surface erosion and internal erosion, as part of the dominant structure in the zone.

Photograph 38. Arco Iris Urbanization, built in dejection cones, Achocalla

8.2.2 Choqueyapu River Sub-watershed - La Paz

This area is located between the Aranjuez gorge up to Peñol.

a) Slopes are abrupt. Fluvial erosion is intense. There are many active soil movements (landslides, collapses, flows, hydraulic lava, subsidence). Subterranean erosion of the Achocalla soil flow is remarkable.
b) In general, the quality of the land is bad.
c) There are flood hazards in vast sectors, starting from the area near the Aranjuez bridge, passing the farmland areas of Mallasa, Jupapina and Lipari. This hazard can be observed in an area of over 10 Km between the first section from the Choqueyapu River to the Lipari Bridge, and a section from the beginning of the La Paz River to the area past the farmland that is located in the jurisdiction of Taypichullo and Llakasa. The river is confined between instable mountainous bank formations. Moreover, owners of the land want to gain more land, which means they deliberately hollow out the base of the natural hills. The third section covers the area between the communities of Palomar, Cachapa up to Huaricana. Although in this sector, the riverbed is wide, community attempts to gain more land have caused considerable floods in the recent past, rendering farmland unfit.
d) The floods registered in 2002 show what usually happens in this region, which must be considered a permanent hazard area. The following references – which are the result of observations by community inhabitants themselves - must be taken into account:

    - During construction of different types of defense walls: inhabitants of the region have a lot of knowledge on the transportation of materials in the La Paz River. Research in the zone shows that in the Lipari Bajo area, solid deposits amount to 8 to 12 cm yearly (“collapse” of the riverside defense structures built with community participation occurs accordingly). A clear

sign of this situation is that the piers of the old Lipari bridge are gradually being covered with material dragged along the La Paz River.

In Taypichullo and Llakasa, defense walls are “sinking”, on average 10 cm a year.

In Palomar and Huayhuasi, defense walls seem to sink an average of 8 cm every year.

In Huaricana, people say that defense walls will disappear in 10 to 12 years from now, because they are sinking right where they were built, except in some cases where gabions were destroyed by the river.

- Hydraulic lava flows are an important risk factor for communities, farmland and areas for urban expansion, as we have seen in the respective analysis, especially for the communities of Lipari Bajo, Ananta and Huajchilla, Taypichullo and Llakasa to a lesser extent. The communities of Avircato, Palomar, Huayhuasi, Huaricana and Peñol are exposed to sudden and frequent attacks of hydraulic lava. Although the population says they have found methods to control hydraulic lava flows, building torrent control canals to “canalize hydraulic lava”, it is possible they are not prepared in case of water damming and the subsequent sudden hydraulic lava streams.

9 AGRO-FORESTRY COMPONENT

9.1 Objectives

The objectives of the agro-forestry component are the following:

- Identify and make a general description of the vegetation found in the study area,
- Identify the application of agro-forestry practices that contribute to agricultural and forestry processes,
- Identify factors that contribute to the increase of erosion processes and the transportation of materials through micro-watersheds.

9.2 Methodology

In order to make the description of species in the study area, field visits were made. The species were identified during on site visits. Notes and photographs were taken and the classification was later verified in the office, based on descriptions in previous studies and specialized bibliography.

9.3 Description of the study area

The study area is located in the province of Murillo of the department of La Paz, covering the upper part of the La Paz River basin, from the north where the Choqueyapu River begins, up to Tahuapalca in Río Abajo in the south. In the east and west, limits are the micro-watersheds of the tributaries to the La Paz River.

The approximate size of the study area is 983 Km2 at an altitude of 5,546 meters above sea level to 2,300 in Tahuapalca. The area is located in the following strata: puna, pre-puna and dry valley; the upper Andes, subnival and nival strata are also represented in the area. The area is composed of plains or alluvial plains, riverbeds, alluvial fans, mountain streams and banks, which dominate the landscape. Slopes vary between 30 and 70% and in some cases over 100% in the case of scarps of landslides, abrupt slopes and watercourses.

The presence of vegetation is mainly influenced by altitude factors, which vary strongly, even in small areas. One specific zone is the upper part of the watershed where bofedales (spring fed year-round pasture plain) are located, the characteristics and biodiversity of which is specific and rather complex.

Upper part of the watershed area

This zone is located at an altitude of over 4,200 meters above sea level with a cold climate, an annual average temperature of between 5 and 7oC and an average minimum temperature of -10 to -14oC. This zone is often hidden in mist, with frequent hailstorms and occasional snow.

Photograph 39. Bofedales (spring fed year-round pasture plains) in the upper part of the La Paz River Watershed area ([1])

The soil shows rocky outcrops, some slopes with soft slopes have black soils with abundant organic material. The characteristic species of the this zone are grass species such as: *Stipa hans-meyeri, Festuca cf. Andicola, Calamagrostis spp, Aciachne pulvinata* and other typical species on the edge of the bofedal such as *Senecio serratifolius*.

Photograph 40. Senecio serratifolius ([1])

Bofedales can be found in the glacial valleys of Hampaturi, Chuquiaguillo, Chacaltaya and Kaluyo.

The altitude of 4,200 meters above sea level is the upper limit for agriculture. The principal crop is potatoes, especially bitter varieties (*Solanum curtilobum*). Other important crops are barley and oats.

Valley of La Paz and environs

The valley of La Paz shows a series of physiographic characteristics that can be grouped as follows: ([2]):

[1] Photograph taken from the book "Historia Natural de un Valle en los Andes": La Paz . 1991. "Los Bofedales de la Cuenca Alta del Valle de La Paz". E. Sylvia Estensoro Cernadas.

Watersheds and Open Plains:
The Center of La Paz and surrounding hillsides
Llojeta, upper and lower Achocalla
La Florida, Calacoto, Cota Cota and Ovejuyo

Lower Valleys
Achumani and Irpavi

Upper Valleys
Achachicala, Limampata and Chuquiaguillo
Huaripampa and Pampahasi

Corridors
Obrajes
Aranjuez Gorge and Río Abajo

Soils composed of:
Clay, mud and sand
The north and northeast sector also contain gravel and rocks with a dark grey clayey matrix.
The south area mainly contains rocky and clayey soils.
In general, soils are poor in nutrients, erosion-prone and hence, they tend to present ditches.

9.4 Vegetation:

Vegetation in the Center of La Paz, the east and west hillsides and neighborhoods such as: Llojeta, La Florida, Calacoto, Cota Cota, Ovejuyo, Achumani, Irpavi, Achachicala, Limampata, Chuquiaguillo, Huaripampa, Pampahasi and Obrajes, has suffered most from human activity; urban expansion has given rise to loss of a large part of native vegetation. The formation of peri-urban belts has given rise to the population exercising more pressure on the vegetation as an alternative source of energy in the first phase of the settlement pattern. Today, as firewood is hardly available anymore, people use other energy sources such as LPG.

Native vegetation is confined to small, discontinuous areas in places and watercourses that are inaccessible. The population in general shows an aggressive attitude against trees and shrubs of a native or exotic origin, the latter resulting from reforestation campaigns or as public decoration.

[2] Classification taken from "La Flora de la ciudad de La Paz", written by Emilia García. Instituto de Ecología. Excerpt of the book "Historia Natural de un Valle en los Andes": La Paz . 1991.

Photograph 41. Urban area with scarce vegetation

Urban expansion has modified watercourses and contaminated soils. Enormous quantities of waste are disposed of, erosion is intensified as wastewater is disposed of in landslide and erosion-prone soils.

Vegetation dynamics have been severely altered, reducing the population, the potential area of natural distribution and in general, the ecosystem.

A considerable percentage of arboreal and bushy vegetation on the hillsides belong to the following species:

Table 5. Most frequent species on the hillsides of La Paz

SCIENTIFIC NAME	COMMON NAME
Achyrocline ramosissima	Uchuj huira huira
Adesmia miraflorensis	Ayacauli
Ambrosia artemisioides	Altamisa
Baccharis latifolia	Yurak chilca
Baccharis sp	Thola
Buddleja coriacea	Kishuara
Corriocactus melanotrichus	
Cortaderia jubata	Sehuenca or següenca
Dodonea viscose	Chacatea
Lavatera assurgentiflora	Mallow
Lupinus altimontanus	Kke1a
Nicotiana glauca	Karalawa – Kakaya
Sambucus peruviana	Elder
Senecio clivicolus	Huaycha
Senna aymara	Takarkaya
Solanum nitidum	Chinchi chinchi
Spartium junceum	Broom
Stipa ichu	Ichu – Paja
Viguiera pazensis	Suncho

One of the species that has turned out to be a good alternative for slope stabilization is the *Lavatera assurgentiflora. (Malv.)*, which is used for example in slope stabilization of the Laycakota hillside, in works in the Pasankeri River, etc. This species has a wide radicle system, it grows quickly and multiplication is easy. These characteristics are highly desirable for reforestation in area that are not easily accessible.

Photograph 42. Lavatera assurgentiflora

On the western hillside, part of the vegetation in watercourses of the Pasankeri and Melchuco Rivers are trees resulting from municipal reforestation campaigns.

The *Spartium junceum* (Broom) is also a rather widespread species, with considerable capacity for natural regeneration. It easily adapts to compact, clayey soils and is resistant to short periods of frost. The population uses this species in religious activities.

Senecio clivicolus (Huaycha) and V*iguiera pazensis* (Suncho) are the most abundant species on the hillsides surrounding the city of La Paz

Photograph 43. *Senecio clivicolus* (Huaycha) and *Viguiera pazensis* (Suncho)

On the western hillside, *Lupinus altimontanus* is scarce to almost inexistent, as opposed to the eastern hillside where small and compact groups of this species can be found, preferably on rocky soils.

Photograph 44. Eucalyptus globulus and Pinus radiata

Planted woods are mainly of *Eucalyptus globulus,* the Pura Pura small wood being the largest one with 190 Ha and small areas in the Juancito Pinto, Matadero, Zarzuela, Siete Enanos, Viscachani, Santa Rosa and Pokeni Rivers, Chapuma in the Orkojahuira River basin, covering a total area of 50 Ha. *Cupressus macrocarpa* and *Pinus radiata* are two other species that are usually used for reforestation. They can be found in disperse areas, covering a total area of approximately 15 Ha. Some of these plantations are up to 60 years old.

Eucalyptus globulus areas in higher sectors such as Ciudad Satélite, show adaptation problems, which are expressed in low growth. Moreover, they are the constant victims of damages such as broken apices and branches, damaging their development. These reforested areas suffer from severe contamination as they are used as rubbish and construction debris dumps.

Photograph 45. Forested areas contaminated with garbage, *Eucalyptus globulus* trees of over 10 years old

9.4.1 Vegetation in the urban area

Because of its complex topography, variations in altitude, solar exposure, types of soils, water availability, etc., La Paz has a variety of microclimates that enable development of a wide variety of species. Until some years ago, decoration of the city was preferably based on exotic species, from the perspective of candid refusal of the native vegetation. It seems this vision is now changing.

A partial list of arboreal species that can be found in the city is shown in the table below. More than an inventory, the idea of this list is to show that the city has many possibilities to use different species for decoration purposes.

Table 6. Most frequent Arboreal Species in the Urban Area ([3])

SCIENTIFIC NAME	COMMON NAME
Abies pinsapo	Spanish fir-tree
Acacia dealbata	French acacia
Acacia dealbata	Aromo
Acacia dealbata	Mimosa
Acacia melanoxylon	Acacia
Acacia retinoides	Florid Acacia
Acacia retinoides	Mimosa
Acer negundo	Maple tree
Acer negundo	Negundo
AIbizzia lophanta	Albizia
Alnus acuminata	Alder tree
Araucaria angustifolia	Araucaria
Araucaria angustifolia	Brazil Pine-tree
Araucaria excelsa	Araucaria
Betula pendula	White birch-tree
Brachychiton populneum	Brachichiton
Brugmansia arborea	Floripondium
Buddleja coriacea	Kishuara
Buddleja coriacea	Kolli
Casuarina cunninghamiana	Casuarina
Cedrela odorata	Cedar
Cedrus atlántica	Atlas cedar
Cedrus atlantica glauca	Silver cedar
Cedrus deodara	Weeping cedar
Celtis australis	Lames
Citrus aurantifolia	Lemon-tree
Criptomeria japonica	Criptomeria
Cupressus macrocar var. lutea	Yellow cypress
Cupressus macrocar var. lutea	Golden cypress
Cupressus macrocarpa	Cypress
Cupressus macrocarpa	Pine-tree
Cupressus sempervirens	Pyramid cypress
Chamaecyparis lawsoniana	False cypress
Eleagnus angustifolia	Boliemia Olive-tree
Eriobotrya japónica	Medlar
Erythrina crista-galli	Ceibo
Erythrina falcata	Ceibo
Eucalyptus cinerea	Eucalyptus
Eucalyptus globulus	Eucalyptus
Ficus carica	Fig tree
Ficus elastica	Rubber tree
Ficus elastica	Gum-tree
Frarinus americana	Ash tree
Fraxinus excelsior	Ash tree

[3] Modified list from the book “Arborización Urbana”. Heleen Weeda

Grevillea robusta	Silver oak
Jacaranda mimosifolia	Jacaranda
Juglans regia	European walnut tree
Laurus nobilis	Laurel
Ligustrum lucidum	Privet
Magnolia grandiflora	Magnolia
Malus sylvestris	Apple-tree
Melia azederach	Paradise tree
Myoporum laetum	Míoporo
Olea europea	Olive tree
Phoenix canariensis	Palm tree
Pícea smithiana	Spruce
Pinus patula	Pine tree
Pinus radiata	Pine tree
Platanus acerifolia	Plane tree
Polylepis besseri	Kewiña
Polylepis besseri	Queflua
Populus alba	White poplar-tree
Populus balsamifera	Balm poplar
Populus deltoides	Canadian poplar
Populus nigra var. italica	Lombardy poplar
Populus nigra var. italica	Pyramid poplar
Prosopis laevigata	Carob tree
Prunus armeniaca	Apricot tree
Prunus cerasifera	Plum- tree
Prunus cerasus	Cherry-tree
Prunus persica	Peach-tree
Prunus serotina	Capulí
Prunus serotina	Criollo cherry-tree
Prunus serrulata	Japanese plum-tree
Pyrus communis	Pear-tree
Quercus robur	Oak
Robinia pseudoacacia	False acacia
Salix babylonica	Weeping willow
Salix humboldtiana	Criollo willow
Sambucus peruviana	Elder
Schinus molle	False pepper plant
Schinus molle	Molle
Tecoma stans	Canary tree
Tilia platyphyllos	Lime tree
Ulmus glabra	Elm tree
Ulmus pumila	Chinese elm tree

9.4.2 Achocalla Valley:

In recent years, Achocalla has suffered a strong urbanization process, with adverse effects on native vegetation, as the areas that have been and are still being prepared for new urbanizations do not have any plans to mitigate the impact on vegetation.

These unplanned urbanization processes – e.g. the Arco iris urbanization – do not only affect vegetation, but they are potential disaster areas as the urbanizations occupy high-risk areas (landslides, hydraulic lava flow).

Photograph 46. Urbanization built in the dejection cone of a watercourse

Vegetal coverage in Achocalla, as an area with urban-rural characteristics, is proportionately higher as compared to the La Paz valley. Agro-forestry practices are applied, such as the use of wind-breaking screens, live barriers, etc. In general, there is a practice to associate agricultural crops with arboreal areas to obtain multiple benefits. Probably, this type of agriculture is the result of communal experience, with support from some NGOs that operate in the area (for example, SEMTA).

Achocalla is one of the sectors with most forest plantations: planted areas in small and disperse groups or in lines (wind-breaking) or at the edges of parcels. The best-known species is the *Eucalyptus globulus*, which is appreciated because of its rapid growth, good timber quality, outbreak capacity, and because of its multiple usages.

Other important species are the *Salix babilonica* and *S. humboldtiana*, *Populus balsamifera, Populus nigra* and others of the *Salicaceas* family. *Spartium junceum* is also an abundant species and to a lesser extent the following species:


Photograph 47. *Lupinus altimontanus* (wild tarwui), and Populus in the Achocalla valley

Table 7. Other species in the Achocalla valley

SCIENTIFIC NAME	COMMON NAME
Achyrocline ramosissima	Uchuj huira huira
Adesmia miraflorensis	Ayacauli
Ambrosia artemisioides	Altamisa
Baccharis latifolia	Yurak chilca
Baccharis sp	Thola
Buddleja coriacea	Kishuara
Cortaderia jubata	Sehuenca or següenca
Lupinus altimontanus	Kke1a
Nicotiana glauca	Karalawa - Kakaya
Sambucus peruviana	Elder
Senna aymara	Takarkaya
Solanum nitidum	Chinchi chinchi
Spartium junceum	Broom
Stipa ichu	Ichu - Paja
Viguiera pazensis	Suncho

9.4.3 Río Abajo

This valley is a meso-thermal valley located south of the city of La Paz, it is a semi-arid area with average temperatures of 20°C, an irregular relief, not very high mountains, little consolidated rocky areas.

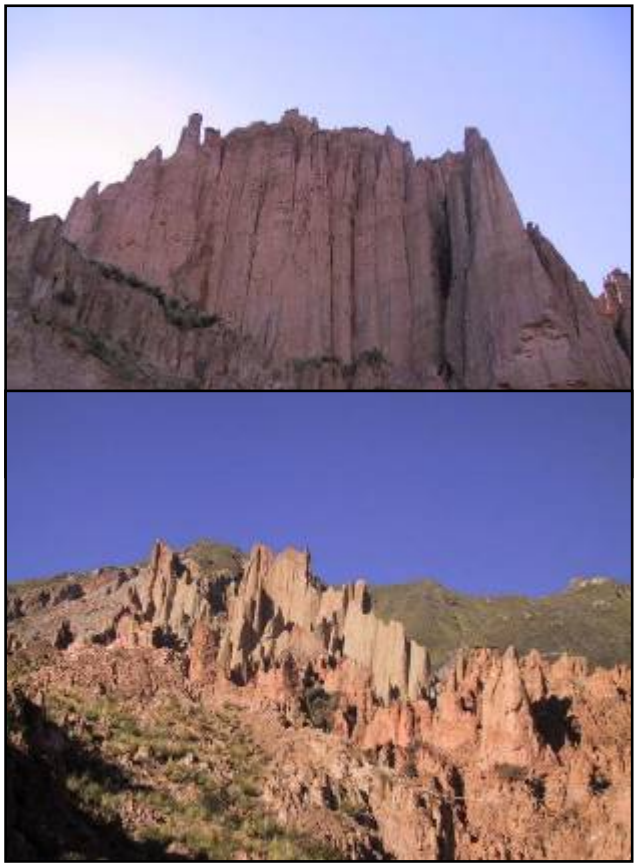
The area has the following physiographic characteristics:

riverbeds
terraces and plains
alluvial fans
mountain streams
slopes (dominant)

General characteristics of soils:

sedimentary rocks and little consolidated conglomerates
sandy and sometimes clayey soils
other sectors have alkaline soils with salt efflorescence

Water and wind erosion are intense, forming deep columns and ditches. The rivers drag along considerable material. Hillsides show steep slopes, with frequent landslides. Large areas are affected by intense erosion.



