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Co-operation on the Lake Titicaca

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and Rolando Zuleta Roncal
in collaboration with Aníbal Pacheco Miranda
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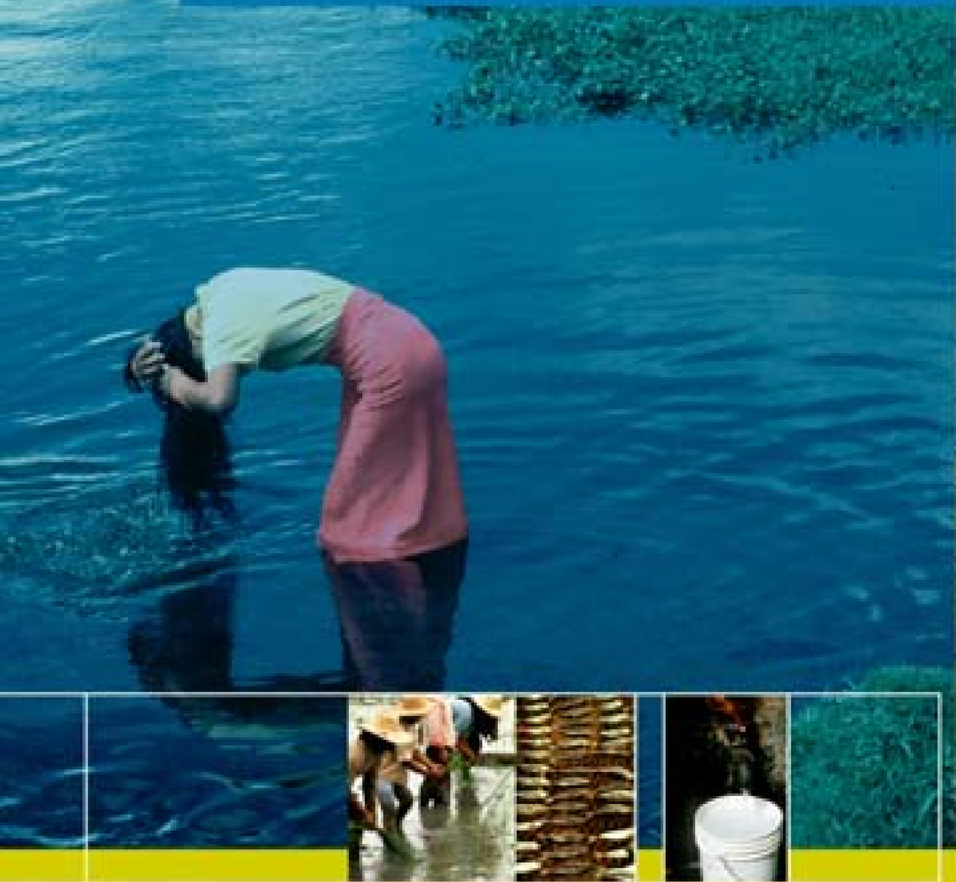

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LAKE TITICACA CASE STUDY

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ACRONYMS AND ABREVIATIONS

ALT:	Binational Autonomous Authority of the Lake Titicaca, Desaguadero River, Lake Poopó and Coipasa 'Salar'
CAF:	*Corporación Andina de Fomento,* Andean Development Corporation
CONAM:	*Consejo Nacional del Medio Ambiente*, National Environmental Council
CORPUNO:	*Corporación Departamental de Desarrollo de Puno,* Puno Department Development Corporation
EEC:	European Economic Community
ECLAC:	United Nations Economic Commission for Latin America and the Caribbean
GEF:	United Nations Global Environment Facility
GIS:	Geographical Information System
IADB:	Inter American Development Bank
IAEA:	International Atomic Energy Agency
IATE:	Administrative and technical guidelines
IBTEN:	*Instituto Boliviano Tecnológico de Energía Nuclear*, Bolivia Nuclear Energy Institute
IMARPE:	*Instituto del Mar del Perú*, Sea Institute of Peru
INADE:	*Instituto Nacional de Desarrollo*, National Development Institute
INRENA:	*Instituto Nacional de Recursos Naturales*, National Natural Resources Institute
IPEN:	*Instituto Peruano de Energía Nuclear*, Peru Nuclear Energy Institute
MDS:	Ministry for Sustainable Development
OAS:	Organization of American States
OLDEPESCA:	*Organización Latina de Desarrollo de la Pesca*, Latin American Organization for Fishery Development
PELT:	*Proyecto Especial del Lago Titicaca,* Lake Titicaca Special Project
PET:	Potential evapotranspiration
SENAMHI:	*Servicio Nacional de Meteorología e Hidrología*, National Meteorological and Hydrological Service
SUBCOMILAGO:	Lake Titicaca Binational Joint Subcommission
TDPS:	Lake Titicaca, Desaguadero River, Lake Poopó, and Coipasa 'Salar' System
UNDP:	United Nations Development Programme
UNESCO:	United Nations Educational, Scientific and Cultural Organization
UOB:	*Unidad Operativa Boliviana,* Bolivian Operative Unit

INTRODUCTION

The world acknowledges, by and large, that freshwater is not a renewable resource, and given its misuse by humanity, and that its availability on the planet is highly heterogeneous, conflicts concerning the use of this important resource may arise in the future between regions and countries. This perspective has driven Peru and Bolivia to reach agreements on the joint and peaceful management of hydrological and hydrobiological resources in the Lake Titicaca basin. The procedure they used may serve as an example to be followed in similar scenarios. It is in this context that the United Nations Educational, Scientific and Cultural Organization (UNESCO) has considered it appropriate to disseminate, through the Lake Titicaca Case Study, the results of the achievements of Peru and Bolivia. To this effect experts were selected in coordination with the Foreign Affairs Ministries of both countries to work within the Programme 'From Potential Conflict to Potential Cooperation'.