Photograph 48. Images of the Huacullani micro-watershed

Agriculture is vital for various communities alongside the Río Abajo area. Communities established on the hillsides prepare farmland even on pieces of land with steep slopes. In general, soils of these parcels are superficial, poor in organic material. Farmers use traditional agricultural methods, there are few institutions that support and orient activities.

On the slopes and high areas crops are temporary, there are no irrigation systems (except in Cohoni) and production depends on climatic conditions.

Average annual rainfall is 672.7 mm. There are two clearly distinguishable periods in the year: the rainy season from November to March and the dry season from April to November.

The annual average temperature amounts to 11.02oC, with higher average temperatures in the summer between November and March. The maximum average temperature is 14oC.

Erosion processes are very intense and give rise to the loss of various hectares of cropland every year. Although these processes are caused by geo-morphological conditions, another important factor are inadequate agricultural practices that contribute to the deterioration of agricultural parcels, e.g. sowing furrows following the slope. The construction of terraces is a forgotten practice. Existing terraces are very old and are no longer maintained. Live and dead barriers are still used, although this is not a mass practice.

Photograph 49. Inadequate agricultural practices, furrows following the line of the slope

The principal crops are: potatoes, beans, peas and barley. Cattle, especially sheep, use native vegetation as pastureland. Slopes are burnt to renew pastureland.
During the low water season, part of the cattle is taken to the low areas, especially the La Paz riverbed, where fodder can be found the whole year round.

The lower part of the watershed, i.e. the riverbed itself, shows narrow valleys, surrounded by hills with steep slopes, dissected by many rivers and streams with temporary courses. These valleys have a width of between 90 m up to a maximum of 1,400 m.

Annual average rainfall is 482.6 mm, the distribution of which shows a dry season between March and December and a rainy season from December to March.

The annual average temperature is 15.32oC, calculated based on the thermal gradient considering data from three stations: Paica, Collana and La Paz; the highest temperatures are registered in the summer from November to March, with an average maximum of 17.3oC. Information supplied by the population shows that on scarce opportunities minimum temperatures were registered of under 0oC.(4)

[4] Data taken from the final report of the Program for Integrated Rural Development, Watershed Management and Torrent Control in Río Abajo. Vol III. Consultants CONSA-SERINCO. 2000. Prefecture of the Department of La Paz.

The calculated annual average evapo-transpiration is 705.09 mm, as compared to the annual average rainfall of 482.6 mm; there is a difference of 222.49 mm- representing the humidity deficiency in the months of April to November, and on the other hand, excessive humidity from January to March.

There are various peasant communities in the lower part of the watershed, such as: Lipari, Jupapina, Ananta, Huajchilla, Taypichullo, Carreras, Valencia, Mecapaca, Cachapa, Avircato, Palomar, Huayhuasi, Huaricana, Millucato, Peñol, etc. Together, these communities represent approximately 60% of farmland in the alluvial plains.

The average size of agricultural parcels is smaller in areas such as Jupapina or Lipari and larger in the communities of Palomar or Millucato, with an extension of 0.1 to 1.15 Ha.

The agricultural production is varied, one of the most common crops alongside the river are vegetables. Areas such as Jupapina, Mallasa, produce flowers (gladioluses, carnations, lilies, and others). Production is both in the open and in greenhouses.

In zones such as Huaricana and lower areas, the principal crop is maize, followed by vegetables. Fruit production is important in the agricultural production, especially in Palomar, with various hectares of pear-trees.

All irrigation water comes from the La Paz River. This water is contaminated by the city sewage system, which causes sanitary problems at the moment of consuming these products.

Peasants incorporate organic material in their parcels, through controlled flooding.

9.4.3.1 Vegetation:

In general, vegetal coverage is dominated by few species, mostly shrubs, intercalated with few arboreal species. Most species are concentrated in the La Paz riverbed and its tributaries. The same occurs in intermediate slopes that are also influenced by watercourses. The upper part of hillsides and summits of hills are dominated by the following species: *Baccharis* (Comp.) and grasses such as *Stipa ichu, Festuca dolichophylla, Bromus catharticus.* These species reappear vigorously after burning.

Photograph 50. General view of Río Abajo. Shrub strata dominate vegetation

On the high parts of the western slopes, especially the zone near the community of Kera, there are quite some examples of *Senna aymara*. This species is common on the edge of agricultural parcels. In lower areas, the principal species is the *Adesmia miraflorensis*.

Photograph 51. *Adesmia miraflorensis*, Thorny species used for live barriers

In the community of Uncura, the vegetation in ravines and mountain streams is dominated by *Dunalia spinosa*. This species is used for live barriers.

Photograph 52. Flowers and fruits of the *Dunalia spinosa*

In the Huacullani sub-watershed in the community bearing the same name, there are well-developed examples of *Sambucus peruviana*, as well as *Spartium junceum*, with abundant natural regeneration.

At the bottom of the ravine, on the terraces formed by the Huacullani river, near the point where it joins the La Paz River, there are species such as the *Colletia spinossisima*, a species that provides good firewood and that is used for live barriers. Its roots can be used for soap, because of the high saponin content.

The influence area of the watercourses provides humidity to terraces, as well as to the lower part of the hillsides, benefiting growth of the *Tecoma cochabambensis* and *Cortaderia jubata.*

Photograph 53. Elder-tree (*Sambucus peruviana*), detailed picture of the flower

On the upper parts of the internal slopes of the mountain stream ravines, we can find *Tillandsia sp*, with pink flowers.

In recent landslide areas and dejection cones, the principal vegetation is *Nicotia glauca*, which forms pure areas that seem to be the product of plantation.

Photograph 54. Air carnation (*Tillandsia sp*)

One of the species with dominant presence in dry soils is the *Dodonea viscosa,* on all intermediate slopes and summits of lower hills. Presence of this species is more dominant on the high slopes of Millucato and Huaricana, near the La Paz River. The *Kageneckia lanceolata* is another important species in this zone.

Photograph 55. Karalawa (*Nicotia glauca*), growing on a recent landslide

The *Puya glabrescens* and other saxicolous bromelia grow on hillsides with steep slopes incrusted in fractured rocks. The population uses these species as fuel to prepare bread.

Photograph 56. Puya glabrescens

In dejection cones composed of compact materials and the abundant presence of salt, the *Atriplex semibaccata* grows, a species with considerable forage value that must be taken into account in repopulation efforts aimed at reducing laminar erosion.
In the plains and on the hillsides of Huajchilla and Taipichullo there are some isolated examples of the *Prosopis laevigata*, small thorny trees that have been used as fuelwood and that are adequate to obtain charcoal with a high calorific content.

On lower hills with steep slopes, prickly pear plantations have been developed (*Opuntia ficus indica)*, with the objective of both producing fruits and harvesting the cochinilla (*Dactilopius coccus),* a parasite on the prickly pear that is produced for the extraction of carmine acid, a natural coloring agent used in cosmetics, medicaments, the meat and dairy industry, confectionery and the textile industry.

Photograph 57. Opuntia ficus indica infested with Dactilopius coccus

Among other cactus species, we can find the *Pereskia diaz-romeroana, Corriocactus melanotrichus* and other prickly species, which are used for barriers and fuelwood.

Photograph 58. Example of the *Corriocactus melanotrichus*

Peasants from all communities on the terraces of the La Paz River permanently struggle to gain more cropland, building defenses to recover river space. Although these activities have been applied for a long time, they are not done using technical criteria. Hence, won areas become high-risk areas, especially when inhabitants want to squeeze in the river in sections with an extremely narrow width of 10 m.

Regarding the use of agro-forestry practices, these activities are routine activities that are the result of experiences and knowledge transmitted from one generation to the other. Some of the most disseminated practices are: the formation of boundaries, live and dead barriers, alley crops and forest plantations in support of agricultural activities, as well as civil infrastructure (gabions, defense walls, etc.). The most used species are *Eucalyptus globulus, Salix humboldtiana* and *Salíx babilonica*.

Photograph 59. Community of Llakasa, defense walls supported by arboreal vegetation

Some phyto-sanitary problems that were detected in the study area are: presence of the *Phoracantha semipuctata*, which attacks the *Eucalyptus globulus* species in the community of Llakasa.

Larvae of this insect cause damages, as they attack the cambium, thus interrupting the nutrient flow until death of the attacked species. There is an urgent need to attack this plague, otherwise the *Eucalyptus globulus* population is at risk because of the aggressiveness of this insect. Attacks increase in the dry period.

Photograph 60. Attack of the *Phoracantha semipuctata*

Another plague affecting the *Salix humboldtiana* is an insect of the Hymenoptera type, which is causing the death of willows. It seems the larvae attack the willows. This problem was detected in the zone of Llacasa. A diagnostic must be carried out to confirm the origin of these damages.

Photograph 61. Willows attacked by an insect

In the area of Palomar, pear-tree plantations are attacked by the *Phoradendron sp*. (Loranth.) species, a semi-parasitic plant that can cause death of the pear-trees and reduce fruit production if it is not controlled.

Photograph 62. *Phoradendron sp.* attack in pear-trees (Community of Palomar)

9.5 Conclusions

Vegetation in the study area is severely degraded, vegetal populations have been drastically reduced and some are at risk of extinction, e.g. the *Escallonia myrtilloides*.

Expansion of the urban area and the need for energy sources are the principal causes of vegetal degradation on the slopes and in the valleys.

In the area of Achocalla and Río Abajo, vegetation decreases because of expansion of the agricultural frontier and the exploitation of vegetation mainly as fuelwood.

Intentional fires on slopes along the watershed area of the La Paz River and its tributaries decrease and damage the development of vegetation.

The presence of cattle, particularly sheep, is another factor that adversely affects the development of vegetation. Nonetheless, this is not a determinant variable at present.

The urban population in general shows an aggressive attitude towards vegetation, in other words, damages to trees and shrubs planted under reforestation or public decoration initiatives or of a natural origin are common.

9.6 Recommendations

In the urban area

Reforestation activities must be implemented focusing on the decreased dragging along of materials into watercourses, thus avoiding the entrance of those materials in vaulted sections and subsequent underground floods, floods and other hazard events.

It is important to implement forestry projects in close cooperation with the municipality of the city of La Paz. The starting point must be achievements of the municipality in reforestation efforts.

Current forest masses, such as the Pura Pura wood and other small woods require intervention to increase development and implement phyto-sanitary control measures.

Headwater sections of watersheds require special attention: as from these zones, erosion and sediment dragging must be controlled. Agricultural areas on slopes must be the object of promotion and application of agro-forestry systems.

Río Abajo Region

Increasing vegetal coverage in the Río Abajo area is an urgent need. Therefore, reforestation projects must be executed. The upper parts and slopes of mountain streams must be reforested, promoting native vegetation.

Small works must be executed for ditch control, such as strips, ditch traps, stonewalls, etc., reinforced with vegetation. The use of native species is indispensable, as this will ensure successful reforestation.

Although inhabitants of communities already use agro-forestry practices, they must be used on a massive scale, to achieve higher levels of productivity. The incorporation of trees in support of agriculture will supply peasants with a higher income.

The implementation of agro-forestry practices, such as riverside defense walls, along the La Paz River, will reduce flood hazard.

10 SOCIO-CULTURAL COMPONENT

10.1 Introduction to the Socio-cultural Component

On February 19, 2002, the city of La Paz suffered one of the worst natural disasters of the last decades with a tremendous flood due to a strong hailstorm that fell upon the city in less than an hour. Sixty-eight people died in the tragedy, hundreds were taken to hospital, and 576 had to take refuge in the Closed Coliseum. Material damages surpassed 10 million dollars. Avenues and streets in the city center became one big water torrent that dragged along people, vehicles, goods and especially an enormous amount of urban waste and construction debris that was accumulated on the streets. Streets, avenues and houses were flooded, various houses collapsed, the energy supply system collapsed and drain systems got stuck.

Likewise, at a distance of 30 minutes from the city in the Río Abajo region, twenty-one communities on the banks of the La Paz River suffered from severe flooding of their vegetable gardens, with the resulting loss of crops. Approximately 450 hectares of agricultural cropland on the La Paz riverbanks, belonging to nearly 1,200 families, were affected. Moreover, 118.12 hectares of farmland were lost due to the flood, severely affecting over 300 families, see also table 4 on Page 12.

Although these floods and overflowing of the La Paz River in the Río Abajo region were important events, it is essential to understand that this was not a sporadic event. These events are recurrent and are often even caused by less intense rainfall. The riverside population is used to live with these events. On the contrary, tragic events in downtown La Paz have shown that neither the population nor the city are prepared to avoid and even less to manage this type of situations.

In this sense, experts warned that rainfall with similar characteristics but double the duration of that in February could have caused the total collapse of the city. Likewise, reports issued by the municipal government indicate that during the disaster, the full capacity of different ducts of the city's drainage system was not used. This was because most of the canals entrances and drains, as well as most canals of the system were obstructed with debris and huge quantities of urban waste.

Consequently, just like some natural characteristics typical of the city constitute disaster hazard factors, the practices, habits and costums of the population are also direct critical factors that give rise to this type of hazards. However, a revision of different studies on natural disaster hazard in La Paz shows that these studies limited consideration of the human factor to socio-economic and/or demographic aspects. Those studies ignored the importance of the behavior and the analysis of habits and practices of the population[5].

This study, on the other hand, considers and underlines the socio-cultural behavior as a critical and central factor provoking natural disaster hazard. This approach makes it possible to know and understand the perspective of the actors themselves, their knowledge, habits and practices, as well as the expectations of people potentially affected by natural disasters. Likewise, this perspective is useful to identify the awareness of people on the effects of their practices and habits regarding the generation of natural disaster hazards.

[5] Report of CONSA SERINCO 2001; Study B.R.G.M.- B.C.E.O.M, Prudencio Claros y Asociados, 1977

The report is structured as follows: the first part presents the specific objectives of the study, followed by a synthesis of the conceptual framework on which the study is based. The theoretical meaning of the approach based on the socio-cultural perspective of actors is explained, as well as the usefulness of designing interventions for prevention of natural disaster hazard. This is followed by a description and analysis of the research methodology. The following chapter – the central part of the document – shows the findings and results that were obtained, with the respective analyses and conclusions for each topic. These findings and conclusions are presented with different testimonies of people that were interviewed. Finally, a series of recommendations are suggested, focusing the most important aspects with the biggest potential impact in terms of risk mitigation, in order to start reverting the current situation.

10.2 Objectives of the Socio-cultural Component

The socio-cultural component was based on the following research and diagnostic objectives:

- Identify socio-cultural costums, habits, attitudes and practices of the population, which cause or contribute to natural disaster hazard and environmental contamination in the La Paz River watershed.
- Propose actions to decrease the causes of problems in identified risk areas, which are related to the population's socio-cultural behavior.
- Identify local social organizations with which risk mitigation actions can be undertaken.

10.3 Conceptual Framework

What is a "socio-cultural" perspective of stakeholders?

Both peoples and persons exist and behave according to the specific socio-cultural reality to which they belong. This reality is constantly built and rebuilt because of the interaction of actors and dynamics of the resulting relations. However, not everyone perceives this "reality" in the same way. On the contrary, it is the different meaning each actor attributes to the concrete facts that structure this perception some way or other. This perspective that emerges from beliefs as well as from knowledge determines attitudes, creates expectations and finally influences habits and costums of the population. Therefore, the central purpose of the approach of the socio-cultural component is to analyze subjective cultural meanings of the actors who apply cultural practices, habits and costums, build expectations, and especially to understand the way in which their cultural actions influence the environment in which they live.

Why is it necessary to have the "socio-cultural" perspective of actors?

It is necessary to know and understand the socio-cultural perspective of actors, among other things, for the following reasons: a) when interventions or projects are planned or designed related to natural disaster hazard prevention caused by activities of the population, it is necessary not only to take into account the needs and interests of the stakeholders themselves, but also to include the vision, values and beliefs of the population, with the objective of ensuring acceptance, b) it is also important to know and understand habits and costums of the population related to the generation of natural disaster hazard, because they express knowledge and awareness of the population on their behavior regarding environmental deterioration and the generation of natural disaster hazard, and c) it is

important to know the cultural perspective of the stakeholders themselves as prevention and natural disaster hazard mitigation measures will be undertaken with them.

From a conceptual point of view, the behavior, habits and costums of people respond to their beliefs, values and vision of reality. Therefore, this study underlines identification and understanding of these factors. In this sense, objectives were defined focusing on understanding these motives.

10.4 Research Methodology

The information was collected from direct sources, by means of in depth interviews with focus groups and key informants. In this study, we opted for systematically capturing the perspective of the different stakeholders involved in this issue. In the urban area, “neighbors” were interviewed, as well as leaders of local organizations and neighborhood councils. In the rural areas, peasants and peasant unions or social organizations of peasant communities were interviewed. This “qualitative” approach was chosen to understand behavioral patterns, instead of only emphasizing measurement thereof.

Quantitative methods start from the assumption that there is an objective, stable, unchangeable social reality that can be generalized and that must be “quantified” to draw conclusions. On the other hand, qualitative methods, as the one applied here, try to “know” and “understand” that reality from the stakeholders’ perspective, aimed at drawing conclusions from the point of view of stakeholders themselves.

Among other factors, this qualitative approach is based on the following methodological research assumptions:

- Research is not started from a previous hypothesis that limits or reduces the study.
- The description and interpretation of concrete cases and the behavior of individuals by interviewed persons themselves is the principal point of focus. Artificial situations, like those generated by polls or surveys, are avoided.
- The discussion of the defined topics in focus groups is the framework to discuss problems, and gather information. This method is used to collect feelings, emotions, ideas, expectations, aspirations and the perspective of the people that are the object of the study.
- Meanings are interpreted from the perspective of the studied subjects, rather than an approach focusing on the “organization” of reality on the basis of abstract social models based on statistical information.

In short, research tools used for anthropological studies to analyze habits and costums were applied. These tools were used also to collect information on the point of view of the studied subjects. Hence, preference was given to their vision and perspective.
During fieldwork, qualitative information was collected in sessions, including the following techniques:

- Semi-structured interviews with focus groups of inhabitants and neighbors or neighborhood councils.
- In depth interviews with leaders and formal authorities both in their communities and in neighborhoods and neighborhood councils in the city, and
- Participatory observation of people’s behavior in the neighborhoods and communities contemplated in the study.

Development of Activities

More than 276 persons (people who live in communities and the city, local leaders of five riverside peasant communities, four peasant communities in higher areas and 13 neighborhood councils or groups of neighbors) in 22 focus groups were interviewed. Furthermore, six key informants were interviewed individually.

10.5 Results, Findings and Conclusions

The results, findings and conclusions presented below are organized according to the specific objectives agreed for the socio-cultural component of the study. This section describes and analyzes findings and results that were systematized based on focus group interviews in communities and neighborhood councils, which are included in full in annex 5.

10.5.1 Urban Area

The "socio-cultural" behavior (habits and costums) that causes or contributes to natural disaster hazard.

10.5.1.1 Garbage as a risk factor

The population of La Paz, regardless of the neighborhood or social class, is used to cohabit with garbage and debris, which they consider part of their "normal" environment. Perceived differences are related to intensity, levels of tolerance and characteristics of delivered services.

In different places of the city and at different hours, there are enormous quantities of disperse or piled up garbage in the streets and avenues. The population dumps garbage, which is accumulated at street corners, on squares, wasteland, riverbanks and ravines, both in commercial areas, hillsides, and in residential neighborhoods. This garbage is often scattered and ends up blocking the city's drainage systems. The situation considerably increases flood hazard.

> *"I live opposite the place where people throw their garbage and I see what happens, ...they're not ashamed… the dogs come and they pull at the bags, drag them along the road, …then it rains and the garbage is drained and the sewer is blocked, overflows and the water continues to flow on the surface" (neighbor of the Obispo Bosque zone, Cotahuma)*

Photograph 63. The city is becoming a huge rubbish dump

There are no social sanctions and it is socially acceptable to throw packages and wrappers of food, shells, bottles and plastic bags or beer cans on the street. Municipal authorities do not control or sanction this type of behavior either.

This behavior can be observed indistinctly in popular neighborhoods, marginal neighborhoods, popular commercial areas, the financial center of the city, the Prado main street or residential areas. Differences in the presence of garbage in different zones are chiefly related to population density. Likewise, inhabitants of La Paz are used to throw garbage through the windows of vehicles, either popular public means of transportation or luxury cars.

> *" …On the street? …people simply throw away rubbish all the time, we sweep the streets but a couple of minutes later the street is dirty again …" (sweeper of the company Clima)*
>
> *"Neighbors are still throwing their garbage into the streams, in empty places, we cannot control this the whole time, because people come at night to throw garbage and we don't see them" (neighbor of Kupini Bajo)*

Photograph 64. Is garbage eating the city?

"There is also garbage left after collection trucks have passed. That garbage is left until the next day. The problem is that people who live up there (shows the sector above the avenue) don't know when the truck will pass, when they come down in the morning, they leave their garbage. We, who live on the avenue, know that if we do not take out our garbage by seven o'clock, we must wait until the next day" (neighbor of Obispo Bosque, Cotahuma)

Regardless of the magnitude, quality and effectiveness of garbage collection services, every day the city is overflowing with scattered garbage on public roads, because of the attitudes, habits, costums and expectations of the population, which impeded keeping the city clean.

Although there are important cleaning and garbage collection efforts[6], every day the city is filled with residential and commercial waste, construction debris and other types of garbage. Normally, streets are cleaned and waste collected every day or every two days, depending on the zone. In some commercial areas of the center, waste is collected up to three times a day. On the hillsides, waste is collected on a door-to-door basis, and the contract even implies that places that are not easily accessible must be cleaned, such as deep ravines, canalizations, river areas, etc. Many neighbors openly declare that as they are now paying for waste collection services, maintenance is no longer their responsibility, but the exclusive responsibility of the companies that deliver those services.

"*Neighbors simply throw their garbage anywhere,. they lack education, there are rubbish dumps, but they simply throw it anywhere" (neighbor of the 14 de Septiembre zone)*

[6] According to the report of the Municipal Sanitary Authority, the company Clima collects 337 tons / day in the central area of the city, and nine micro enterprises collect 110 tons / day of waste in different zones on the hillsides. Sanitary services cover 89% of the city.

Photograph 65. Garbage scattered on public roads

"….The same happens in my zone, there's a lot of garbage on the streets, neighbors don't care, they also throw garbage in the river …and the riverbanks are so steep that we cannot pull out all rubbish. We beg neighbors not to throw their garbage in the river, but they don't listen, they don't care. Today we collect garbage, tomorrow it's there again. Later on the day we collect garbage, just a little later, there's again rubbish"

"…in the upper part of Pampahasi, opposite Litoral, there is a river in a ravine, it's very steep and we can neither enter nor leave, so we use ropes. At that point, CLIMA also collects garbage, but there is simply too much garbage, too much debris, waste, dead dogs, etc. in that river…." (Justina, manager of a waste collection micro enterprise)

Most people are not disciplined and they do not respect norms regarding hours and places for waste disposal.

It is a common thing to find piles of garbage on spots where people implement informal rubbish dumps few hours after the waste collection trucks or sweepers passed. Likewise, it is not uncommon to find piled up garbage a few steps from waste disposal containers. In restaurants and other places that serve food, garbage and leftovers are thrown on public roads just after lunch and dinner, without respecting established garbage collection hours.

"They collect garbage on three days: Tuesday, Thursday and Saturday, but we have the bad habit of not waiting until they collect garbage. Sometimes, when garbage collection trucks come, employees try to throw the bag on the truck, but it breaks and they just leave it there. There are pre-established places for waste disposal and that's where the trucks collect garbage, but only a few places have containers. In other places, they use jute bags, and if they don't have jute bags, they sometimes do not collect all the garbage"

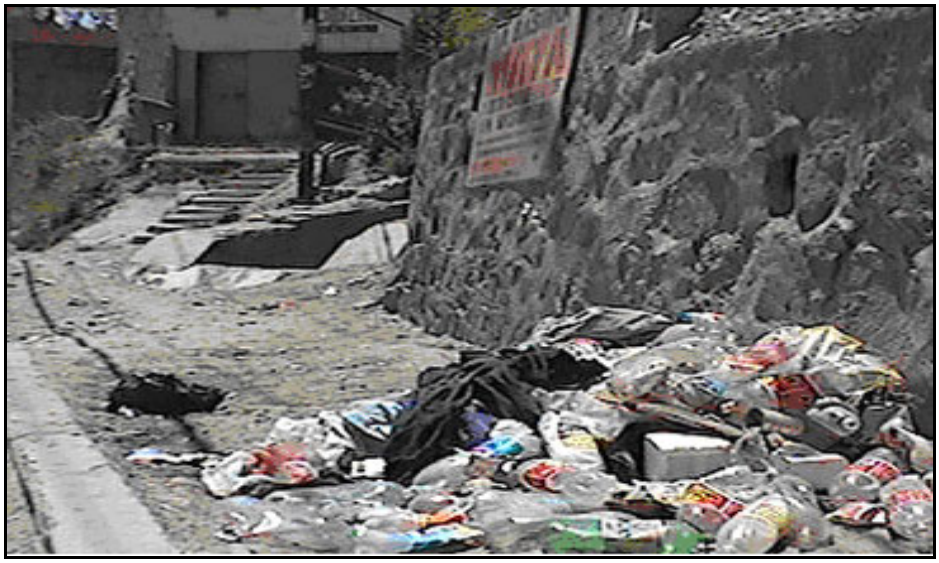
"People are not used to deliver their garbage to waste collection services, although they have told us at what time they come. For example, in my case they ring the bell and so I do not have to throw my garbage into the river, they simply pick it up. Some people are careless and are always throwing garbage everywhere… in the river, ravines, places where no one walks, especially there" (Ana, neighbor of Kupini Bajo)

"…There are garbage cans, but people simply throw their garbage anywhere, they urinate anywhere …" (neighbor of the 14 de Septiembre zone)

Photograph 66. Garbage on corners and streets

There is neither effective control nor municipal surveillance regarding urban sanitation and waste disposal, which would enhance discipline and disinterestedness of the population with regard to maintenance of urban sanitation. People are not aware of and do not have a positive attitude regarding cooperation to keep the city clean.

The absence of municipal control and surveillance is evident regarding non-compliance of the population with waste disposal norms, which permits "undisciplined" behavior regarding waste disposal places and hours. Nonetheless, this behavior is not only related to the remarkable absence of municipal control and surveillance. The lack of a disciplined attitude regarding waste disposal is mainly related to the lack of awareness of living in a garbage free environment, and environmental protection.



Photograph 67. Garbage next to a drainage canal

Many neighbors do not have a sense of ownership or identification with their neighborhood, which results in a remarkable lack of interest for sanitation and maintenance.

Many neighbors are not interested in cleanliness, maintenance and improvement because they have not yet developed a sense of ownership or identification with the zone where they live which reflects the considerable percentage of recent migrants towards these neighborhoods The behavior described in the previous points is the result of a series of factors, among others: a) many of these zones are mere "commuter suburbs", which means the population is not always there when garbage collection services pass through their streets, so they leave the garbage on the street or throw it into ravines at night; b) many temporary neighbors refuse to pay for the service. In houses where "rooms" are let to many independent families, tenants usually share one electricity meter. Many families avoid payment of garbage collection services, arguing that they do not have any garbage as all their activities are outside the house, but then they throw their garbage into the river and nearby ravines at night.

> *"…at least in my sector, people work in commerce, they leave early in the morning and come back late at night. So most of them have only just arrived or settled in the area… Those people don't care, they only go home to sleep… Most of them are from the rural area. Before, this sector was less populated, this place was almost deserted" (leader of the neighborhood council of Pasankeri Alto Norte)*
>
> *"Garbage has always been a problem, and as tenants don't pay, they don't care one bit. Or maybe they're afraid, as the owners of the house pay for waste collection services, maybe because they don't pay they throw garbage into the river or any other place at night. So they don't dispose of their waste adequately because they don't pay. I don't know what agreement they have with the owner. That's a problem: those who collect garbage say that some people never have any waste, but the thing is that those people take their garbage to the river at night" (Pedro, manager of a garbage collection micro enterprise)*

Many neighbors believe that paying for garbage collection services releases them from the responsibility to keep their sector clean.

The unaware and uninterested attitude of neighbors to keep their zone clean and avoid waste in their environment is remarkable. People believe that because they pay for this service, they have the right to "throw" garbage anywhere as cleaning and garbage collection are the responsibility of waste collection companies and the municipality.

Photograph 68. Men collecting garbage

> *" … The owners of the house… they say I pay so I can throw my garbage where I want to. Some leaders of the zone are worried, they send us notes saying the garbage collection system is effective and what aspects are still lacking. But most people claim they pay for the service so they can throw their garbage wherever they want to. Tenants are worse, they need more education" (Mario, manager of a garbage collection micro enterprise)*

The accumulation of large quantities of scattered garbage in markets and urban fairs in the course of the day once again shows the lack of awareness and interest of traders and clients to "live" in a garbage-free environment.

A considerable part of the city is "occupied" by markets and fairs. Large areas (neighborhoods) of the city have become large markets or permanent fairs.[7] Many of them are located on public roads in the center of the city. In these markets, traders, carriers and others who work in this sector, daily "occupy" large areas of the city as a fundamental part of their daily life. There "daily life" does not only imply commercial activities, which generates enormous amounts of garbage, but also many other social activities that also contribute indiscriminately to the garbage dump that is growing in the streets, at sight and challenging the patience of passers-by.

[7] The Rodriguez market in the Max Paredes zone, and the Huyustus, Graneros and Tumusla streets are typical examples of how streets become trade fairs.

Photograph 69. Plastics obstructing drains

Thus, everyone "waits" passively for the waste collection and cleaning service to come at the end of the day, although some union leaders insist on keeping the place clean. Most people do not show interest or say they do not care working the entire day in the middle of agricultural residues mixed with garbage – chiefly plastic bags and bottles – piled up on public roads. But people do not take measures to avoid this situation. This passive attitude causes the constant blocking and obstruction of drains in the drainage system in these zones.

> *"The instruction was given that at ten o'clock at night the garbage collection truck passes and that owners and tenants should take out their garbage as from nine o'clock… In the Buenos Aires avenue, CLIMA comes very late, almost at dawn and sometimes it doesn't even show up, and then people sit on top of the garbage to sell their goods" (neighbor of the 14 de Septiembre zone)*
>
> *"Other neighbors are too lazy to take their garbage to the waste disposal areas, they just leave it anywhere, in the ravines that surround the area where we live" (neighbor of the Antofagasta zone, Pasankeri Alto)*

The population is so used to the very bad environmental and sanitary conditions in the area where they buy their food that they are not aware of the risk this attitude implies, they accept this behavior as a natural characteristic of this place.

Many city-dwellers who regularly go to the markets and fairs are not aware of the sanitary and environmental conditions in those places that even lack minimum facilities for people's biological needs. People sell, buy, eat and defecate all on the same place. Likewise, different animal species (dogs, cats, rats and mice, etc.) prowl about the area looking for food. The municipality organizes general cleaning campaigns, but those campaigns are sporadic and insufficient. The mentioned behavior shows the extent to which the population has accepted deficient environmental sanitation in the zones where they buy their food and their unawareness of the risks resulting from the presence of garbage.

Photograph 70. Scattered garbage in street markets

"We take the garbage of our market stands to the container, and when there is no container… well, some vendors take it with them, others cover it and sit on top of it, but when it is warm, it starts to smell and then the flies come" (Flora, street vendor in the Rodriguez Market)

"…generally, we have the bad habit of throwing our garbage under the table… we all do this. Customers come with ice cream and they throw the wrapper under the table, and when it rains all that garbage is dragged along and obstructs drains. Clients buy soft drinks in disposable bottles and simply throw the bottle on the street" (retailer in the Huyustus Market)

"Using cloths, they collect all garbage at night. In the morning, our market stands are quite clean, but then the people from Río Abajo come to sell their goods and they leave behind their garbage" (seller on the Rodriguez Market)

The population knows some harmful characteristics of garbage, and the problems garbage causes.

People identify disposable plastic articles as the type of garbage that causes most problems and they know it increases flood hazard due to drain obstruction particularly. Interviewees particularly identified different plastic objects and disposable articles, and not only in commercial zones, as products that cause the obstruction of sewers. They mention nylon bags, disposable diapers, disposable soft drink bottles and disposable plastic cups, toilet paper and other types of synthetic containers as the principal materials that cause obstruction of the pluvial drainage system.

"It takes one hundred years for a small nylon bag to decompose, I think bags have a bad influence, because before there were no nylon bags, if we bought a pound of rice, they wrapped it up in a newspaper, nylon bags never decompose, they need one hundred years, that is why they obstruct sewers" (retailer of the Huyustus Market)

Photograph 71. Plastics obstructing drains

Many people insist that an effective way to put a halt to contamination with plastic bags is to prohibit use of these bags.

> *"Factories should be required to make paper bags… If there were paper bags, even we would buy them to sell our goods and we would sell more decently (laughs)" (retailer of the Huyustus Market)*

The lack of awareness on disaster hazard is so deeply rooted in some sectors of the population, that individual interests even destroy or render pluvial drainage infrastructure unfit.

In different streets near these markets, a variety of problems have been found with drains and sewers. Besides being completely stuck with all types of garbage and "drag materials", the gratings are deliberately destroyed to throw in bigger objects. Sewers are completely obstructed with plastic garbage and debris, and some drains are even completely eliminated with concrete. Explanations for these illegal acts are always related to personal interests that prevail over community interests. Local supervisors of the municipal government of La Paz seem to know these cases, which once again shows the municipality does not enforce its authority.

> *"No one cleans drains, only once a year, but this year Aguas del Illimani did not do any cleaning, because when we walk through the Avenida Baptista, we can see leeches are already coming out of the drains" (neighbor of 14 de Septiembre)*

Photograph 72. Drain blocked with cement

Photograph 73. Drain “closed “ with cement

Resistance to authority is explicit; people disobey instructions and recommendations regarding waste management that are explained on posters the municipality hangs up.

Most neighbors of the visited neighborhoods interpret preventive posters of the municipality saying “GARBAGE KILLS, DO NOT THROW GARBAGE HERE” as signs on waste collection. Precisely the places where those posters were hung up are places where garbage bags are piled up as from midday. Dogs and people looking for food then scatter the bags everywhere.

"They simply do things the other way around, throwing garbage exactly on those spots… I suppose people who are not content feel like contradicting the mayor" (neighbor of Pasankeri Norte Bajo)

"People don't understand, they don't respect posters and simply leave it there. Maybe, some of them don't know how to read, whatever, we don't get it. We put the signs there so people wouldn't throw garbage there, and we thought they wouldn't leave it there, but they still do. But, well, that's on some places, on other places, people do respect the signs" (Pedro, manager of a micro enterprise)

"I think they read the sign s and think we will collect garbage at the hour mentioned on the sign. We put it next to the river so they wouldn't throw their garbage into the river" (Justina, manager of a waste collection micro enterprise)

"I think people throw their garbage there because the sign says something about garbage, so that's where they dispose of it" (neighbor of the Obispo Bosque Cotahuma zone)

Photograph 74. Preventive sign saying "Garbage kills" with a heap of garbage next to a canal

Rivers and streams are considered natural rubbish dumps, a place where garbage is usually disposed of.

Because of a series of deficiencies in municipal waste collection services and no waste collection services on the hillsides of the city in past decades, people got used to throwing their garbage in rivers and ravines. Currently, in spite of increased effectiveness and coverage of the service, this practice still persists, as people perceive these places as "normal" waste and debris disposal areas.