The Lake Titicaca Case Study begins with a characterization of the region in terms of socio-economic, hydrological, geographical and meteorological data. This is followed by a historical overview of the actions undertaken to achieve a common governmental approach to the problem of the shared use of hydrological and hydrobiological resources. Finally, topics related to the elaboration of the Peru-Bolivia TDPS System Master Plan, and to the creation and functioning of the Lake Titicaca Binational Autonomous Authority (ALT) are presented, stating in detail the main actions carried out.

The study is, above all, an appraisal of the experience acquired as a result of the achievements made in the joint management of the Lake Titicaca Basin, and analyses the ALTs relationship with other local institutions. It also discusses the perception of the ALT that authorities from both countries points of view, which were noted in interviews conducted by the team of consultants in the cities of Lima and Puno in Peru and La Paz and Oruro in Bolivia. The study closes with conclusions and recommendations on the subject.

The study shows the evolution of a process articulating the decisions of both governments concerning an issue that, legally as well as institutionally, reflected the particularities of the two sovereign states. Both states worked towards the achievement of a single conception of a hydrological and hydrobiological resources management modality for the Lake Titicaca Basin. This joint vision arose from the technical and scientific approach and treatment proposed by the experts to the authorities as an orientation and a basis for decision-making.

Today the actions foreseen in the Master Plan for the Lake Titicaca, Desaguadero River, Lake Poopó, and 'Salar' of Coipasa Hydrological System (TDPS System) – being carried out by the ALT – progressively require the continued participation and commitment of organized civil society, mainly at the local level. It is within this context that the ALT re-orientates its actions towards dissemination and coordination tasks in conjunction with governmental and civil institutions. [1]

The elaboration of this study was coordinated by UNESCO, also responsible for its dissemination worldwide. This action implies both countries commitment and agreement to the public divulgation of this successful experience of their governments. Particular mention should be made of the government of Andorra, whose financial support made possible the completion of this work.

The Lake Titicaca Case Study team expresses the hope that this document satisfactorily covers all aspects related to this issue. The team submits that the document demonstrates in detail the enriching experience of the governments of Peru and Bolivia towards sustainable cooperation in the management of this basin. It is hoped that that the basins particular hydrological characteristics, the hydrobiological richness of its ecosystem and the implications toward the social and economic development of the region as well as the use of its available resources, will become the basis of cooperation between the two countries.

[1] The Spanish word 'salar', generally speaking, can connotate the notions of a salt lake, salt marsh or salt pan/flat. It has been left in its Spanish form throughout this text.

1. CHARACTERISTICS OF THE LAKE TITICACA BASIN

1.1 Location

The Lake Titicaca Basin is located in South America, in the south of Peru and northwest of Bolivia, between 14° 05 y 16° 50 longitude North and 68° 10 y 71° 05 longitude West. It has an area of 56,270 square kilometres (km^2).

See figure 1. Lake Titicaca Basin general location map [Annex, page 81]

1.2 Main physical characteristics

The basin is bordered by the eastern mountain range to the east and by the western range to the west. Altitudes vary from 6,421 metres above sea level (masl) at the snow-covered Illampu peak to 3,810 masl average of the mirror surface of Lake Titicaca. Topography is abrupt in the zone of the hills and plain in the Altiplano (high plateau).

The most important factors determining the basins climate are the following:

- The geographical and astronomic position, determining the angle of incidence of solar rays on the Earths surface, creates typical tropical climate conditions, with moderate thermal seasons.

- The relief is determined by the altitude, form and orientation of the mountain masses. The main characteristic of the system is its high altitude, generally higher than 3,800 metres, which makes for a cold climate.

- The atmospheric circulation in the zone determines to a great extent the spatial and temporal distribution of precipitation. The South-American continent, and within it the Lake Titicaca Basin, is under the influence of three semi-permanent high-pressure systems and a low pressure one.

The described atmospheric circulation explains the annual rain regime. Moreover, the northern part of Lake Titicaca receives greater rainfall, whereas the south – more subject to anti-cyclonic winds – is dry, thus generating a north-south precipitation gradient.

1.3 Main climate elements

1.3.1 Precipitation

The spatial distribution of the average annual precipitation has a decreasing north-south pattern, which generally varies from 200 to 1,400 mm, with highs (from 800 and 1,400 mm) over Lake Titicaca. The highest rainfall outside the lake area occurs in the northern extreme of the basin (at the heads of the Coata and Ramis Rivers), where rainfalls attain between 800 and 1,000 mm, followed by a gradual decrease starting in the Altiplano region down to 400 mm in the Mauri River Sector. In close relation, the number of days of rainfall per year decreases from 131 to 153 mm at the heads of the Coata River, down to 80 to 100 mm at the banks of Lake Titicaca.

See figure 2. Average annual precipitation map [Annex, page 82]

1.3.2 Rainfall regime

The temporal distribution of rainfall is quite similar along and across the basin: wet summers and dry winters. It is a typically single-mode regime, with a rainfall period from December to March (maximum in January) and the dry period from May to August (minimum in June-July), the remaining months being transitional.