"…people who live in La Paz have always thrown their garbage and debris there, that's the way it is, it's what we're used to do" (Leader of the neighborhood council of the Munaypata zone)

"I understand that in the upper part, without vaulting, neighbors are used to throw their garbage into streams and river basins. There is a lot of garbage, they even throw dead dogs and cats in vaulted sections. This affects maintenance of the vaults. And on the other hand, there are a lot of rocks because the vaulting wears away" (Leader of the neighborhood council of the Munaypata zone)

"In Rincón La Portada, the Apumalla River is like a ravine, in the upper part, that's where they throw garbage, old stoves, mattresses, just about everything. And then it's difficult to pull these things out, we have serious trouble. On that side also, in the Onkohuira River, the Tinieblas River and the San Lorenzo River" (Pedro, manager of a waste collection micro enterprise)

Photograph 75. Vehicle scrap and garbage in a drainage canal

10.5.1.2 Debris as a Risk Factor

Debris and construction waste management is not only a critical factor in the generation of disasters from flood and overflowing hazard, but it severely attacks the stability of rivers and mountain streams.

The situation of debris and construction waste is even worse and more dramatic than the garbage situation. Every day, hundreds of tons of construction debris is disposed of indiscriminately in all rivers and mountain streams of the city. In the rainy season, torrents regularly drag along debris downstream, causing destruction and obstructing canals and other drainage structures and especially increasing flood hazard caused by the overflowing of rivers. This hazard situation is not unknown to the people who were interviewed.

Photograph 76. Truck dumping debris in the Orkojahuira River

"…we have complained a lot about debris disposal. Just where the stonecutters work – because the Company Usimacon has dump trucks to transport this type of material - that's where they have started dumping debris, just above the place where the stonecutters work. We have filed complaints with the municipality, and because we have insisted so much, they have started to clean part of the Naciones Unidas avenue, a principal avenue" (leader of the neighborhood council of Munaypata)

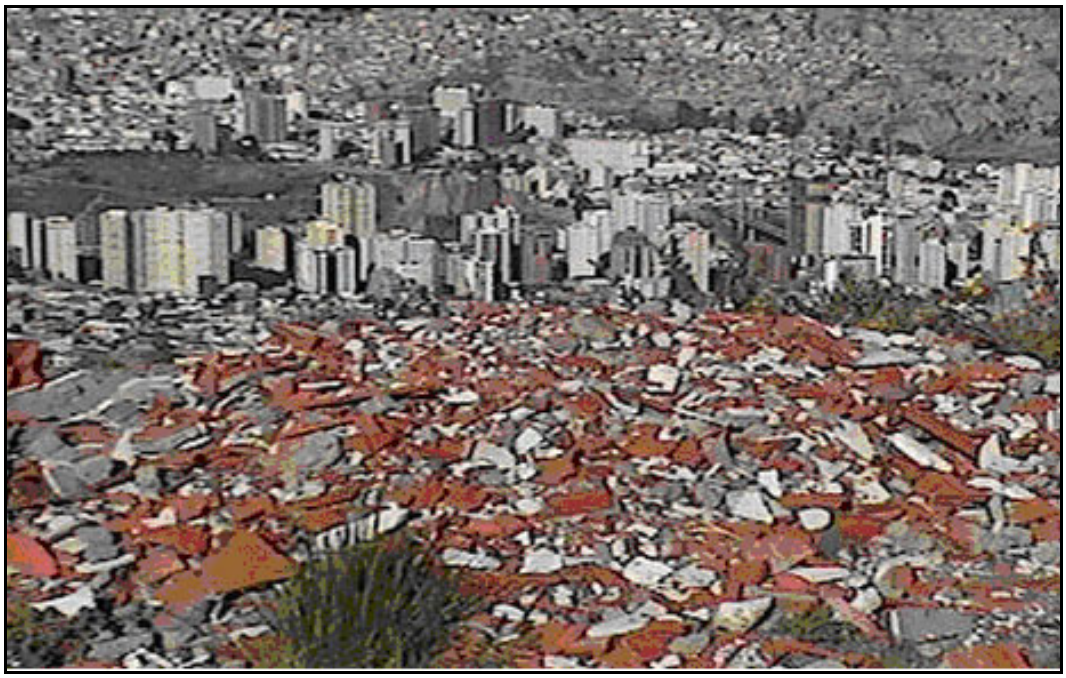
The municipality of La Paz does not have a regular and permanent system for the collection and final disposal of debris and drag materials.

The collection and disposal of construction waste and drag materials is separated from garbage collection. Solid garbage collection companies are not allowed to include debris and drag material. Debris disposal is the responsibility of builders. The municipal government of La Paz has official sites for the final disposal of these materials. However, as there is no control, in practice, debris is usually dumped on more "convenient" places. Hence, these materials are dumped in rivers and ravines near the respective building sites.

On the other hand, employees of the Municipal Emergency Relief Service are responsible for cleaning drag materials on the streets. Nonetheless, this important work is neither a regular nor a systematic activity; on the contrary, the unit in charge only acts "in case of emergencies". Consequently, often huge quantities of drag material are accumulated on the streets and then flow into the pluvial drainage system, obstructing sewers and drains.

"We collect all organic and inorganic waste, less debris… Collecting debris is subject to sanctions, if they find us out (in Mallasa), they discount a fine from our pay… The Emergency Relief Service is responsible for debris collection. But they only do this in the center of the city, where people call the service and file a complaint. But that's different on the hillsides, debris stays there for months and months without anyone collecting it" (manager of a waste collection micro enterprise)

"…the dragging of soil is also a serious problem, … as slopes are very steep, more material is dragged along… and that's why drains get stuck" (employee of a street-cleaning micro enterprise)



Photograph 77. Debris all around the city

Dumping debris and construction waste into rivers and ravines all over the city is common practice, builders in the city accept it as "…our long-time habit". Although they know the harmful effects of this practice, people are not aware of the hazard or damages to rivers.

Rivers and mountain streams in La Paz are the principal construction rubbish dumps of the city. This practice has been adopted by everybody in the construction activity: neighbors who live near the streams or rivers and small and big building companies, dump truck operators that provide debris disposal services and even municipal dump truck operators.

On the other hand, besides a lack of municipal control to avoid the dumping of construction waste and debris into rivers and streams, the population does not apply social sanctions either. Moreover, the general opinion of the population is that if operators of the municipal government of La Paz dump debris and other drag materials in the rivers, the population can do the same. In other words, they do not have to observe the little known existing official regulations.

Photograph 78. Big pieces of reinforced concrete end up in the rivers

"They even use the Amupalla River, and any other empty space to dump debris. Transporters look for the easiest way" (leader of the neighborhood of Munaypata)

"They simply throw debris on the streets or into the river. Just the other day, I saw a man building something who dumped all debris in the river" (neighbor of Kupini)

Individual convenience prevails over the common good of the city, even at the expense of generating disaster hazard and harming public security of the zone.

Although they know the potential hazard of causing environmental disasters, dumping debris in the rivers, streams and drainage canals, immediate convenience justifies this practice for many people. This hazard-generating attitude does not distinguish between damages in the zone itself, and damages as far away as the Río Abajo Region. Although there are official sites for debris disposal, in general people reason that debris is disposed of on the "most convenient" place. This means, on the nearest place, which is also cheaper. In fact, today it is irrelevant whether there are or are no official rubbish dumps, as the municipality of La Paz does not enforce control. Even worse, people justify their attitude with the example of the municipal dump truck operators themselves.

"There are also trucks from other zones that come to dump debris here. And that in spite of the fact that the municipality has assigned an area in San Isidro. But, well, they still dump waste here because it's easier. Especially, the people from Pampahasi dump things into the river. Once, all this came down like a mazamorra" (neighbor of Kupini)

"People who have debris hire dump trucks to collect the debris and take it to Llojeta. They also bring it here, but when we see it we don't let them. But when we don't see them, they simply dump it here" (neighbor of the Antofagasta zone, Pasankeri Norte Alto)

Interviewees seemed not to ignore the danger of dumping debris in the rivers, but they mainly showed an attitude of unawareness of the generated hazards.

Both truck operators that provide debris transportation services and interviewed neighbors and bricklayers know the different harmful effects of dumping waste in the rivers. They mentioned obstructed vaults, and the obstruction and deterioration of canals. They were especially able to identify these problems as a cause of floods in the Río Abajo region. However, at the same time, they also displayed an irresponsible and disinterested attitude regarding maintenance of rivers and canalizations of the city's drainage system.

> *"People from Pampahasi have always dumped debris into the Uno River, which has caused the tragedy because the small vault of the river of about 50 meters got stuck and they had to break it down. The entrance to the vaulted area was obstructed about five years ago, before the landslide, and the river now flows over it" (neighbor of Kupini)*
>
> *"All around the community, especially people from Pampahasi just throw it into the river. Once, all this came down as a mazamorra. And all this up to street 17 of Obrajes" (neighbor of Kupini)*
>
> *"It was not permitted to dump waste but at night they come to dump it, to fill it and that is harmful to us, it causes obstruction… Sometimes they do not throw it into the river, but on top, and when it rains it's all dragged and the river is full of junk… We don't say anything, we don't feel like fighting. And others dump things at midnight. The first times, we even wrote down their license plates, but we no longer do that" (neighbor of the Obispo Bosque zone, Cotahuma)*

Photograph 79. Garbage and debris in a ravine

10.5.1.3 Sewage Systems and Wastewater

Social commitments prevail over residential sanitary facilities, and throwing wastewater in the street is not subject to any type of social sanction.

In neighborhoods with sewage infrastructure, it is common that some houses are not connected to the system and in many other houses, only the toilet is connected. The rest of the wastewater – from the kitchen, bathroom or laundry – is directly emptied on the streets.

Photograph 80. Improvised rustic sewer system

In general, neighbors attribute this practice to a lack of economic resources. However, others contradict this version, claiming the problem is rather related to people having different priorities and lacking education, besides poverty. They say that many people without installed connections prefer to spend their money on "social" commitments and obligations, instead of investing in service connections. In fact, this is explained by the fact that there is no explicit social sanction for disposing of wastewater on the street. This explains why many neighbors don't see the need of spending money on connecting the kitchen and laundry to the system. In unstable zones, this practice contributes to landslides and the collapse of houses, due to hydric soil saturation.

> *"They don't have enough money to pay for the sewage connection, because they also have many commitments… Well, they dance, or they are someone's godparents, or they organize huge wedding parties…" (neighbor of Pasankeri Norte Bajo)*

Some neighborhoods in lower areas are threatened by wastewater and rainwater coming from higher zones and neighborhoods. The wastewater disposed of in the rivers or streams in the upper part crosses the lower parts without being canalized.

This is the case of the Kupini neighborhood, which is frequently flooded by rainwater and sewage from the Pampahasi area that comes down the Uno River and makes it overflow.

> *"This is the Uno River, over there it joins the Pampahasi sewer system; a bit further is the Dos River, both of them come together a bit higher up. This means that when it rains, the amount of water is terrible and everything slides, some places are falling down. In the sector of the bridge and also further down, there used to be gabions, but now there's nothing, the river took everything.*
>
> *Further down, the river eats everything, the water is eating the land and causing everything to fall down. That is dangerous for us because there are some houses on the riverbanks, one is mine, and I have seen that the houses are showing cracks and are leaning over" (Ana, neighbor of Kupini Bajo)*
>
> *"The worst thing about this river is that the water volume has increased since all sewage from Pampahasi flows into it, the water is undermining the soils. The only thing that used to support all this was the "placket" but now it's gone and many more accidents will happen" (neighbor of Kupini)*
>
> *"In the upper part of Ciudad Satélite the sewer system has filtrations. When it rains, the water comes from everywhere and the water flows everywhere, not only through the Melchuco River. Not only the Melchuco, River, also the Katari River. Now they're vaulting it, but that doesn't mean a thing, because what I see is that the vault is very narrow and it rained, and it got stuck with the rubbish dragged along in the water" (neighbor of the Antofagasta zone, Pasankeri Norte Alto)*

Photograph 80.Tolerance to slides risk

People's experience and knowledge of their zone are an important direct source of information on latent risks.

In the neighbors' opinion, some of the new public roads built in the upper areas cause floods and landslides because of the overflowing of rainwater. Neighbors of Kupini said that when the new avenue was inaugurated linking their neighborhood to Pampahasi, floods and damages to houses along the avenue increased significantly because now an important amount of rainwater flows down the avenue. Kupini suffered various important landslides, the last big one occurred in 1998, when 70 houses were lost in four blocks.

> *"I have been affected in that area, I have lived in this zone for 35 years. We did neither have potable water nor sewer systems. But what has also affected us was the extension of drinking waster in Pampahasi. Before, they didn't have sewer systems, only septic pits. Another reason is that in 1984 the Rojas avenue was opened, connecting us to Pampahasi. The road was built on a place where there used to be a cemetery. When it rained, all the water from Pampahasi came down the avenue and was held back here forming a lake. I wanted them to make a ditch so the water would flow into the Uno River, and also drains. The current mayor is still expanding this avenue, but without a sewer system and all the rainwater from the Illimani Neighborhood in Pampahasi is still flowing down here. The streets definitively must discharge all this water into the Uno River, this avenue transports the water of the 8,000 people who live in Pampahasi" (neighbor of Kupini)*
>
> *"The Apumalla avenue has not been finished either, it's merely a dirt road. so all the water flows down and the water eats into the soils and cement" (neighbor of Callampaya)*

Neighbors are skeptical about the intentions and fitness of some employees of the municipal government of La Paz.

As neighbors do not know resource distribution and internal control mechanisms of the municipality, their perception of disasters caused by water saturation is that municipal employees do not verify the quality of works of the company Aguas del Illimani. They believe that there is no quality control because when repairs are required after landslides and collapses, employees are benefited with "shady deals". They say that the companies use bad or inappropriate materials for sewer systems.

> *"The municipality never appears, we don't trust them, they never do things and they never won't. They say they don't have money, but we have that money for the neighborhood. I'm quite sure they pocket the money" (neighbor of Callampaya)*
>
> *"The municipality has done almost nothing in Kupini. Drinking water and the school are the products of the neighbor's work. We have even paid for and built the sidewalk kerbs ourselves" (neighbor of Kupini)*
>
> *"We neither trust the municipality nor the prefecture. Should any assistance be given under this project, we would want the project to work directly with us… In El Alto, NGOs are working directly with neighborhood councils and they have done many things: sewer systems, public water taps,… Without intervention from the municipality, because if we are going to wait for the municipality… Well, another*

mayor is going to take charge and nothing will happen" (retailer of the Huyustus Market)

10.5.1.4 Practices, Knowledge and Beliefs regarding Green Areas

In the city, green areas are not a priority for neighbors.

Neighborhood councils do not consider green areas in their Annual Operational Plans, and they believe that maintenance and improvement of those areas is neither their responsibility nor a priority. Priorities of neighborhood councils are generally linked to road asphalting projects, sport fields, cemented community squares, etc. Parks for children are often vandalized and destroyed, neighborhood councils do neither maintain nor repair them, as they are not considered a priority.

> *"…In the Council? No, because people are interested in improvement of the zone… they want cemented streets, public lighting,… that's what interests them,… not the other things, because they don't know a thing about that. They don't care. They live day to day. (leader of the neighborhood council of Munaypata)*

The population does not know well the functions of trees and neither gives importance to green areas.

The principal function of trees as perceived by neighbors is that trees improve the air quality. The second function less neighbors attribute to trees is that they hold the soil in its place, preventing landslides. No one mentioned trees as ornaments.

> *"They protect our respiration,… they say trees improve the air…" "…they produce oxygen" (Fidela, neighbor of Pasankeri Norte Bajo)*

> *"I think it's a good thing to have trees, many people say the roots of trees hold soils in their place. For some time now, they have sown a couple of little trees at school" (Ana, neighbor of the lower sector of Kupini)*

Many inhabitants of neighborhoods on the slopes associate green areas and trees on the streets with the concept of citizen insecurity.

The principal problem attributed to green areas is that they are associated with citizen insecurity. These green areas – small woods, ravines, or wasteland – often become dangerous places, especially at night as there is no public lighting.

> *"The zone with the small woods is called a red zone. In this sector, there are bad people that assault, attack, and rape people. Lately, they say people have been murdered near the highway. This affects the neighborhood" (leader of the neighborhood council of Munaypata)*

> *"….thieves, alcoholics and bad people meet and hide there" "In this river, there used to be willows, it was very nice, but debris and waste have covered them. Others burnt them… Young boys and other neighbors say that young boys go there to drink and fight" (neighbor of the Pasankeri Norte Bajo zone)*

Photograph 81. Small wood on a plain in Pasankeri Alto Norte

Sometimes, this concept of insecurity is even associated with the presence of trees on the streets. In some neighborhoods, people mentioned that trees are places where thieves hide at night to surprise their victims.

> *"Many neighbors prefer not to have trees because that is where rascals hide… Two weeks ago we tried to plant some trees in the San José avenue and in these weeks they robbed the iron structures they put there and on Sunday morning they also robbed our little trees"*

> *"On the other hand, neighbors didn't want these trees because that's where criminals hide, neighbors are convinced that if we put trees there, delinquents will use them to hide, especially if we want to plant trees every 30 to 40 meters. Because thieves will use the trees to wait until night for their villainy" (leader of the neighborhood council of Munaypata)*

There is no culture of taking care of trees on the streets.

Trees are indiscriminately destroyed in streets and parks of the city during the first months of life. In spite of various municipal efforts and private projects to plant trees in streets and on squares, there are hardly any trees. Some neighbors attribute this situation of permanent destruction of trees to uneducated young people and children. Likewise, the habit to leave different types of animals on the streets in these zones to graze destroys plants on the sidewalks.

" …only a few trees are left that have grown quite high. There should have been 500 to 1,000 trees because all parents at school and students were obliged to plant one each. But most people planted tree or even four…"

"The problem is that there are sheep, pigs and when the tree is small, they eat it. There are also young people and children who are always maltreating them" (neighbor of Kupini Bajo)

Photograph 82. Pig looking for food

People are convinced that the roots of trees on the streets destroy sidewalks and foundations of constructions.

Many neighbors are convinced and believe that tree-roots produce small cracks where the water enters and then destroys constructions. They are strongly opposed to tree-roots as they consider they destroy the sewers and sidewalks they built themselves. They say the roots particularly look for drains, to penetrate and destroy them.

"Another reason why neighbors don't want trees on their sidewalks is that when the tree starts to grow, the root lifts up the cement of the sidewalk and they say the root might do the same to their houses,… besides, they build the sidewalks with their own money, that's why…" (neighbor of Munaypata)

10.5.1.5 Damages caused by Sewer Connections

Unconcluded sewer works cause damages to the streets, which in turn cause walls to collapse because they get wet.

Connections to water and sewer systems after asphalting of the roads, deteriorate the roads as they are not immediately repaired. Often, the ditch dug to install the connection is left open, or is poorly repaired and slowly destroys a bigger part of the street. In practice, house owners dig the ditch for the connection pipes, but then they wait for the service providing

company to conclude sealing off with asphalt. This practice causes the water to flow underneath the asphalt layer and gradually destroy it. This frequently happens in popular commercial zones such as the Huyustus Market, where this fact was observed.

> *"Lately, the municipality has laid new sewers,… connections are not covered, they wait for Aguas del Illimani to cover them, …then the walls get wet, …and then they fall" (retailer in the Huyustus Market)*

There is no tradition of mutual assistance among neighbors-owners and retailers of markets in streets of the zone.

The relationship between house-owners and retailers who occupy the streets in different markets is tense, not to say conflictive. They "tolerate" each other because they have to, but they do not help one another in case of problems. Both groups accuse each other of causing drain obstructions. When there are floods or underground floods in vaulted sections in the streets, they do not work together and there is no solidarity. They act independently, without any type of coordination. When so called communal works are executed, they relate to interests of the immediate group or individual interests.

> *"They do things on their side, we on our side. When once the street subsided, the owners of the houses didn't help us at all. We collected money to buy stones, sand, everything… Neighbors didn't do a thing, but we were losing our source of employment, that's why we helped on that occasion" (retailer in the Huyustus Market)*

10.5.1.6 Educational Campaigns

There is an evident lack of actions to inform and educate the population on waste management norms, and even less on environmental hazard mitigation.

The interviewed population could not remember having heard anything about educational campaigns on urban cleanliness, rubbish disposal, forestation, green areas or the urban environment. Hence, they do not know the topics of the messages. Sporadic educational campaigns were ineffective, they are too general, and they do neither focus messages nor subdivide the public into different segments. This is why the population does not adopt or assume them. Finally, neighbors did not identify with the content of the messages, persons or situations, which is why they did not remember them.

> *"…Nothing, absolutely nothing. I believe there was a program called 'Environmental Education' some months ago, but we didn't see it on the hillsides, it was limited to the center… We didn't have the program. It was supposed to be for the entire city, but we never saw it on the hillsides. We, the people who work on the hillsides must invest 2% of what we earn in educational campaigns" (manager of a waste collection micro enterprise)*

10.5.1.7 Legitimate Social Organizations Recognized by the Urban Population

The fundamental social organization in neighborhoods of the city is the Neighborhood Council.

The principal social organization in neighborhoods and different zones of the city are Neighborhood Councils. This was not only verified in a visit of the central organization of these councils, the Federation of Neighborhood Councils (FEJUVE), but also interviewing inhabitants of all areas covered under the study. Neighbors in most neighborhoods and zones of the city are not only organized in Neighborhood Councils, but these councils are also members of FEJUVE.

10.5.2 Rural Area

10.5.2.1 Knowledge on Natural Disaster Risk Factors

In Peasant communities there is considerable knowledge on local natural characteristics that imply disaster hazard.

Most peasants of rural communities where group interviews were conducted, had specific and detailed knowledge on different risk factors that cause natural disasters and the danger those imply for their communities. Because of their rural life directly related to the local nature, experience in agriculture and livestock activities, and orally transmitted traditional wisdom of the community, peasants have accumulated knowledge on the behavior of their natural environment. Likewise, in general, the rural population also knew different natural causes that give rise to or increase the risk of occurrence of some of these disasters.

> *"The water always flows over defense walls. We secure the structure with galvanized wire, number eight, but the water breaks it very easily… the water is so strong that it simply lifts everything up and breaks it. It drags along enormous stones as if they were very light… and then the water flows over all defense walls in the entire Río Abajo Region" (peasant of Jupapina)*
>
> *"The thing is, the Khellkhata River comes down loaded, not only with water like the Chuquiago (La Paz River). The Chuquiago only transports water… it undermines the soil and turns the gabions upside down… those retentions worsen the flow" (peasant of Avircato)*
>
> *"The hydraulic lava flow of the Saytu has destroyed all houses in Avircato. It occurs every four years and destroys everything around here" "Before, the village was located on this pampa (shows a place covered with hydraulic lava). The hydraulic lava flow obliged us to take our houses to the hill because every time, the mazamorra destroyed our houses"*
>
> *"Each time the mazamorra flows down, it drags along houses, we can't control it…" (union leader of Avircato)*
>
> *"…Because the plants are burnt, now a lot of things are happening, because there is no forestation with trees, and when there is forestation, with plants, the water simply washes them away. It's because of the burning, in San Juan, for example" (peasant of Yupampa)*

Photograph 83. Land at risk at the point where the La Paz and Khellkhata Rivers meet

Peasants of communities know, identify and give priority to the principal natural risks their communities confront.

For the riverside communities, contingencies are concentrated on the following two principal risks: a) extensive floods, causing the flooding of vegetable gardens, with the resulting loss of their harvest and even agricultural land; and b) the displacement of huge mud masses called "mazamorras" (hydraulic lava flows) on farmland and even populated areas, in those communities where these flows occur. Both types of contingencies are the principal hazard these communities confront.

> *"…the water attacks us heavily, …the water comes down the Yupampa hill, to Valencia, and from there to us in Mecapaca. About three hundred meters lower, it meets the big river (the Choqueyapu), then the Khellkhata also joins. From that part over there, the water attacks us, that is the most dangerous spot because in the rainy season, the river comes with a tremendous strength. Then it overflows or moves the defense walls, we won't be able to cope with that blow anymore" (peasants of the community of Mecapaca)*

> *"The thing is, the Khellkhata River comes down loaded, not only with water like the Chuquiago. The Chuquiago River only transports water… it undermines the soil and turns the gabions upside down. But the Khellkhata River comes down loaded. They thought it comes down with water only that will undermine the soils and make gabion collapse. But that's not how things are, so retentions worsen the situation" (peasant of Yupampa)*

Photograph 84. Partially destroyed defense structure to protect vegetable gardens

Causes are of a different nature, because of geological characteristics of the region and human activity. Inhabitants of communities know them and distinguish them clearly:

> *"The defense wall between Mallasa and Jupapina had space enough. I've known it for thirty years, there were never floods, maybe just some small-scale 'overflowing' when there was a storm in the city of La Paz. But the problem is the hill, this hill is a danger to us. We have given the river enough space, we haven't tried to gain more land, it had enough space to come down quietly" (peasant of Jupapina)*
>
> *"…nearly twenty-eight years ago, the mazamorra buried Huaricana Alto and almost Huaricana Bajo as well, the Chaquerini mazamorra, … vegetable gardens, houses, farmland, everything… There are three rivers in Huaricana Bajo: Cementerio, Cosmin and Huanuni. In Huaricana Alto we have the Chaquerini and Chacantani Rivers, all are mazamorra-prone" (leader from Huaricana Bajo)*

Photograph 85. Hydraulic lava flows, the principal hazard factor in Río Abajo

Natural disaster risk factors in highland communities depend on climatic conditions and the topographic and geological characteristics.

The principal potential disasters in communities at high altitudes are directly related to extreme climatic phenomena. Severe hailstorms, frost or long periods of drought are a recurrent cause of the total or partial loss of their agricultural production. Nonetheless, specifically in relation to this study, an important area of cropland is lost also due to landslides and soil subsidence. Inhabitants of communities described this natural phenomenon as one of the principal problems they face. However, none of the communities located in higher areas mentioned local measures for prevention or mitigation with the objective of avoiding loss of their agricultural or pasture land. Although they classified this situation as very serious, their attitude was rather passive.

> *"…hailstorms and frost also affect the community" "…every year, soils subside near the river, …in the rainy season the soils get wet and the land slides away, …and every year, the water causes parcels to slide" (peasants of the community of Uncura, in the Saytu river watershed)*

Photograph 86. Humid land in high areas at risk of sliding. Community of Huacullani

In the community of Kera, for example, peasants reported that in recent years they have lost approximately 40 Ha of cropland.

> *"We have lost cropland, more than 40 Ha. Slowly, we loose land, about five hectares every year"*
>
> *"Before, there was a place called Duraznani because there were a lot of peaches ("durazno", in Spanish). But now, there is no farmland left, everything is lost, we probably lost about sixty hectares" (peasant of Kera)*

Because of landslides and soil cracks, community houses had to be moved. Landslides started in mountain streams higher up.

Landslides in this zone contribute to the Chaquerini River coming down as a hydraulic lava stream, affecting the community of Huricana.

> *"One year, the mazamorra that came down from our zone completely buried Huaricana. We didn't know where to go and what to do, we lost our crops and our land, not one institution visits us. Last year, we told mayor Ramos that we are loosing our potato crops, our land, but nothing. Before, we had big parcels, we produced maize, even tomatoes, but all that flew down into Huaricana" (peasant of Kera)*

Inhabitants of the community of Ñuñumayani specifically attribute landslides of their parcels to the humidification of the soils, caused by flooding of the three rivers, tributaries to the Khellkhata River, that pass through the village.

> *"We have three big rivers:: Chacajahuira, Challachullo, Chalavera. Two flow into the Khellkhata and the Korikorini, that's why soils are sliding, up there in our cropland and down here also. Approximately twelve years ago, we still had farmland here, next to Chojo and Lluto. We also had farmland in the environs of Chulluani. Towards the north, we are loosing nearly twenty hectares in twenty years, the same happens on the other side" "..and the municipality does not acknowledge that we are loosing land and we continue paying taxes" (peasant of Ñuñumayani)*

Hydraulic lava flows that find their origin in the headwater section of the river on higher areas are a source of tension and accusations among communities.

Riverside people claim that agricultural activities of highland peasants who live near mountain streams are a partial cause of hydraulic lava flows. They explain that those cultural practices deteriorate soils, causing landslides and soil subsidence, which in turn cause mazamorras in the rainy season.

> *"…I'm sorry, but it does not affect them, it affects us. They should stop sowing on that place because they wear down the soil and then everything slides in the rainy season" (peasant of Avircato)*

Photograph 87. Landslide and Hydraulic lava

Traditional practices for mazamorra and landslide control coordinated among different communities or neighboring former estates have been abandoned.

Inhabitants of the community of Kera affirm that before the land reform, large estate owners in Kera and Huaricana coordinated actions and joint efforts to deviate the course of the Chaquerini river to Sapaqui, thus avoiding hazard to Huaricana. Currently, this practice has been abandoned and the communities of Huaricana are constantly affected and threatened by hydraulic lava flows.

> *"Before, in times of the large land owners, they reached agreements. The Kera and Huaricana landowners reached agreements… Just behind this place, there is a ditch to Sapaqui, landlords maintained that ditch, and the water did not go down to the river, I have told people in Huaricana a hundred times that we should keep the ditch clean with a tractor" (peasant of Kera)*

Photograph 88. Hydraulic lava directing canal, Huaricana

Institutional weakness and political instability of the Municipality of Mecapaca derive in ill-planned urban development without adequate technical control in this region. Thus. risks and natural disasters increase.

The Municipality of Mecapaca is very weak institutionally, and its administration is constantly involved in political party conflicts. Because of this situation, many private urban development projects in the region are officially approved although they do not meet urban planning standards. Peasants of Yupampa state that the hydraulic lava flows of the Korikorini River, affecting their vegetable gardens, was the result of the division and selling of lots of land on the hillsides where the river flows down. The division of the area into small lots exterminated the vegetation that held the soil in its place, and that offset the force of downward hydraulic lava flows.

"The river they closed was a river after all, they have started to sell lots and Rolando P. took advantage of the situation and sold lots on top of the river"

"… he built a cement wall to protect his urbanization, and that's where the river bounces and affects our side, that's why there have been floods"

"… there was broom, but as they burnt the area now there's nothing, there were molle trees, broom, carob trees, … but not anymore, they have disappeared slowly with the burning" "Now, there are no longer carob trees or broom, the place has been completely divided up into small lots" (peasants of Yupampa)

Inhabitants of communities express their skepticism and criticism regarding the technical design of some prefectural projects.

Many people in the community have a negative perception on the technical design of the works executed by the Prefecture. Peasants of Yupampa say that the floods caused by the Khellkhata River are the result of the material dragged along the rivers being retained in the energy dissipating walls, pushing the water to communal vegetable gardens. They insist that the Prefecture of La Paz made a mistake on building a series of transversal energy dissipating walls along the canal. Furthermore, they consider that the strength of the Khellkhata River has increased because of canalization works that narrowed the natural course of the river, which was done "gaining land" on the riverside to establish an urbanization. This river canalization causes frequent overflowing, floods of vegetable gardens and crop destruction.
On this point, rather than the technical certainty of community inhabitants, it is important to capture and know their subjective perception on the institutions with which they work, to understand the attitudes they could assume in future projects. Projects with beneficiary's resistance can hardly be successful.

"I remember that in the year when technicians built gabions they also built cement retentions. We asked them not do this, because when the retentions are filled, the river comes down with more strength and that is what has covered all gabions. And that is why there were floods also after 19 February, that is when the river took our land"

"In Yupampa, we always have trouble in the rainy season. For example, the Khellkhata River is the most dangerous one and the little bridge we have is not safe… the river will destroy it any moment. All this is because they closed the river on the other side of Yupampa, before it was wider" (various peasants of Yupampa)

The general perception of peasants is that the Río Abajo region suffers floods caused by urban development of the city of La Paz.

Other peasants affirm that the volume of the La Paz River increased considerably in recent years. They explain that this phenomenon is related to growth and urbanization of the city. In their opinion, both the asphalting of streets and avenues and canalizations of different rivers do not only avoid filtration of the water in the city itself, but – because the volume increases – the force of the water also increases. This situation causes severe flood hazard and the overflowing of the downstream area.

"…all streets in the city of La Paz are asphalted, so the water slips like on a sheet of corrugated iron and all the water comes together in the Choqueyapu River,… then all defense walls in the entire downstream area are flooded" (peasant of Jupapina)

"I was born in the region, I'm from Lipari, I'm 73 years old and I'm worried when I see how this situation has changed. We worked on protective structures with our bare hands, there were no machines, but because the city grew and because all streets are asphalted, the water comes together quickly and makes the river overflow, destroying our cropland. This means more water flows through the river and our defense walls can no longer resist all that water" (peasant of Jupapina)

10.5.2.2 Beliefs regarding disasters

For peasant communities with a strong presence of evangelical churches, natural disasters are the result of supernatural events.

Inhabitants of Jupapina attribute the landslide of the Mallasa hill on top of Jupapina farmland in 2001 to the appearance of a mythological being (a golden snake). They insist that some time after the appearance of this supernatural being, the landslide occurred, affecting their cropland. Consistent with this belief, their attitude was passive, waiting for supernatural forces to intervene and solve the problem.

"… there is a "devil",…some people have seen him at night and others even during the daytime, …that's when the landslide occurred, first down here, and then on the other side" (peasant of Jupapina)

"Also further down on the other side, many people say the devil did it, the devil in the shape of an enormous golden snake… the place where they saw it slid six months afterwards…"

"Some believers say it's better to fast and pray" (peasant of Jupapina)

Vernacular religious beliefs of the native culture still persist in communities although they receive contrary pressures from foreign churches.

On the other hand, inhabitants of higher areas consider that landslides occur because lately, many people have abandoned their old costums and rites for ancestral Gods of the native culture, such as the Pachamama (Goddess of the Earth). They affirm disasters are occurring because many inhabitants of the communities converted to the evangelical faith. Some interviewees said that these natural problems reflect the feelings of the native deities of the earth. They admitted it may be wrong that they are no longer practicing ancestral rites.

"… before, we asked the Pachamama, but now, we can't do that anymore, in the cult they tell us it is prohibited" "We can no longer worship Pachamama, maybe because we abandoned her, these problems are occurring"

"…that's why, always,…those people from the cult, they say bad things about our costums…" "they say those costums are devil worshipping… it is prohibited to prepare tables with offerings for the Pachamama"

"Before, they used to say they knew how to use bull horns to stop the slides, but not anymore" (peasant of Lluto).

10.5.2.3 Practices and Costums regarding River shore management

Agriculture in Río Abajo was established and developed on the basis of the riverside community's capacity to occupy the La Paz Riversides.

Riverside communities have implemented farmland on the shores of the La Paz River since before the Land Reform, in the era when there were still large landestates.

> *"I remember that when I was a child, when there were still landlords, we used branches and trunks, nothing else, to build defense walls, but just like Cristóbal said, we don't have trunks anymore, the area was flooded and took everything" (peasant of Avircato)*
>
> *"…before, land was gained with defense walls in Lipari, Ananta, Huajchilla, Taipichullo, Carreras, Llacasa, Avircato and Huayhuasi, that's how things have always been"*
>
> *"Before, Lipari was not like it is today, it was just a small area. Where the Huacallani River comes down, that's where the landlord's house was, that's all there was, there was no other farmland" (peasants of Jupapina)*

Photograph 89. Vegetable gardens of two riverside communities on both sides of the La Paz River

The construction and permanent maintenance of defense walls for agricultural land is the most important cultural practice in the region to protect the population's means of subsistence.

Vegetable gardens were implemented by means of the construction of defense walls that canalized the river and enabled development of these areas. However, these constructions must be reinforced constantly to avoid overflowing of the river and the resulting loss of crops and the land itself. Maintenance of defense walls is annual.

"There are years when it rains too much, but other years it doesn't rain and nothing happens with the defense walls and we even gain more land. But there are years when it rains quite a lot, so then the river destroys the defense walls and it destroys us so then we have to start again fighting the river. That is how we fight the river" (peasant of Jupapina)

"The defense wall is the most vulnerable spot, you know what happened last year, when the floods came and the flood affected the land we prepared for sowing, so to defend ourselves, we then have to reinforce them…" (peasant of Mecapaca)

Photograph 90. Destroyed defense wall

Occupation of the river shores is a historical practice of inhabitants in the La Paz River area.