1.3.3 Air temperature

The air temperature depends on various factors, namely latitude (the south is colder than the north, due to the latters proximity to the Equator); longitude (the east warmer than the west, due to the influence of wet air masses from the Amazon; altitude (temperatures decrease with altitude); and the thermal-regulating effect of Lake Titicaca.

1.3.4 Thermal regime

The region has moderate thermic seasons, the highest temperatures occurring between December and March and the lowest between June and August. The thermal spectrum of average monthly temperatures varies from 5.8 – 6.5 degrees Celsius in the north, up to 7.8 – 10.6 degrees Celsius in the south. The coldest month is generally July and the warmest one is December.

1.3.5 Surface winds

Surface winds result mainly from the local relief patterns. They tend to channel wind in specific directions. In the Lake Titicaca zone there is also a lake-land-lake circulation, resulting from the temperature differences between the land and the water surface. During the day, winds blow from the lake towards the shores. Since the land becomes warmer than the lake, a zone of lower pressure over the land is generated. At night the circulation is reversed, for the land gets cooler than the lake, subsequently the lower pressure occurs over the lake.

Regarding speed and direction of the wind, the situation is similar throughout the year:

- In the north (heads of the Coata and Ramis Rivers), calm winds predominate, with values frequently 50% higher, and speeds can reach 4.8 m/s. In winter, the wind speed tends to be 1m /s higher than in summer.

- In the Lake Titicaca zone, the dominant winds blow mainly from the lake. Speeds vary from 2 to 4 m/s. Nevertheless “calm” winds can reach fairly high speeds locally.

1.3.6 Relative humidity

The relative humidity in the Lake Titicaca Basin is low in general. The annual average is 54%, even if it varies from 42-47% in the dry southern region to 62-65% at the shores of Lake Titicaca. Whereas from June to October, the air humidity in general is equal to or lower than 50% in the entire region, in the rainy season (December to March) it can reach up to 70%.

1.3.7 Average atmospheric pressure

Atmospheric pressure values are very similar throughout the whole system and vary principally with altitude. In the Altiplano, the pressure reaches 645 mb in the north at Juliaca in Chacaltaya, and in the mountains north of La Paz it is 536 mb.

1.3.8 Radiation and insulation

Overall solar radiation is between 462 $cal/cm^2/day$ in Puno (north of the basin) and 518 $cal/cm^2/day$ in Patacamaya (south). Nevertheless, it changes significantly during the year. Thus, in Puno, it goes from 390 in July up to 549 in November; and in Patacamaya from 457 in June to 596 in November.

Closely related to radiation, insulation is 3,005.1 hours of sun per year in Puno and 2,751.5 in Patacamaya, with an yearly distribution equally contrasting between summer and winter. In Puno, the average daily number of hours of sun changes from 9.6 in July to 6.0 in January; and in Patacamaya it varies between 8.8 and 5.4 during the same period.

1.3.9 Potential evapotranspiration

Potential evapotranspiration (PET), or the loss of water from a natural surface (by evaporation from the soil or the water surfaces and by plant transpiration), is a function of humidity at the level of that surface and a function of the energy available (radioactive energy, if the energy comes from the sun, and advective, if energy is provided by the moving air mass). Even though there are various procedures for measuring PET, in this case reference is made to results obtained by means of the Penman formula.

The PET varies approximately between 1,000 and 1,800 mm along the entire basin of Lake Titicaca.

1.3.10 Climate classification

According to the Thornthwaite climate classification system and using PET estimations in the framework of the Binational Global Master Plan, the following climate types can be found in the Lake Titicaca Basin:

BF:	Rainy and polar
B(o,i,p)D:	Rainy and semi-frigid, with dry fall, winter and spring
B(o,i,p)C:	Rainy and cold, with dry fall, winter and spring
C(o,i,p)C:	Semi-rainy and cold, with dry fall, winter and spring
C(d)C:	Semi-rainy and cold, with all seasons dry
D(d)C:	Semi-arid and cold, with all seasons dry

See figure 3. Climate classification map [Annex, page 83]

- **Rainy and polar climate**

It is found at altitudes greater than 5,000 metres in every area covered with snow and ice during most of the year. The average annual temperature is lower than 0 degrees Celsius and precipitation, either liquid or solid, is over 600 mm. The area is not agriculturally productive.

- **Rainy and semi-frigid climate, with dry fall, winter and spring**

This climate is found in the upper basins of the Suchez, Ramis and Coata Rivers, at altitudes between 4,400 and 5,000 metres. Average annual temperature varies from 5 to 2 degrees Celsius and the minimum averages are lower than -4 degrees Celsius. The frequency of freezes exceeds 150 days. Precipitation varies from 700 to 1,000 mm, thus determining its rainy nature. However, the low temperatures severely limit the use of soil for agricultural purposes.

- **Rainy and cold climate, with dry fall, winter and spring**

This climate characterizes the zone that surrounds the lake, the medium basins of the Súchez, Ramis and Coata Rivers (approximately 4,200 masl) and the medium and low basin of the Llave River. The average annual temperature varies from 6 to 8 degrees Celsius and average minimum temperatures exceed 0 degrees Celsius in the area surrounding the lake, where the frequency of freezes is lower than 150 days per year (in the middle basins it exceeds 150 days). Precipitation varies between 700 and 1,000 mm per year, of which 73% occurs in summer (December-March).

- **Semi-rainy and cold climate, with dry fall, winter and spring**

This is the climate of the lowest portion of the Ramis and Hancané River basins and of the southern sector of Lake Titicaca, between Pizacoma in Peru and Irpa Chico in Bolivia. The average annual temperature varies between 7 and 8 degrees Celsius, and the average minimum temperature is higher than 0 degrees Celsius, since the thermoregulating influence of the lake cannot yet be felt. The number of frost or freezing days is lower than 150 and precipitation varies between 600 and 800 mm per year.