Community inhabitants remember that this practice of land occupation on river shores for vegetable gardens was not only applied in the Río Abajo region, but also on the shores of the Choqueyapu River in the city before it expanded covering those pieces of land.

"…even in the upper part, people have always won land on the river. The Monos Park used to be a river but the land was gained with contention walls. Near the Tennis Club fields around the Calacoto Bridge, all that used to be river, but the land was gained…. the same happened in Obrajes. As my friend says, the Aranjuez sector, the Bartolina Sisa Park, all that used to be river …, our friends who live in the lower parts have more experience on how to put the supports and branches" (peasant of Jupapina)

The construction and maintenance of defense walls to protect vegetable gardens is one of the central activities of communal life. This activity requires considerable labor force and time from communities.

The construction and basically maintenance of defense walls on shores or banks of the La Paz River – which the local population calls "*reparos*" – and the occupation of land on river shores is a common practice of peasants in Río Abajo. As they say, the defense against floods is "an annual fight against the river". These are communal activities all year round, which require up to two days a week.

> *"When there are problems, we build defense walls, …we work the whole year round. Every week, every Monday, …and whenever there is trouble we work entire months"*
>
> *"Defense walls are fundamental, that is how we avoid the river attacks us, because different rivers come together with the Khellkhata River and than they overflow…" (peasant of Mecapaca)*

Nonetheless, efforts invested in the construction of defense walls do not always have the expected results. Sometimes, the "land occupation" practices merely result in sporadic benefits for the community, because the little land that was gained is lost once again the following year.

> *"…we have planted willows on the edge of the river, to then tie trunks behind them, as defense walls for our vegetable gardens, …we prepared the structures rather well, …but the river won, …the river attacked us and took everything, …" (peasant of Avircato)*

The generalized practice in communities to "occupy riverside land" is an important risk factor causing losses and floods in the land of neighboring communities.

One of the principal causes of overflowing of the La Paz River and the resulting flooding of the riverside community's cropland is the generalized practice of communities to "**occupy riverside land**". This practice does not only cause a decrease of the natural course of the river, but it also often redirects the river towards the opposite river shore.

> *"This is the river, and there are communities on both sides of the river. One community gains land, and so does the other. It seems both want to be affected, this has been a constant fight. For example, we caused Mecapaca to be affected. That is what happened, so we haven't managed things very well..., because when the water is strong and affects us, we are the most severely affected parties" (peasant of Avircato)*

The expansion of vegetable gardens on river shores is the most frequent and widespread factor causing inter-community tension and conflicts.

Many visited riverside communities are involved in permanent inter-communal conflicts with other communities located on the other side of the river because of the widespread practice of "land occupation" on the riverbanks. This practice decreases the natural width of the riverbed and the land "won" in one community causes pressure, "pushing" the river to the neighboring community, causing the flooding of their vegetable gardens.

> *"The people from Mecapaca occupy more land every year, and that affects our land because we have crop land further down. They use our stones to build defense walls, …with the stones we had piled up. So we will certainly have problems with the Mecapaca people" (peasant of Avircato)*
>
> *"Llacasa is out of its line. They built defense structures, deviating the river in our direction, just after the Huancarani bridge. They should have built their structures according to the river course, but they didn't and they are still not following the river line"*
>
> *"They (Llacasa) have problems with Carreras, Huajchilla, Taipichullo, with everyone. They have defense walls everywhere, they have three defense walls. On one occasion, just like here they vaulted the river, but then the river flooded Carreras and the municipality of Mecapaca had to remove the defense wall with a bulldozer" (peasant of Yupampa)*

Conflicts arise because of the obsolete definition of boundaries in the La Paz River shores and communities' permanent attempts to expand their cropland.

> *"We have documents and they don't. Our land borders on the river, they say their land borders on us. They want to make the river disappear. We still pay taxes for the part the Choqueyapu River took from us, approximately 3,000 meters" (peasant of Valencia)*
>
> *"…us? No, that's not how things are. Rather, they are gaining more land, affecting us. And that part belongs to Carreras, the people of Carreras worked on the upper parts. The Yupampa defense wall was merely 50 to 100 meters, because the others didn't have one. Now, they are abusing, pushing us toward the river, they planted trees up to the middle of the river, it's but too clear"*
>
> *"They bought nearly 1,000 meters from Mr. Pastor and with what they bought they won nearly 3,000 meters"*
>
> *"We asked for a field sketch, a map of Carreras, which the Secretary General now has. We have old defense walls according to the plans of our grandfathers. So I think we'll have trouble with Yupampa because we won't let them advance more with their defense walls" (peasants of Avircato)*

Problems result from ill management of the river course, which is frequently deviated to the opposite shore with defense walls. People affirm that the "land occupation" practice in neighboring communities causes flooding of their cropland.

"Once, when everything was flooded, people went to the municipality to complain and ask why they had allowed construction of those defense walls. The municipality sent a bulldozer to remove it, the people in Llacasa watched quietly because they saw that everything was flooded" (peasant of Yupampa)

There is social pressure among peasant communities in the region related to the occupation and production on riverside areas.

Migrants from less benign zones of the region come to the communities and settle. They start to produce their crops on unoccupied land in those communities. These new vegetable gardens do not only give rise to logical land ownership conflicts, but they also intensify watercourse management problems.

"The front side used to be simply a river shore, …but the people from Yaniri came to Avircato, about eight persons and occupied that pampa. That pampa used to be ours, I had three parcels there, but they took it away from us, they came from Yaniri and Saytu and now more people want to come to this side, and they're many" (peasant of Avircato)

10.5.2.4 Mazamorra Practices and Management

Elder peasants know old and traditional practices for mazamorra management, but younger people are loosing this knowledge.

In the past, haciendas and communities used to build ditches and defense walls to deviate hydraulic lava streams to the river.

"…we used to build "cumanas" [sort of defense structure] to fight against the force of the mazamorra. People also used to blow up the stones dragged along with the mazamorra from the Saytu River"

"According to our grandfathers' beliefs, we used to defend ourselves with trunks, but the river always won"

"We built cumanas. Cumanas are a type of wall made of bars, shrub and stones. We had to rebuild them every year to direct the hydraulic lava flow. Sometimes, our work resists the mazamorra, but at other times, it doesn't and then we have to build them again"

"We used to blow up the stones dragged along the Saytu with dynamite. For four years, we haven't done this and the hydraulic lava is piling up"

10.5.2.5 Garbage management

Local garbage management in the Rio Abajo Region is inadequate; however, it does not represent an immediate critical risk for the region. Rather, the region suffers from contamination from the city of La Paz.

Community inhabitants assume passive and careless attitudes regarding the presence of garbage in their environment.

They chiefly attributed the presence of waste in their communities to their own attitude of carelessness and laziness. Garbage is dumped into the river, neighboring land or more frequently on places far from their houses. It is obvious that people are not interested in living in a garbage-free environment. Paradoxically, on feasts, the whole population cleans the village when they expect people from outside the community to come, which once again produce and scatter enormous amounts of urban waste.

> *"…it's everywhere… no one in the village says that garbage should be taken to another area, that it should be dumped elsewhere, maybe it would be a good idea to appoint someone who organizes the village cleanly…"(peasant of Mecapaca)*
>
> *"We only organize ourselves to clean the village when there's going to be a feast, that is once every year, because then people from outside come and we can't receive them with garbage" (peasant of Huaricana Bajo)*

There is a generational change in the attitude and values regarding waste management.

Although elderly people in the community still burn and bury waste regularly, young people say they do longer maintain this practice, they prefer to throw their waste into the river. As garbage now contains plastic material, the smell and smoke when burning these plastics bothers people, so they refuse this practice.

> *"…our grandfathers used to burn it, …but we start to work early on our land … so we bring the garbage to dump it in the river. …it's better this way, because if we leave the garbage in bags then the dog tears it open, and when the wind blows the garbage is taken everywhere" (young peasant of Huaricana)*
>
> *"Before, we used to burn our garbage on our crop land, but now garbage is different. Before, our garbage was straw, rests of vegetable. Before, we packed our vegetable in straw, now everything is packed in bags and boxes…"*
>
> *"I think burning is better, but years ago, we didn't have any disposable bottles and bags. We only used newspapers. Now, there are plastic bottles and bags everywhere, …and it stinks when we burn them" (peasant of Valencia)*

Peasants are aware that garbage that is dragged along the La Paz River is the principal source of environmental contamination in Río Abajo cropland.

Huge amounts of garbage with plastic waste coming from the city are accumulated and mixed with the soils of the vegetable gardens and pastureland after the floods. People said the presence of plastic waste was "harmful and dangerous" for their animals' health. However, people's attitude toward plastic waste in pastureland is passive.

"…it makes them sick when they eat it… they swell like toads, …sometimes they die …plastic soft drink bottles, nylon bags are bad for animals, especially nylon when they eat it, but we don't see it when they eat it"

"…when the animals are grazing, they also eat garbage… it kills them, they don't gain weight, it stays in their intestines"

"Every household should collect and burn its garbage, but no one does it" (peasants of the community of Avircato)

The presence of urban garbage in the environment is neither a priority nor worries communities. They completely delegate solution of this problem to the local municipality.

Many people in communities expressed their indifference regarding waste collection and urban sanitation. They said that "by law" the municipal government of Mecapaca is responsible for garbage collection, but the municipality does not have the capacity or resources for this aspect. In the communities of Jupapina and Mallasa – the only communities of the region that are benefited with waste collection services from the city - people behave in a similar way to people in the city. Few people wait for the garbage truck and leave their garbage on the streets. Stray dogs destroy the bags, or the wind or rain scatters them all over the place.

"About three to four years ago, everyone used to take their garbage to empty places. But now the municipality of La Paz sends it garbage collection truck on Monday and Saturday afternoon and I think it picks up garbage up to Umamamta" "Some people don't want to wait for the truck and take their garbage to ravines" (peasant of Jupapina)

10.5.2.6 Local Practices and Costums regarding Vegetal Soil Coverage

Trees are valued as a natural resource because of their usefulness.

Riverside communities mainly use trees to build defense walls to protect their vegetable gardens against floods. Mainly eucalyptus trunks are used to build defense walls. People also plant willows and eucalyptus on the river shore as part of the natural defense structure.

Peasants are aware that trees avoid erosion.

"Trees are used to build defense walls. Eucalyptus trees and willows have a lot of roots, and are convenient for defense walls. …you probably saw how Aranjuez lost its defense walls because they cut the willows"

"We only use trees of hillsides, such as the molle and carob tree and also the taco tree, for defense walls, we rarely use them for fuelwood" (peasants of Jupapina)

"It would be nice to plant trees up there (on the hill), they would hold the soils on their place" "Roots would avoid landslides, they would prevent erosion" (Peasants of Ñuñumayani)

"In Uncura, there used to be a hacienda, full of trees, but after the landslides, all those trees disappeared and so, when it rains, when there is a hailstorm in the rainy season, the water is accumulated and hydraulic lava flows come down" (peasant of Avircato)

Peasants in highland Communities use vegetal coverage – trees and shrubs – as fuelwood to cook and also to build the roofs of their houses.

> *"…There's no gas here, we use firewood, that's what we use to cook. We don't use everything, only the most resistant ones, the very small ones have no resistance" (peasant of Uncura)*
>
> *"The trees we bring from further down are also used to build our roofs" (peasant of Kera)*

The cultural practice to burn vegetal soil coverage is still maintained in spite of official information campaigns on the environmental damages this practice causes.

On the other hand, many communities still maintain the ritual habit of burning vegetal coverage on hills and ravines during certain times of the year, especially during the San Juan feast. Normally, burning is twice every year: once in January as a rite to avoid frost during the year, and once in June – July as an offering for the Pachamama Goddess of the Earth and Achachila Forefathers.

> *"…it is a yearly habit. Before, our grandfathers burnt every year in San Juan, we follow that habit… Some people burn because they believe burning will bring them good luck … in the harvest, they know why they poke the fire"*
>
> *"San Juan is to have more cattle, more cows, a bigger harvest. We offer alcohol to the Pachamama, the Achachilas so they would bring us more…. We make offerings for everything, this and that, that's how it works"*
>
> *"We burn when there's frost. When there's frost, it's very cold and we burn to get warm. In January, we make fire to ask for no more frost during the year… In San Juan, we make fires on the hills and in January in the farmland" (peasants of Uncura)*

However, in some communities, for example in Kera, this practice was prohibited especially because pastureland for their animals is scarce.

> *"In this community it has been forbidden for more than ten years to make fires in San Juan, because then there's no food left for the cattle and then the animals don't grow"*
>
> *"Before, we had fires, but not anymore. Now, we bring firewood to our parcels and burn it there. The community has passed a decree, prohibiting the burning, because we have few shrubs and because the burning affects the environment. That is why burning is prohibited in San Juan and at any other time, if you don't respect this rule, you have to pay a fine of Bs. 50" (peasants of Kera)*

Excessive grazing of sheep also causes depredation of smaller vegetal soil coverage.

In general, inhabitants of communities on higher areas have ewe herds. Sheep overgraze on the pastureland and they depredate vegetation coverage. Nevertheless, because of the characteristics of some shrubs in the ravines – thorny species and branches with few leaves – these species are unfit as fodder, which is why inhabitants burn these species to remove the thorns.

"Thorns are burnt to allow sprouting of a new plant. Thorns are used as fuelwood. We burn the thorns because the sheep won't get near the plants, even we can't cut them away sometimes" (peasant of Kera)

10.5.2.7 Artisanal exploitation of sand and stones

Stones and sand are exploited on the river shores without any type of technical norms or support from the municipality.

Some people in riverside communities work in the artisanal exploitation of sand and stones on the riversides of La Paz. Although, before the municipality of Mecapaca tried to control this activity, there is no control at present. The communities fix charges to people who exploit the river. This practice is not only a source of income for some local inhabitants, but also generates income to some communities.

"…in order to exploit sand and stones, the municipality must have thought that they owned the river" "…I extracted sand, and the municipality charged us Bs. 10 for every truck. Lately, I believe they don't charge anymore, now the communities are responsible for their part of the river and the municipality no longer interferes… they reach agreements. The trucks can collect stones and as payment, they have to give a couple of stone loads to the community to build defense walls" (peasant of Yupampa).

10.5.2.8 Legitimate Social Organizations Recognized by the Rural Population

The principal social organizations in peasant communities of the region are peasant unions.

The central organizations of peasant communities in this area are the Peasant Unions. This was not only verified in all communities where interviews where conducted, but also in a meeting with the three Regional Peasant Sub-Federations. All communities of the region are not only organized in Peasant Unions, but they are also members of the mentioned Sub-Federations, as part of the regional structure of the National Peasant Organization.

10.6 Recommendations

Based on the identification and analysis of practices, costums and habits of the population of La Paz and the communities in Río Abajo as well as on the conclusions described above, we recommend development and implementation of the following lines of action:

1. Educational programs on safe waste and debris management practices, which promote a change of habits and costums, with the objective of achieving and keeping the city free of waste and debris, and reducing environmental contamination.
2. Educational programs on the need and use of sewer systems and environmental sanitation to improve use of the service and reduce landslide hazard.
3. Awareness-raising campaigns on disaster hazard resulting from the ill disposal of waste and debris and wastewater in the city.

4 Awareness-raising campaigns on the dangers resulting from riverbed “land occupation” practices with new vegetable gardens, thus reducing the river’s width.

5 Reforestation Programs on hills to control landslides in communities in highland areas of Río Abajo. They must include environmental awareness actions and technical training. Awareness-raising campaigns on damages caused by burning the vegetal soil coverage.

6 Information Campaign on hours, routes and norms regarding waste collection service delivery.

7 The Municipal Government of La Paz must establish a construction debris collection and final disposal system. This system should not only identify and determine rubbish dumps, but it should control and watch over compliance with provisions and norms.

8 The Municipal Government of La Paz must structure a control and surveillance system to enforce norms related to disaster hazard prevention in the city, considering as a minimum the following topics:

a) Behavior of neighbors with regard to waste disposal.

b) Behavior of debris disposal service providers.

c) Indiscriminate division and sale of lots (illegal occupation of municipal areas, hazard areas, etc.)

d) Organization of utility service provision (e.g. water without sewer systems in risk areas).

9 Implement a project for research, advocacy and lobby with the National Government (Ministry of Sustainable Development and Planning) to promote the decreased use of plastic bags and packages. This can be achieved by benefiting industries that change disposable plastic containers by other reusable containers with tax incentives.

10 Implement a project for research, advocacy and lobby with the National Government (Ministry of Sustainable Development and Planning) to promote the decreased use of plastic bags and packages. This can be achieved with tax incentives, by benefiting industries that change disposable plastic containers by other reusable containers.

11 Implement a program to promote opportunities to transform, recycle and add value to garbage. This program should be a complete program and include training and technical assistance, and even marketing support for the recycled products.

All these initiatives must promote citizen inclusion and participation to ensure success and a positive impact.

11 PROSPECTS FOR HAZARD MITIGATION: PROJECT IDENTIFICATION

In order to provide a short-term response to different questions resulting from the issues treated in this document, this chapter presents some profiles of lines of action that could contribute to a reduction of the levels of vulnerability of the identified areas at risk. The proposed lines of action should be prioritized taking into account the needs and lines of intervention of different sources of funding, as well as the operational plans of the involved municipalities.

Although these projects emphasize specific activities, all projects will be conceived within the framework of integrated watershed management.

11.1 Canalization of Pilot Sections of the La Paz River

11.1.1 Objectives

- Improve riverside defense conditions in one section of the La Paz River, benefiting the communities of Valencia, Mecapaca, Carreras and Yupampa in the municipality of Mecapaca, Province of Murillo, Department of La Paz.
- Implement infrastructure for canalization of the La Paz River, with the purpose of mitigating flood hazard for the people settled on the riversides, and protecting farmland.

11.1.2 Description of the Initiative

The initiative consists of the integrated execution of activities related to the building of defense walls on riversides at the point where the Khellkhata River flows into the La Paz River, aimed at testing integrated intervention methodologies for building canalization facilities, forestation activities and educational and information campaigns on hazards, with community participation.