- **Semi-rainy and cold climate, with all seasons dry**

This climate occurs in a narrow strip in the central and southeastern portion of the System. It constitutes the transition into the semi-arid climates of the south. The average annual temperatures in this zone are estimated at between 5 and 6 degrees Celsius, with average minimums from 0 to –4 degrees Celsius. Therefore, frosts or freezes take place almost all year long (between 180 and 300 days).

1.4 Geology and geomorphology

1.4.1 Geological formations

The geological evolution described explains the great variety of lithostratigraphic formations identified in the Lake Titicaca Basin.

- **Paleozoic**

Formations from the Lower Paeleozoic era mainly appear to the north of the basin, in the slopes of the Real and Apolobamba mountain ranges. It is also found to the north of the Lake Titicaca, in the Lampa and Ayaviri region, where it is formed by a sequence of sandy pelite combined with massive quartzites and micaceous (or: mica-bearing) fine sandstone, and yellowish greenish pelite deposited in the Upper Ordovician and from the Silurian to Devonian eras. To the south-west of Juliaca, in Peru, the Silurian-Devonan sequence is as much as 2,500 m thick.

The Later Paleozoic era is found to the north and northeast of the lake and along the south-western flank of the Eastern range, between Nuñoa, Crucero, Ananea, Puerto Acosta and

Escoma. Also in Juliaca, Lampa, the Copacabana Peninsula, Isla del Sol, Estrecho de (strait of) Tiquila, Taquiri and Paco Islands, in Cumaná, Yaurichambi and Colquencha.

- **Mesozoic**

The early and middle Mesozoic eras are practically absent in the Lake Titicaca Basin. However, the Cretaceous period is well developed in the Altiplano and the Eastern Ridge.

The marine Jurassic outcrops are limited to those observed in Puno (Peru), known as the Lagunillas Group, which present a sequence of fossil limestone, pelites and bituminous marl, and in the higher part, a thin layer of sandstone. Outcrops are absent in the rest of the basin, thus giving evidence that the zone was exposed for more than 120 million years (Lanbacher, 1977, cited in the Master Plan), forming a stable platform that was interrupted only by epirogenic movements that favour batolites in the Eastern Ridge and the Real Ridge in Bolivia. The Sipin and Muni formations in the southern part of the Altiplano, in Peru, are attributed to the late Jurassic – early Cretaceous.

- **Tertiary**

The Cretaceous-Tertiary boundary is hard to establish in the basin. The Eocene-Oligocene is represented by the Tiwanacu, Coniri and Kollu-Kollu formations. In the Tiwanacu mountain range this formation is up to 2,200 m thick. These formations are correlated to the Puno Group of Peru, formed by conglomerates, sandstones and red pelites, generally badly selected and lacking transport. To the west of the basin, the volcano-sedimentary levels of the Puno Group are covered by a thick volcanic calc-alkaline series, composed of andesites, basalts, tobas (tuffs) and ignimbrites known as the Tacaza Group.

- **Quaternary**

The Pleistocene deposits lie in discordance over the Pliocene, slightly distorted and corresponding to glacier, glacio-fluvial and lake deposits. In different places along the southern and eastern shores of Lake Titicaca terraces are found, which could correspond to the lacustrine period of Lake Minchín. The most recent terraces are located in Taraco (Bolivia) and in the south of Lake Arapa (Peru), at a height of 3815 m and represent the higher level of Lake Tauca (Servant and Fontes, 1978, cited in the Master Plan).

1.4.2 Geomorphology

From the geomorphological point of view, the Lake Titicaca Basin constitutes a unitary and interconnected ensemble, within which one can recognize four primary basins with different geomorphological characteristics and fluvial dynamics.

- **Lake Titicaca Basin**

It is a typical mountain basin, where the portion of the high plateau is reduced and mostly covered by lake water. The water represents 39% of the Lake Titicaca Basin and is mainly located in the northern part. Here the high plateau becomes narrower and the western and eastern mountain ranges come together into one single mountain system. The eastern and northeastern slopes are quite irregular, with moderate to high gradients, constituting mountains and hills of sedimentary rocks, mostly dissected and with significant detritus material accumulations, glacio-fluvial in particular. The hydrographic network in this sector is well organized and dense, resulting in considerable erosion activity. The network is drained by the Suches, Huancané and in particular the Ramis Rivers, the latter forming a large delta where its mouth connects with the lake. The valleys of these rivers and their related fluvio-lacustrine terraces represent the areas of highest value, but bear problems of flooding during the rainy season. The southeastern sector is varied and maintains a state of relative equilibrium; the main components are the narrow and rugged Eastern Mountain range, the Corocoro mountain range, the Catari River plain and an ensemble of hills bordering the lake.

The western slope, mostly belonging to the Western Mountain Range, is mainly composed of volcanic massifs of rounded and broad mountainsides, separated by some headlands of sedimentary material, with a moderate and regular incline towards the northeast which continues into the Lake Titicaca up to its deepest part. In the context of this morphology, many plains have developed, especially at the terminal areas of the major basins (Coata, Ilpa and Ilave). These basins are occupied by fluvio-lacustrine deposits that continue to a large extent under the level of the lake; and the lake-front is shaped by 'bofedales' [1] and floodplains.

See figure 4. Geomorphological map of the area [Annex, page 84]

1.5 Major socio-economic characteristics

1.5.1 Origin and culture

The history of the Lake Titicaca region may be divided into three major eras: pre-Hispanic, Colonial and Republican.

- **Pre-Hispanic era**

The evolution of pre-Hispanic civilizations in this region may be divided into four large periods: formative or pre-classical, classical, post-classical and Incan.

- The **formative** period extends approximately from 1200 BC to 133 AD and apparently begins with arrival of the first sedentary communities (among them, Tiwanacu I and II in the high plateau). They engaged in agriculture and, to a lesser scale, livestock raising.

- The **classical** period, from 133 to 1200 AD, which is usually divided into three cultural directions or tendencies: Tiwanacu III or Tiwanacota (133 to 375 AD); Tiwanacu IV or pre-maturity (375 to 715 AD); and Tiwanacu V or expansive direction (715 to 1200 AD). During this period, intensive agriculture and irrigation was developed, trade was enhanced, society became stratified and the state was organized into major populations under a governmental and religious system. There was a development of arts and crafts, pottery and adobe construction; large temples and fortified castles were built. During the maturity period, the Tiwanacu culture extended up to Ayacucho in Peru and Arica in Chile and during the expansion period it reached the northern part of Peru and northwestern part of Argentina. However, this civilization disappeared between 1150 and 1200 A.D., probably due to a severe drought that dried up the region.

- The **post-classical** or post-Tiwanacu period extends from 1200 to 1430 AD, and corresponds to the period of local reigns, which in the high plateau is represented by the Colla or Aymara culture or civilization, which extended up to Cuzco in Peru and Chuquisaca in Bolivia. The most important culturs in the high plateau were the: Pacajes, along the

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[1] 'Bofedales': Local Andean name for certain wetland systems.

Desaguadero; Charkas, to the northeast of lake Poopó; Lupakas, between Puno and the Desaguadero; and Carankas, in the current department of Oruro.

- The **Incan** period extends from 1430 to 1532, a period mostly dedicated to the conquest of Colla civilization by the Incas, who by the end of the fifteenth century reached Chuquisaca and Tarija. Later, Huayna Capac colonized the Cochabamba valley. The Incas exploited the mineral wealth of the region, and also established llama- and alpaca-raising farms, using their wool to make clothes.

During the period immediately preceding the Spanish conquest, there existed in the region an indigenous population organized into communities, in which most of the agriculture and livestock-raising activities were carried out communally. Although, according to the Spanish choniclers, the population was not very numerous, there were large expanses of grassy exploited areas, where herds of llamas and alpacas were raised for wool production, whereas agriculture was developed in the wetland areas bordering the lake, utilizing the system of elevated terraces.

- **Colonial era**

With the arrival of Spanish colonialists, this situation changed substantially. The lands were distributed among the Spanish colonialists who were granted command and jurisdiction over areas called 'encomiendas' (i.e. concessions or holdings). The exploitation of precious metals was given priority, using the indigenous labour force, especially in the region of Bolivia. Alpaca raising slackened due to the introduction of sheep and cattle, while llamas were given much importance as beasts of burden to transport the minerals to the ports for shipping to Spain. A political and administrative system was imposed, organized around an increasing network of urban centres.

- **Republican era**

With the advent of the republican era (1821 in Peru and 1825 in Bolivia), the transformation into "haciendas" of the former colonial concessions ('encomiendas') did not satisfy all the new interests. In the process many of the indigenous communities lost their lands which were expropriated to create large estates benefiting powerful creoles who became the new landlords. This system of large estate property (extensive *haciendas*) was maintained until the application of the agrarian reform laws in 1953 in Bolivia and 1969 in Peru, although these laws possibly will undergo future amendments.

It is worth mentioning that at the beginning of the twentieth century, wool was one of the main export commodities in Peru.

These centuries of history have developed hostility and distrust in the population of the high plateau. Open market policies have reduced the prices of agricultural products with the importing of subsidized products and donations, at the expense of indigenous producers. Meanwhile, the development of service and production infrastructures is concentrated in the big cities, weakening the rural activities within the national context. In spite of these circumstances, there is a strong desire evident in the local population to improve their living conditions, and in this context, providing support to these people would produce excellent results in the future.

Taking into account the mobilization of these populations throughout their entire history and from the ethno-linguistic viewpoint, the Peruvian-Bolivian TDPS system is at present divided into three large areas: the northern zone of Aymara, a central Quechua zone and southern zone of Aymara. As well, there are the Uros, who are scattered mainly in some sectors of the

Lake Titicaca (the Puno totora, or cattail, plantations), in Lake Poopó and along the Desaguadero Basin. In general, the population of the high plateau is indigenous (the originals). The mixed or westernized people live in cities and large towns.

1.5.2 Growth, distribution and urbanization

According to the data of the last census, the total population of the high plateau is 2,734,901 inhabitants, of whom 1,444,301 (52.81%) live in the urban areas and 1,290,600 (47.19%) in the rural areas. Of these, 1,137,030 live in the Peruvian side and 1,597,871 in the Bolivian side.

The rural population has been decreasing its percentage of the high plateaus total population. It has decreased, in the Peruvian sector, from 68.2% in 1981 to 60.8% in 1993 and 57.57% in 2001. In the Bolivian high plateau, in 2001 the rural population was 39.80%, while in 1993 it was 42.7% of the total population.