The idea is to build canalization infrastructure that is complementary to the canalization that was built recently in the Khellkhata River, which responds to eminently theoretical design criteria and is based on hydrological information, taking into account historical restri1ctions. The canal that will be built consists of 72 modules of 20 meters, with intermediate gabions. The total riverside defense structure will have a total length of 1,440 meters and 288 meters of gabions along the La Paz River. The idea is to find out how the connection of both rivers will work. In these circumstances, the civil works will be complemented with densely populated forest plantations to ensure stability of soils in the river connection area. Likewise, the population will be involved in a process focusing on adequate and aware management of the elements for riverbed improvement at the point where both rivers meet and the surrounding area.

This profile considers the pilot construction of structures at the river mouth, as a larger-scale initiative would require bigger investments, which are not realistic considering the current economic situation of the country. This place was selected because there is space along the La Paz River to build a demonstrative section with a riverbed width consistent with hydraulic designs.

11.1.3 Participating population

Up to 320 families could participate in project activities.

11.1.4 Project execution

Project implementation will be subject to execution of the following subsequent steps:

- **Formalization of relations with the Prefecture of the Department, the Municipality of Mecapaca and the selected communities:** This implies the signing of specific agreements, defining institutional roles. Expectations are that both the Prefecture of the Department and the Municipality of Mecapaca participate in implementation of the project with heavy equipment and financial counterpart resources according to the budget structure proposed in this profile. The project will be executed with communal participation, as well as external qualified labor and technical assistance. Non-local materials will be supplied using the project budget. Communal participants will receive food for work as an incentive for non-qualified labor in the project.
- **Preparation of the Final Design of Riverside Defense Structures:** A professional responsible for the design will be hired for this activity. Design criteria adopted by CONSA SERINCO shall be revised and taken into account.
- **Contacts with Communities, the Municipality and the Sub-prefecture:** The purpose of this activity is to inform, explain and achieve committed community participation as the work modality, with the resulting definition of roles of the parties and programming of activities.
- **Community organization:** Through this process, a structure will be formalized to facilitate communication and relations between all participating institutions and the community.
  - **Setting up of defense structure building committees:** Building committees will be set up based on existing peasant unions in every community that participates in the project, i.e. Valencia, Mecapaca, Yupampa, Carreras and, if possible, Avircato. Members of the committee will be oriented on their role and functions.
  - **Definition of the activity timeframe:** On the basis of the final timeframe to be developed by the designer.
  - **Organization of warehouses for non-local materials:** On the basis of criteria and requirements regarding the handling of non-local materials.
  - **Organization of the food for work distribution system:** Based on FFW handling requirements for food USAID donates.
- **Procurement and transportation of non-local materials and basic tools:** This process will be carried out, taking into account procurement norms of CARE BOLIVIA, consistent with norms of USAID Bolivia.
- **Administration of non-local materials:** Community organizations will be responsible for this aspect. In this sense, they will provide safe spaces to keep non-local materials.
- **Hiring of qualified labor:** This refers to the hiring of a responsible for the works in every community.
- **Staff allocation for technical assistance:** This refers to the official designation of technical staff responsible for the project in every participating instance.

- **Construction of defense structures:**
  - Reopening of the works.
  - Excavations to collect local materials.
  - Gathering of local materials.
  - Excavations to channel surface water.
  - Excavations for foundations.
  - Lower foundations, upper foundations and defense walls.
  - Technical Assistance and Supervision of the works. Quality control of the works, by means of application of the technical specifications of the design.
- **Monitoring of the constructed works:** In order to verify effectiveness of the constructed works.

Parallel to construction of the works, activities related to environmental education and orientation on integrated watershed management in the Río Abajo region will be implemented, through the following process:

- Identification of relevant groups for environmental education and activities regarding integrated watershed management.
- Organization of relevant groups according to possibilities for training and orientation on environmental education and micro watershed management.
- Participatory development of training plans and active participation in activities related to environmental care and integrated watershed management.
- Execution of developed plans for training and participation.
- Monitoring and evaluation.

A plan will complement civil works with densely populated forest plantations, with the objective of holding riverside soils in their place in the area where the rivers join. The population of the communities of Valencia, Mecapaca, Yupampa, Carreras will be encouraged to participate in a process of adequate and conscious management of the elements that improve the riverbed at the point where the rivers come together, as well as the surrounding areas. The most important activities for the reforestation process are:

- **Projections of the established process:** Aspects resulting from an analysis of the training, construction and forestation process will be discussed with the population of the communities and authorities. Based on this analysis, projections will be formulated, so that the lessons learned could orient future actions aimed at solving the problem of a lack of riverside defense structures in the region.
- **Control of the execution of works, involving the UTIM (Municipal Technical Unit for Infrastructure):** At least one official of the Municipal Technical Unit for Infrastructure will be involved in the execution and supervision of works, so that (s)he will be trained in the subsequent supervision of similar processes.
- **Management Staff and construction of riverside defense structures:** 10 persons
- **Staff to organize environmental training and integrated watershed management activities:** 2 persons
- **Staff to implement the agro-forestry component:** 4 persons

Time required for implementation: 4 years

11.1.5 Budget

Table 8. Budget for the construction of canalizations in pilot sections of the La Paz River

Item	Total Amount	External Funding	Prefecture	Municipality	Communities
Project management and civil and social Technical Assistance	678,000.00	678,000.00			
Non-local materials, equipment and tools	312,300.00	312,300.00			
Local materials	35,000.00				35,000.00
Local labor	230,880.00				230,880.00
Rent, operation and maintenance of light vehicles	72,300.00	72,300.00			
Rent of heavy equipment	366,000.00		366,000.00		
Operation and maintenance of heavy equipment	90,000.00			90,000.00	
Transportation of materials and tools	17,300.00	17,300.00			
Transportation of food + logistics	23,500.00	23,500.00			
Office expenses	14,200.00	14,200.00			
Insurance	7,200.00	7,200.00			
Travel expenses and per diems	8,200.00	8,200.00			
Administrative costs	45,800.00	45,800.00			
CDC	55,500.00	55,500.00			
NICRA	71,000.00	71,000.00			
Total	2,027,180.00	**1,305,300.00**	**366,000.00**	**90,000.00**	**265,880.00**

11.2 Agro-forestry project in Río Abajo

11.2.1 Objectives

- Set up forest plantations in support of the civil infrastructure, to control the La Paz River course.
- Incorporate and reinforce agro-forestry practices in support of the agricultural production.
- Train the population in forestry, agro-forestry aspects and environmental education.

11.2.2 Generic activities to be developed

11.2.2.1 Production of plants

A greenhouse will be prepared for the reproduction of native and exotic species, which are destined for plantation in forested areas and agro-forestry practices.

Areas for the clonal propagation of species identified as priority species will be implemented.

Seed producing trees will be identified in the project zone for seed collection, special attention will be dedicated to native species.

11.2.2.2 Forest plantations and implementation of agro-forestry practices

Forest plantations will be implemented on the banks of the La Paz and Khellkhata Rivers, with the objective of reinforcing canalization structures and reducing the flow of materials transported to watercourses.

Plantations will have a high density (2 x 2 m in between the plants), to ensure that the root mass will hold soils in their place.

Plantations for ditch control will be emphasized, these plantations will be associated with small works, such as belts, ditch traps, crown ditches, energy dissipaters, stone dikes, infiltration ditches, etc.

On the slopes of steep hills, activities will be implemented to enhance retention, germination and establishment of existing native species in the area.

The implementation of agro-forestry practices will be concentrated in the cropping area, both in the alluvial plains and on the hillsides. Extension activities will enhance and promote the use of arboreal species in support of the agricultural production. Trees will be combined with shrubs and herbaceous species in the agro-forestry practices to be implemented, such as the formation of terraces, wind-breaking screens, boundaries, live barriers, frost screens, riverside defense walls, etc.

11.2.2.3 Forestry research

Applied research activities will be developed, which will form part of the forestry and agro-forestry program.

There is no basic forestry information available in Río Abajo, for example data on growth rates, percentage of sprouting in plantations, information on natural regeneration, etc. This is why the project should gather and systematize information to adjust its activities and achieve more impact in the shortest possible time.

A database shall be established, which will be fed with data and findings from field activities, accumulated experience in communities, data collected in other national and international projects
.

11.2.2.4 Agro-forestry extension

The activity of this component focuses on the development, with community participation, of strategies to establish and expand vegetal coverage in the project area.

Educational material will be developed and disseminated to orient activities of communities within the framework of integrated watershed management.

Project activities will be chiefly participatory, the idea is for community inhabitants to actively participate in activities to ensure continuity of the activities promoted under the project in the long-term.

11.2.3 Involved staff

The minimum staff is composed as follows:
2 Forestry Engineers, 1 Agronomist, 2 Extension Technicians
2 Greenhouse responsibles

Temporary staff

11.2.4 Budget

Table 9. Budget of the Agro-forestry Project in Río Abajo

Item	Total Amount	External Funding	Prefecture	Municipality	Communities
Rent of space	12,000.00	2,000.00			10,000.00
Infrastructure	23,600.00	20,000.00		3,600.00	
Materials for the production of seedlings	16,200.00	10,000.00		6,200.00	
Equipment and vehicles	50,900.00	50,900.00			
Basic utilities	8,000.00	8,000.00			
Insurance	32,000.00	32,000.00			
Fuel and lubricants	32,000.00	32,000.00			
Office supplies, materials and input	7,500.00	7,500.00			
Staff	392,000.00	372,000.00	20,000.00		
Plantation 50 ha / year	100,000.00	90,000.00			10,000.00
Sowing of pastureland on 50 ha / year	90,000.00	80,500.00			9,500.00
Per diem allowance	21,600.00	21,600.00			
Office expenses	12,000.00	12,000.00			
Local materials	28,000.00			18,000.00	10,000.00
Administrative costs	18,500.00	18,500.00			
CDC	25,000.00	25,000.00			
NICRA	32,000.00	32,000.00			
Total	**901,300.00**	**814,000.00**	**20,000.00**	**27,800.00**	**39,500.00**

11.3 Model of an Early Warning System for flood events in the La Paz River watershed

The tragic event on February 19, 2002, showed the vulnerability of the city of La Paz and the Río Abajo area to emergency situations. One of the reasons why so many people died was the lack of a process to alert the population so people could take all required previsions, get away from the risk zones or look for an adequate place of refuge.

In the following paragraphs, we will summarize a model Early Warning System in case of flood hazard in the city of La Paz and Río Abajo.

As opposed to regions with rivers with permanent, considerable water volumes, the biggest part of the La Paz River watershed consists of rivers and tributary mountain streams with little or no water at all during most of the year. In case of intense rainfall, the volume of water flowing through these mountain streams increases considerably all of a sudden. In turn, the steep slopes, even with energy dissipating structures represent considerable risk for the population. In the urban area, an important number of watercourses is canalized and/or vaulted.

These characteristics limit the implementation of traditional early warning systems using instruments to measure the level of water volumes in riverbeds, for example limnimeters or limnigraphs.

Therefore, a modified early warning system must be adopted, based on the short-term prediction (3-4 hours) of intense rainfall.

This system is composed of three important phases:

- Monitoring of climatic conditions,
- Alert of the population at risk, and
- Reaction of the population, authorities and pertinent organisms

11.3.1 Monitoring of climatic conditions

SENAMHI is the institution in charge of the daily registration of weather conditions in the country. Moreover, it provides forecasts of the probable climatic conditions in the country. This process is based on information generated by a network of manual meteorological stations and satellite images that do not directly reach the country, but first pass through Brazil in coordination with the Brazilian meteorological service. This information is transmitted through the Internet.

With the current monitoring system of SENAMHI, it is impossible to forecast probable extreme and unforeseen events such as the “black Tuesday” event. The system is limited to issuing the weather forecasts that are daily published in the media.

For SENAMHI to be able to predict unforeseen extreme events, its infrastructure must be improved. A meteorological radar system is required, which must be located northeast of the city of La Paz in the La Paz mountain range. Then, it will be possible to detect fronts arriving from the Amazon region and determine cloud formations around the city and predict rainfall and the respective risks. A network of automatic meteorological stations that transmit real-time information and that are located on strategic spots is also needed.

This way, it will be possible to monitor weather conditions 24 hours a day and SENAMHI will be able to detect climatic conditions that may give rise to events that imply hazards for the population of La Paz.

Here, we should stress the need to establish the minimum conditions regarding equipment and resources for the generation of timely information from the technical structures of SENAMHI, concretely the following ones:

- Detailed design of an early warning system.
- Procurement of or procedure for donation of equipment, including: a Meteorological Radar (Doppler System), a High Atmosphere Radio Station and a Meteorological Network with automatic pluviograph recorders of the data logging type.
- Implement a system in Bolivia for the High Resolution Reception of Satellite Images, GOES 8 – NOAA.
- Installation of automatic pluviograph recorders of the data logging type in the headwater sections of the Choqueyapu, Orkojahuira and Irpavi Rivers, that is to say in Alto Achachicala, Chuquiaguillo and Ciudad del Niño. Moreover, stations must be implemented in other places of the city, e.g. in the Apumalla River watershed, the Cotahuma River watershed in the Jaimes Freyre street, the Mejahuira River watershed in Villa Pabón around the Batallón Colorados, Miraflores Alto near the Plaza Villarroel, Miraflores Bajo in Laycakota, Venecia River watershed in Villa Copacabana, the south zone of the city in Aranjuez.
- Training for staff in charge of 24-hour monitoring of the system.
- Budget allocation for operation.

- Testing of the Meteorological Radar (Doppler System), the High Atmosphere Radio Station and the Meteorological Network with automatic pluviograph recorders of the data logging type. Testing of the entire early warning system.
- Lobbying to establish norms that promote and enable participation of the media in the early warning system.
- Implementation of the early warning system.
- Monitoring of the system by the pertinent technical unit of the municipality.

11.3.2 Cost Estimate

Below, an overview is given of the costs of the required equipment to implement the early warning system (data supplied by SENAMHI):

Table 10. Estimated Costs of Equipment for an Early Warning System.

▪ Network of automatic meteorological stations	USD	400,000
▪ Network of automatic hydrometric stations	USD	400,000
▪ Radio station	USD	400,000
▪ Meteorological Radar	USD	1,400,000
TOTAL	**USD**	**2,200,000**

11.3.3 Alert and Warning of the Population at Risk

Once probability of a hazard is determined, it is necessary to warn the population on the possible occurrence of an extreme situation so that people can take all necessary previsions.

In this sense, the media (radio, TV) play an important role in alerting the population, as there is no other more efficient means.

There are no norms in the country on the compulsory involvement of the media in the dissemination of this type of alerts. This would be possible if there were legal provisions and appropriate methods to do so in a simple manner that does not imply any complications for the media.

However, as this is a community service, this service should be free or the cost should be symbolic. As the dissemination of this type of information can be considered “hot news”, the logic is that the media disseminating this last minute information can obtain higher ratings.

In the case of TV channels, it is enough to include warnings in messages at the bottom of the screen, supplying the necessary alert information on hazard situations, without interrupting normal TV programs.

Radio stations should necessarily issue radio spots. Although this requires broadcasting time and participation of radio staff, this type of messages may imply possibilities to expand their public. Also, we should not forget that there are thematic information spaces that are regularly broadcasted by the media, e.g. prices of products, market opportunities, etc. One space could be dedicated to early warning information.

In the first instance, it is necessary to implement a process for orientation / information for the population on how the system will work, for the subsequent implementation of a pilot phase for early warning communication.

Should an initiative for the establishment of this early warning system be implemented, then it is recommended to enter into agreements with the relevant media. At the same time, lobby work should be focused to establish norms to promote and enhance participation of the media, without this being “bothering to the media”. The media should be the first to understand the importance of having a communication system for early warning.

In the rural area, especially in Río Abajo, participation of the media is also important. Another possibility is to recur to local peasant unions for the organization and alert in case of flood hazard from the city of La Paz and other nearby micro watersheds.

11.3.4 Organization and reaction of authorities, the population and relevant Institutions

In order to respond to flood hazard and potential consequences, it is necessary to establish structures for leadership, coordination and support, as well as relations between structures at the level of municipalities and sub-municipalities, departmental structures, including Grassroots Organizations (Peasant Unions or Neighborhood Councils), both in the urban area and the rural area in Río Abajo, the Municipal Emergency Relief Service (or technical units of the municipalities of Río Abajo) and instances of the National or Departmental Civil Defense Service.

The Emergency Relief Service and technical units of the municipalities of Río Abajo must be prepared and ready to respond immediately in case of early warnings. They must then mobilize themselves immediately to the places where occurrence of the event is predicted and other hazard areas. In the case of the city of La Paz, it must be taken into account that combinations of events occur, such as floods, underground flooding, falling walls, and landslides, as mentioned on the hazard map.

It is important and fundamental for the population to know what to do in case of intense rainfall that may result in floods, landslides, soil subsidence and the collapse of constructions. For example, street vendors must abandon the streets in case of flood alert, pedestrians must look for shelter in places outside risk areas, such as the subterranean tunnel in the Mariscal Santa Cruz avenue or the end of the Mercado street. The population living on the hillsides must be on the alert for landslides, floods, underground flooding and other inherent risks, etc.

11.3.5 Information Campaign for the Population

In order to ensure adequate performance of this proposal, a campaign must be organized to provide simple information on operation of the Early Warning System against flood hazard. It is important for people to know how to react in the case of flood alert and to be prepared to decrease their vulnerability.

Possible risks in the city of La Paz must be stressed, encouraging the population to identify possible risks for their houses, such as landslides, floods, underground flooding, etc. This way, it will be possible to organize campaigns focused on prevention and awareness raising.

11.4 Forestry Project in the City of La Paz

11.4.1 Justification

Analyzing the events map of the Municipal Emergency Relief Service, the conclusion is that in all watercourses of the city of La Paz, floods, underground flooding, falling walls and landslides are recurring events. One of the principal causes of these events is the dragging along of sediments to the rivers and mountain streams of the city, many of which are vaulted,

which is why accumulated sediments together with the geometry of this infrastructure cause obstructions and the events mentioned on the map of the Emergency Relief Service.

11.4.2 Objective

11.4.2.1 Overall Objective

Reduce the dragging along of sediments and stabilize the micro watershed of tributaries to the La Paz River in the urban area.

11.4.2.2 Specific Objectives

Stabilize micro watersheds in and around the urban area of the city of La Paz based on forest plantations. These plantations will support already established civil works for watershed and watercourse control.

Silvi-cultural practices will be applied in existing plantations, with the objective of inducing growth in these plantations and maintaining a good phyto-sanitary state.