See figure 5. Population distribution in the Altiplano [Annex, page 86]

The main urban centres in the Peruvian side are Puno (94,566 inhabitants) and Juliaca (148,542 inhabitants), and in the Bolivian side, El Alto (647,350 inhabitants) and Oruro (215,660 inhabitants). The city of El Alto, although connected to the city of La Paz in terms of urban operation, is geographically located in the basin and utilizes the latters resources, therefore in this report it is included as an integral part of the TDPS system. La Paz itself (829,650 inhabitants) is located outside the hydrological basin, immediately on the other side and to the east of the watershed dividing line.

See figure 6. Main urban centres [Annex, page 87]

Except for the city of El Alto, the population growth rate is noticeably less than the relevant national average. In the sub-region of Puno, the growth rate in 1993-2001 was 1.4% compared to 2.5% per year in the country as a whole. The same is true in the departments of La Paz and Oruro, in Bolivia, where the growth rate during 1993-2001 was 2.29% and 1.53% respectively, compared to 2.74% in the whole country. The population growth rate in the rural areas is even lower: 0.7% in Peru and 1.31% in the department of La Paz and 2.99% in the department of Oruro. Accordingly, while in the Peruvian side the rural population remained unchanged during the nineties, in Bolivia it decreased in absolute numbers.

- **Migration**

Migratory processes are mostly responsible for the growth rate trends of the population. In fact, the general trend is that the rural areas are being depopulated. This phenomenon is evidenced by the numbers in the Peruvian side, which indicate that the growth rate during 1981-93 was 3.4% per year in the urban population and only 0.7% in the rural areas. The same is observed in Bolivia, where the urban population growth rate was 3.62% during 1993-2001, while the rural growth rate was -1.42%. In Bolivia, El Alto is the city with the highest population growth rate, mostly as a consequence of the migration trend from the high plateau.

As for Peru, the migration fluxes (most of them definitive) are towards the cities outside the region, such as Arequipa, Cuzco, Lima-Callao and Tacna and cities located within the same basin, particularly Puno and Juliaca. According to data reported in 2001, the net population migrating to the Puno region during 1993 and 2001 was 7,765, while the net emigrant population was 14,993. In Bolivia, the migration is toward La Paz–El Alto and Oruro. This migration is especially of the young people. For this reason, one notices that the population of the high plateau is especially composed of adults and elderly people.

- **Poverty and living standards**

The high plateau region is one of the poorest areas of Peru and Bolivia. In Peru, according to projections made in 2001, 73.5% of the population have at least one basic need that is not met. Based on the available statistics, this situation did not improve in the period 1990 to 2001, compared to 56.8% of Perus whole population whose basic needs were not met.

See figure 7a. Population not meeting at least one basic need (Peru) [Annex, page 87]

In Bolivia, according to the census of 2001, 56.75% of the national population had at least one basic need that was not met, and at departmental level, in the La Paz department, 64.38% and in Oruro 66.03% of the population had at least one basic need not met.

See figure 7b. Population not meeting at least one basic need (Bolivia) [Annex, page 87]

- **Nutritional levels**

Although nutrition and diet in the basin may vary according to the type of crops and location, generally speaking the nutritional level of peasants in the high plateau is poor. By way of example, figures concerning Punos peasant population reveal that their diet is poor in animal proteins, fats, calcium, iron, retinol, thiamine and riboflavin, indicating that their food does not meet basic energy needs, and that such insufficiency seems to be in quantity more than in quality. Likewise, they suffer from a deficiency in vitamins A, B1 and B2, which deficiency could be reduced by consuming more vegetables grown in green houses. Accordingly, studies with an anthropometric indicator of size/age showed that, in 1984, about 51% of the infant population below the age of 6 suffered from chronic malnutrition in the region of Puno, a condition which could be extrapolated to the rest of the high plateau.

- **Employment, income and housing**

Within the Lake Titicaca basin, a significant increase of the economically active population (EAP) was observed during recent years. In 2001 the EAP was estimated to represent about 49.1% of the total population in the Peruvian sector. In the Bolivian side, this increase was about 35.67% in 2001. It is noteworthy that the population increase has a direct impact on the work force, which is part of a labour market saturated by subemployment.

See figure 8a. Economically active population (EAP), Puno (Peru) [Annex, page 88]

The EAP in the TDPS area is largely concentrated in agricultural and cattle-raising activities. It was estimated that in 2001, in the sub-region of Puno, 46.52% of the population was engaged in agriculture and cattle-raising, followed by trade (12.1%), and the manufacturing industry (8.7%). On the other hand, in 2001, in the departments of La Paz and Oruro, 33.07% of their population was engaged in agriculture and cattle-raising, followed by the mining industry, construction and manufacturing industry (19.98%), services and sales (18.33%) and factories and facilities workers (6.21%). However, the agricultural sector has been losing ground in the EAP, due to the poor conditions of the rural people, decreasing from 65.1% in 1980 to 59.8% in 1980 in the high plateau of Peru, and from 74.1% in 1976 to 72.8% in 1988 and to 33.07% in 2001 in the Bolivian high plateau. Instead, trade and services in general have increased considerably, since industrial activity decreased in relative terms in both sides.

The demands on the work force in agricultural activities are seasonal and generally low. It is estimated that the requirements for agricultural labour represent 20% of the total labour force available in the whole region. Cattle raising is a steadier activity, without marked fluctuations or cycles, but requires less labour force. The employment rate is also affected by the extreme climatic and hydrological events occurring in the high plateau, particularly floods and droughts, and the related losses cause the migration of the affected people.

In this region, the main employment sources are the small economic units where all members of a family are engaged in the same activity, and do not receive salaries. Sub-industrialization is observed in the region, with a strong primary sector and a sizeable tertiary sector (mainly informal sales activities in the cities and large villages), as well as a weak secondary sector – evidence of an unbalanced economic system.

See figure 8b. EAP in La Paz, Oruro and Potosi (Bolivia) [Annex, page 88]

In the large villages and cities, houses are generally built with solid materials: foundations are made of stone or concrete, walls of adobe or bricks, roofs made of galvanized corrugated sheets or concrete, and wooden floors. Moreover, more than 50% of the houses have the service utilities such as water, sewage and electricity. However, the constant flow of rural migrants added to the natural urban growth phenomena are causing very crowded conditions in some areas of the cities with serious housing deterioration.

- **Health and morbidity/mortality**

The main characteristics of health conditions in the TDPS system are as follows:

- High rates of morbidity and mortality, mainly in mothers and children. The infant mortality rate/1000 is of 77.64 in the region of Puno, 102/1000 in the area of La Paz and 164/1000 in the area of Oruro. These figures place the region as one of the areas having the highest infant mortality rate in Latin America. The figures for Haiti are 94, Ecuador 61, and Nicaragua 59.

- Low life expectancy at birth, lower than the national average.

- High incidence of infectious diseases, mainly respiratory and gastrointestinal ones. Regarding the subregion of Puno, where the highest incidence of contagious diseases occurs, they appear to be related to the poor environmental and sanitary conditions (poor water quality in the case of gastrointestinal diseases and bad meteorological conditions in the case of influenza and the common flu). In the Bolivian sector, the most frequent diseases are gastroenteritis, influenza and in third place, sarcoptosis.

See figure 9. Morbimortality in the TDPS System *(Note: morbimortality = a combination of morbidity and mortality rates.)* **[Annex, page 89]**

- **Education**

Education levels in the Lake Titicaca basin region are remarkably low, especially in rural areas. By way of example, the general illiteracy rate is 19.3% in the region of Puno in Peru and in the rural areas of the Peruvian side it reaches 24% (2001) and 23.1% in the high plateau of Bolivia (2001). These rates are rather high if compared with the national average of 9.97% in Peru. The illiteracy rate is differentiated by area and gender, being higher in rural areas and among females.

1.5.3 Political structure

- **Generic competences of the three governmental powers**

The legal competences of the three powers are similar in Bolivia and Peru:

- The Executive Power is held by the President of the Republic, who is elected by popular vote and is the head of the government. He is in charge of national defense, public administration of the different economic and social sectors, the provision of basic public services and promotion of development, among other things, in accordance with the Constitution and the laws. In this context, the executive power is responsible for managing the renewable natural resources and protecting the environment. At municipal level, the executive power is exercised by governors or mayors, who are also elected by popular vote.

- The Legislative Power is held by the National Congress, which is in charge of the formulation and enactment of the laws and the fiscal supervision of the Government. Each local government or municipality has in turn its municipal council that is in charge of enacting the rules at this level and of fiscally supervising the municipal administration.

- The Judicial Power, in Peru is headed by the *Consejo Nacional de la Magistratura* (National Council of Magistrates) and in Bolivia by the *Corte Suprema de Justicia* (Supreme Court of Justice) and is in charge of the administration of justice throughout the national territory.

The three powers are separate and independent, and have political and administrative coordination mechanisms to facilitate the tasks of government and the administration of the State.

- **Institutional framework for environmental management**

In Bolivia, the Ministry of Sustainable Development and Environment (MDS), under the President of the Republic, is in charge of environmental management. The basic function of this ministry is environmental regulation within the framework of the relevant laws.

This ministry was created by Law No. 1493 of 1993 and under this legal body, the environmental management of the country is administered intersectorally.

At regional level, the *Dirección de Medio Ambiente* (Environment Office) in the Departmental Prefectures has the function of monitoring, prevention and managing environmental impacts.

At local level, the Environment Unit of each municipality is in charge of the environmental management in the relevant district.

There are civil society organizations that participate in the Departmental or Municipal Councils related to environmental issues.

In Peru, the present model of environmental administration is structured in sectors, although actions from the different sectors should be coordinated by the *Consejo Nacional Ambiental*

(CONAM or National Environmental Council) which was created in December 1994. In addition, the National Constitution, approved in 1993, provides in its articles 67 to 69 the obligation of the State to determine its environmental policy, promote the sustainable use of natural resources, promote the conservation of biodiversity and protected areas, as well as the sustainable development of the Amazon.

At present, environmental management at national level is carried out as follows:

- The *Consejo Nacional Ambiental* (CONAM or National Environmental Council) is the leading body for the national environmental policy, depends on the President of the Council of Ministers and is responsible for the planning, promotion, coordination, monitoring and management of the environment and natural assets of the Nation. In relation to the ministries, the CONAM coordinates actions with the different sectors and institutions of the central, regional and local governments regarding environmental issues, with the purpose of maintaining harmony among the established policies.

- Each ministry is responsible for the environmental management of its respective sector. Accordingly, the Ministry of Mining provides rules and regulations related to environmental protection in mining and controls the relevant applications in the various mines of the country; the Ministry of Industry and Trade does the same with the industries; the Ministry of Agriculture controls the problems of degradation of the land and waters related to the development of agricultural activities, monitors the exploitation of forests and protect biodiversity; the Ministry of Fishery not only promotes but monitors the exploitation of fishing resources with the objective of fish species conservation. The Ministry of Health provides the rules and control the use of water, monitors atmospheric emissions and solid waste disposals from the point of view of human health; and so on.