The population will be trained and oriented in daily practices and attitudes that must be developed and that can reduce possibilities of the occurrence of risk events, such as underground flooding, landslides and floods.

11.4.3 Generic Activities to be developed

11.4.3.1 Production of plants

Greenhouses will be implemented for the propagation of native and exotic species, which will be destined to forestation areas. There will be two types of greenhouses, Central Greenhouses and Decentralized Greenhouses, to avoid exposure of the seedlings to long trips before they are planted.

Areas will be implemented for the clonal propagation of species identified as priority species.

Seed producing trees will be identified in the project area and zones will be established for seed collection. Native species will be specially focused.

11.4.3.2 Forest Plantation and Implementation of Agro-forestry Practices

Forestation will focus on the upper parts of the city's watershed areas, enhancing the implementation of agro-forestry practices in current traditional growing areas, such as: Alto Achachicala in the Choqueyapu River, the upper part of Chuquiaguillo in the Orkojahuira River or areas near the Ciudad del Niño in the Irpavi River and other zones near the urban area, as inadequate agricultural practices contribute to increased erosion.

The idea is to form wood masses on the hillsides with steep slopes. Dense plantations will be implemented, with the purpose of achieving that the root mass will hold soils in their place. Vegetal soil coverage will be promoted in lower strata (shrubs and grasses).

Reforestation on the slopes of mountain streams will reduce the dragging along of sediments in the river. These plantations will also reinforce structures of existing canalizations.

Plantations for ditch control will be emphasized, these plantations will be associated with small works, such as belts, ditch traps, crown ditches, energy dissipaters, stone dikes, infiltration ditches, etc.

11.4.3.3 Extension

Activities in this component focus on achieving the decided participation of the population, training and information activities will be developed so that neighbors would understand their role in risk prevention and that their role in the early detection of factors that condition or contribute to hazard is essential.

The extension methodology will be basically participatory; activities will be implemented in close coordination with already existing grassroots organizations, such as neighborhood councils, mothers' clubs, associations, etc.

The participation of neighbors will be enhanced in the phases for the planning and implementation of reforestation activities, such as the growing of plants, the selection of plantation areas, planting and management. Thus, continuity of the activities promoted under the project will be ensured in the long term.

Educational material will be developed and distributed to orient the activities of neighbors within the framework of integrated watershed management. Training of the school-age population will be emphasized.

11.4.4 Implementation Strategy

The project partner will be the municipality of the city of La Paz, with its units for watershed management and forestation. The project's starting point will be experiences in reforestation and watershed management projects executed by the municipality.

Existing municipal infrastructure will be used for the production of seedlings. Grassroots organizations will be the instances used to reach the population. Interinstitutional coordination will be focused, as a way to optimize resource use, avoid the duplication of efforts, achieve more impact and achieve the project objectives.

11.4.5 Time required for implementation: 5 years

11.4.6 Involved staff

5 Forestry Engineers
2 Agronomists
1 Sociologist
1 Communication expert
10 Extension technicians
6 Greenhouse responsibles
Temporary staff

11.4.7 Budget

Table 11. Budget of the Forestry Project in the City of La Paz

Item	Total Amount	External Funding	Municipality
Production of plants	100,000	80,000	20,000
Equipment and vehicles	150,000	150,000	
Basic services	50,000	50,000	
Insurance	75,000	75,000	
Fuel and lubricants	75,000	60,000	15,000
Office equipment and supplies	24,000	24,000	
Staff	1,482,000	1,318,980	163,020
Plantation 50 ha / year	125,000	87,500	37,500
Sowing of pastureland on 10 ha / year	40,000	24,000	16,000
Per diem allowance	30,000	24,000	6,000
Office expenses	15,000	15,000	
Local input	28,000	0	28,000
Non-local materials, equipment and tools	100,000	70,000	30,000
Administrative costs	55,000	55,000	
CDC	75,000	75,000	
NICRA	90,000	90,000	
Total	**2,514,000**	**2,198,480**	**315,520**

11.5 Project for Agricultural Support in Río Abajo

11.5.1 Project Description

This project consists of the implementation of environment friendly agricultural practices, decreasing infection hazard for final consumers and reducing the loss of farmland due to erosion. Hence, risks for the downstream population will be reduced. This project would be executed in the Río Abajo region, from the communities of Mallasa and Jupapina to the community of Huayhuasi.

11.5.2 Objectives

11.5.2.1 General

Promote a change in agricultural practices of producers in Río Abajo towards a hazard reducing and environment friendly agriculture in the downstream communities.

11.5.2.2 Specific Objectives

Reduce the loss of soils due to erosion by means of the implementation of soil conservation practices and the gradual change of accelerated cycle agricultural crops to crops with a slower cycle or perennial crops.

Promote the use of trees and agro-forestry practices.

Reduce the risk of infections and the transmission of intestinal diseases from selling vegetables irrigated with contaminated water. The idea is to replace the production of edible crops by other profitable non-edible crops.

Reduce the indiscriminate use of chemical pesticides, trying to implement Integrated Plague Management.

Implement an educational campaign aimed at promoting environment friendly agricultural practices.

11.5.3 Generic Activities to be developed

11.5.3.1 Crops to be promoted

The production of semi-perennial, non-edible, profitable and marketable crops will be promoted (or crops that are less vulnerable to contamination with water of the La Paz River): slow cycle flowers, because profits are high and producers in Río Abajo quite appreciate flower production. The following flowers shall be promoted: astromelia, freesia or cartuchos. The plantation of other decorative species or fruit-trees can be promoted as well, which are less vulnerable to river water contamination. Other crops that meet these requirements could be agreed upon with communities and promoted.

11.5.3.2 Selection, Propagation of Species and Model Parcels

Model parcels and greenhouses will be set up for propagation of the species that will be promoted. This process will be composed of three phases; the first phase focuses on testing the most adaptable species, with better market perspectives, the second phase will focus on clonation of the selected plants and the third on implementation of model parcels with all practices to be promoted. The idea is not only to include riverside parcels in this project, but also marginal hillside areas, with specific crops for these latter areas such as prickly pears and ulupica (very hot spice).

11.5.3.3 Extension and Dissemination of Information

A good way to promote the use of new species without the project adopting a paternalistic approach is to charge stakeholders a subsidized price for the plants they buy. This way, all beneficiaries will have access to the seedlings, and they will appreciate and manage them carefully as they were not given to them for free. Moreover, based on the model parcels, extension technicians will disseminate agricultural conservation practices, integrated plague management, performance, yields and markets for promoted crops.

Educational campaigns will have to be carried out to achieve a higher impact, emphasizing the social part. Hence, support of a sociologist will be needed to support all extension technicians in their activities.

11.5.4 Implementation Strategy

The project partner will be the municipality of Mecapaca and inhabitants of communities in Río Abajo. The municipality can participate with the temporary donation of land for greenhouses to test and reproduce seedlings, as well as the first model parcels. Inhabitants of communities can participate through the donation of local materials, labor (food for work) and land for the implementation of model parcels.

In order to optimize resources, avoid the duplication of efforts and achieve a higher impact, activities will be coordinated with other entities.

11.5.5 Beneficiary Population and Project Area

Six hundred families in the communities of Mallasa, Jupapina, Ananta, Lipari, Huajchilla, Taypichullo, Llackasa, Carreras, Mecapaca, Valencia, Yupampa, Avircato, Palomar and Huayhuasi.

11.5.6 Required Time for Implementation

This project will have a duration of 54 months.

11.5.7 Involved staff

3 Agronomists
1 Forestry Engineer
1 Sociologist
4 Extension technicians
4 Greenhouse responsibles
Temporary staff

11.5.8 Budget

Table 12. Budget of the Agricultural Support Project in Río Abajo

Item	Total Amount	External Funding	Municipality	Communities
Project management and Technical and Social Assistance	499,990.00	459,200.00		
Temporary Staff	22,500.00	22,500.00		
Propagation Material	355,555.20	355,555.20		
Propagation	100,000.00	100,000.00		
Non-local materials, equipment and tools	85,000.00	70,000.00	7,500.00	7,500.00
Local materials	50,000.00		20,000.00	30,000.00
Local labor	126,000.00			126,000.00
Purchase, operation and maintenance of light vehicles	122,040.00	122,040.00		
Renting of agricultural machines	6,250.00	6,250.00		
Renting of land for greenhouses	37,800.00		37,800.00	
Renting of land for demonstrative parcels	42,000.00			42,000.00
Transportation of materials and tools	20,000.00	10,000.00	10,000.00	
Transportation of food + logistics	20,000.00	15,000.00	5,000.00	
Office expenses	15,000.00	15,000.00		
Insurance	15,000.00	15,000.00		
Travel expenses and per diems	12,000.00	12,000.00		
Administrative costs	39,620.00	38,600.00		
CDC	43,820.00	42,800.00		
NICRA	58,438.00	57,000.00		
TOTAL	**1,671,013.20**	**1,340,945.20**	**80,300.00**	**205,500.00**

11.6 Awareness-raising for a Garbage and Debris Free City

11.6.1 Justification

In the city of La Paz it is very common at any moment to find enormous amounts of garbage scattered or piled up in the streets, squares and other public places. The population of the city indiscriminately dumps waste and construction debris in the streets and avenues, on street corners, squares, wasteland, rivers and mountain streams. This garbage is accumulated both in commercial areas, hillsides, and residential neighborhoods. Left garbage is often scattered and ends up blocking the city's sewers and drains. This situation considerably increases flood hazard.

The population has a lack of adequate information and education for the management and good practices regarding garbage and solid waste disposal. But more than this, the population lacks awareness on maintaining their living space garbage and debris free. The socio-cultural study CARE carried out identified the absence of social sanctions in the local culture regarding rubbish disposal in public roads and construction debris disposal in rivers and mountain streams. This factor is one of the most critical ones in the generation of flood hazard and other natural disasters, both in the city and the downstream Río Abajo area.

Although they are aware of this situation, different municipal administrations have limited their actions to investments in infrastructure, ignoring initiatives that promote education for a change of habits and costums of the population to ensure attitudes that favor a garbage free city. Due to these priorities, often investments in infrastructure and other technical efforts do not have the expected impact precisely because of the population's behavioral patterns. Current strategies with isolated spots in the media and/or projects that do not focus children, youth and citizen participation as key factors to change attitudes and bad habits, will not solve the problem.

Consequently, investments in long-term citizen education and awareness–raising and the implementation of projects that promote good waste and debris disposal and urban sanitation habits will be a lot more effective for disaster hazard mitigation. This type of projects will not only considerably improve the social impact of investments in infrastructure, but it will lay the foundations to achieve sustainable changes improving the standard of living of the population. Hence, this area must be prioritized.

This project **"Awareness-raising for a Garbage and Debris Free City",** will not only have an impact on natural disaster hazard mitigation in the city, but it will directly benefit riverside communities and villages in the Río Abajo Region.

11.6.2 Objectives

Overall Objective

Awareness raising of the population to live in a garbage and debris free city, promoting a change of behavior, habits and costums by means of an environmental education process and education regarding adequate urban sanitation practices.

Specific objectives

In the pre-investment phase:

Have a document with guidelines for project implementation.

In the investment phase:

- Inform the population on the damages waste and construction debris inflict on the environment.
- Inform the population on obligations and benefits of using the regular residential and commercial waste collection system.
- Ensure increased discipline of the population regarding compliance of waste disposal hours and places.
- Achieve that the population changes its practice of disposing of waste and construction debris in inadequate places (rivers, ravines, mountain streams, etc.).
- Achieve that the population changes its habit of throwing personal garbage on the streets and other public places.

11.6.3 Expected Outcomes

- The population is informed on the damages waste and construction debris inflict on the environment.
- The population is informed on obligations and benefits of using the regular residential and commercial waste collection system.
- Discipline of the population regarding compliance of waste disposal hours and places has improved.
- The population has changed its practice of disposing of waste and construction debris in inadequate places (rivers, ravines, mountain streams, etc.).
- The population has changed its habit of throwing personal garbage on the streets and other public places.

11.6.4 Coverage and Scope

Geographically speaking, the Project covers the city of La Paz. The target population is subdivided into three segments: a) housewives for residential waste, b) students (children and youth) for garbage on the street, and c) retailers in markets and fairs for commercial garbage. The thematic scope will focus on the change of attitudes, behaviors, habits and costums related to waste management and construction debris.

11.6.5 Central Project Activities

The project “Awareness-raising for a Garbage and Debris Free City” will consist of three phases: 1) awareness-raising, 2) implementation, and 3) monitoring and evaluation. The project will have a duration of three years: the first phase half a year, the second and third phases two years and a half.

11.6.5.1 Phase 1.- Awareness-raising

The first phase of the project focuses on awareness raising. In this phase, actions will be implemented to generate interest and motivation and increased knowledge on this topic. Furthermore, the interest and motivation of the government and social organizations of civil society will be focused. This phase centers on the socialization of interest in the project. The overall strategy will also be designed. Educational material will be prepared, and actions will be implemented to strengthen an institutional unit to develop the educational component.

11.6.5.2 Diagnostic on institutional and socio-cultural issues

CARE already executed this component, which implied identification of the principal characteristics, causes and environmental impact of the behavior, habits and costums of the population regarding garbage and construction debris management. Moreover, the diagnostic must identify the institutional strengths and weaknesses of the partner municipal governments.

Results and findings of the diagnostic are the principal input for awareness-raising activities with authorities, officials and employees of the municipalities, and leaders of social organizations. They will also be used to prepare educational material and define the strategy and action plan.

The diagnostic covers the institutional culture and socio-cultural characteristics of the population in both municipalities.

11.6.5.3 Design of the general strategy

In this activity, operational actions of each component will be defined. The activity timeframe will be prepared, as well as operational policies to implement the actions.

11.6.5.4 Design and preparation of educational material

Based on the information collected under the diagnostic, educational material will be designed and developed, as well as material for promotion and motivation, printed material, multimedia and other alternative materials

11.6.5.5 Institutional strengthening for the educational component

A series of actions for information and awareness raising of authorities, officials and technical staff of municipalities and other relevant institutions will be started or continued. Actions will refer to problems resulting from the presence of waste and debris in the city.

The central purpose of the institutional strengthening component is capacity building and the development of technical and administrative capacities of staff in both municipalities. This will be achieved through courses and workshops for environmental reflection, in which educational material and information will be supplied.

Finally, creation of an operational unit for environmental education will be proposed, which will not only execute this project, but also all other activities related to this topic.

11.6.5.6 Phase 2.- Implementation

The project will promote establishment (or strengthening) of an institutional operational unit in the respective municipality. This unit will be responsible for execution of the activities regarding awareness-raising, social mobilization, information and education on waste and debris disposal and urban sanitation.

This unit will not only implement project activities, but it will also be responsible for the coordination of actions both inside its own institution and with other entities. It will promote and enable participation of the highest possible number of organizations of civil society and other public and private entities.

11.6.5.7 Mobilization, Training and Organization of change factors

The idea is to mobilize the student population as the principal factor for multiplication of changed attitudes, habits and costums in the population.

On the one hand, in the short term, theoretical-practical training workshops will be organized on adequate waste and debris disposal and urban sanitation, as well as awareness raising

and reflection on environmental protection. These activities will be implemented with elementary and high school students, university students and teachers.

With high school and university students, voluntary brigades will be organized on dissemination, education and citizen awareness. These brigades will not only be trained on the topics to be dealt with, but also in motivation and citizen training techniques.

On the other hand, in order to achieve a medium and long-term impact, advocacy activities will be implemented. These actions will focus on the inclusion of waste and debris management in the official curricula of schools. Taking into account that the Educational Reform has included environmental issues as a crosscutting topic in new school curricula, advocacy will center on the incorporation of this specific topic in regular educational programs.

11.6.5.8 Education and citizen participation

The population in general will be motivated, informed and trained directly in the streets, public places, markets and fairs specifically organized to this effect. Different communication techniques will be used - theater in schools, streets and squares, wall painting, etc. - as well as printed material.

Thematic workshops and group discussions in schools, churches and social neighborhood organizations and other interested groups will be another important component.

This campaign for mobilization and environmental education of citizens will be carried out both on weekdays and in weekends.

11.6.5.9 Media Mobilization

As part of the strategy to change attitudes, habits and cultural practices regarding waste and debris management, the media will be an important ally in the dissemination of objectives.

Mobilization of the media implies a set of actions regarding information and awareness raising. Work meetings and discussion forums will be organized with opinion leaders to influence and reach a larger public. In order to achieve sustainability in time, aggressive treatment of this topic will be promoted in specialized articles and opinion-leading forums.

11.6.5.10 Phase 3.- Monitoring and Evaluation

A system for project follow-up will be developed and implemented. This system will watch over adequate management, technical administration, implementation and performance of project activities. M&E will supply input according to the needs and will make all required adjustments to ensure continuity and sustainability of the activities. Indicators will be developed for measurement and monitoring, with the objective of ensuring accomplishment of the proposed goals and objectives.

11.6.6 Staff required for Project Execution

The Project team will be composed as follows:

Project Management: A manager, an administrative-accounting assistant, a secretary and a driver-messenger.

Professional Team: Two communication experts, one sociologist or anthropologist, for one year, two coordinators for mobilization, three educational material designers, for one year, and eighteen persons responsible for the brigades of the macro districts.

11.6.7 Budget

Table 13. Budget of the Project “Awareness-raising for a Garbage and Debris Free City”

Item	Total Amount	External Funding	Municipality of La Paz
Project management	117,000	117,000	
Staff	342,200	112,200	230,000
Insurance	14,750	14,750	
Computers and Equipment	15,000	15,000	
Office equipment	5,000		5,000
Vehicles	36,000	36,000	
Fuel and maintenance	18,000		18,000
Costs of educational campaigns, fees, etc.	72,000	52,000	20,000
Equipment for educational campaigns	5,000	5,000	
Radio and TV campaign	60,000	60,000	
Office expenses	5,400	5,400	
Perishable goods	7,200	7,200	
Workshops for dissemination	9,000	9,000	
Printed materials for dissemination and training	148,000	123,000	25,000
External evaluation	5,000	5,000	
External audit	5,000	5,000	
Office rent	12,000		12,000
		-	
		-	
Administrative costs	33,000	33,000	
CDC	36,000	36,000	
NICRA	48,300	48,300	
TOTAL	**993,850**	**683,850**	**310,000**
		69%	31%