- It should be noted that, operating within the Ministry of Agriculture, there is the *Instituto Nacional de Recursos Naturales* (INRENA, the National Institute of Natural Resources) which is in charge of the National System of Protected Areas (SNAP), managing and supervising the wise exploitation of forests and fauna, as well as the conservation and recovery of soils and management of hydrological basins.

At regional level, there are *Consejos Departamentales de Medio Ambiente* (Departmental Environment Councils) that are integrated into the representative institutions of civil society organizations, as well as the Regional Offices of the National Institute of Natural Resources (INRENA) to monitor the environmental provisions of each institution, and finally, in the Regional Governments there is the Management of Natural Resources and Environment, which is the administrative and technical entity in charge of environmental management.

At local level municipalities have an Environmental Unit, responsible for environmental management in the respective district.

The civil society organizations participate as integral parts of the Departmental and Municipal Environment Councils.

Table 1. INSTITUTIONAL FRAMEWORK FOR ENVIROMENTAL MANAGEMENT

COUNTRY	NATIONAL LEVEL	REGIONAL LEVEL	LOCAL LEVEL
PERU			
Institution	CONAM INRENA Ministries	CONAM Departmental Council INRENA Regional Office Regional government	Municipalities - Environment unit
Functions	Regulatory	Enforcement; execution	Operative
Authority	Autonomous	Under national level	Autonomous
BOLIVIA			
Institution	MDS (Ministry of Development and Environment)	Departmental prefectures	
Function	Regulatory	Enforcement; execution	Operation
Authority	Autonomous	Autonomous	Autonomous

1.5.4 Legal framework

- **Legislation regarding the land and its utilization**

Regarding land use, in Bolivia there are departmental and municipal plans that are approved by Supreme Decrees. In Peru, there are laws that establish reserves of property or of soil - and subsoil - use.

The Bolivian Constitution, which went into effect in 1967 and as amended in some aspects in 1994, states that 'the soil and subsoil, with all the natural wealth pertaining thereto, the lacustrine, river and medicinal waters, as well as the elements and physical forces that can be exploited, are the original property of the State, as well as the assets attributed by the law' (Art. 136).

The Peruvian Political Constitution, delivered in 1993, states in Art. 66, that the renewable and non-renewable natural resources are property of the Nation and that the State has the absolute authority to determine their utilization. The conditions and concessions for private use are fixed by law and the concession thereof assigns the holder of the right to use a real right subject to the law. On the other hand, Art. 70 stipulates that property is an inviolable right and that the deprival thereof is only permitted for reasons of national security or public need, after payment of its value. Art. 73 also establishes that the property in the public domain is inalienable and imprescriptible (indefeasible, e.g. land rights; not subject to time-barring, e.g. other rights), and that property of public use may be assigned to private users for their economic benefit, in accordance with the law.

- **Legislation on water and lakes**

In Bolivia, the legislation in force related to waters is fragmentary and outdated. The main legislation is:

- Law dated November 4, 1874, on conducting water for the benefit of low rural property.
- Decree dated September 8, 1879 and Water Law of 1906, on ownership and use of waters.
- Opposition to the granting of water, circular dated June 27, 1913.
- Bolivian Civil Code: provisions related to derived easement.

- Law of November 27, 1945, on the use of excess waters.
- Decree Law N° 03464 of August 2, 1953 and Law dated October 29, 1956 on Land Reform, as regards the '*Régimen de aguas*' (regulation of waters).
- Code of Mining of May 7, 1965, regarding the '*Uso y aprovechamiento de aguas*' (use and exploitation of water).

With reference to the discharge of industrial waste, the legislation is as follows:

- Supreme Decree N° 17815 dated November 27, 1980 and 'Reglamento sobre lanzamiento de desechos industriales en los cuerpos de agua' (regulation on industrial waste discharge in waters) approved by Ministerial Resolution N° 010 dated January 24, 1985.

- Supreme Decree N° 14368 dated February 14, 1977: '*Reglamento general para el manejo de residuos sólidos*' (general regulation for the management of solid waste).

At present, there is a proposal related to the *Ley de Aguas* (water law), which is being studied by the Congress of the Republic.

In Peru, the legislation is as follows:

- Decree law N° 17752 of 1969, or '*Ley General de Aguas*' (general water law), which rules all the aspects related to water use and conservation.
- Supreme Decrees numbered: 261-69-AP, 41-70-A, 274-69-AP, 923-73-AG, 473-75-AG, 930-73-AG, and 495-71-AG, dealing with relevant laws.
- Legislative Decree N° 17505 of 1969 or the 'sanitation code', which rules on all the aspects related to the environmental health, such as water quality, air, noises, waste, and others.
- Legislative Decree N° 611 of 1990 or the 'Código del Medio Ambiente y los Recursos Naturales' (Environment and Natural Resources Code) which stipulates that the Ministry of Health is responsible for the assurance of water quality for human consumption and in general, for such other activities in which the use of water is necessary.

In Peru, Law 17752 or the General Water Law is currently in force, and the Technical Administrator of Irrigation is in charge of applying the rules regarding basins and valleys.

In Bolivia, the Law of 1906 is currently in force but with relative application, dealing with the actions of the civil organizations of water users as those who apply the customary rules and habits related to water use.

It is noted that both countries have subscribed the Montevideo Convention on water management, but they have not signed the Helsinki Convention. These are, in fact, the only two international legal insturments related to waters.

1.5.5 Water resources:

- Hydrology:

The Lake Titicaca Basin is located in an endorheic (enclosed) basin on the border of Peru and Bolivia also called the TDPS system, which is comprised of the basins of Lake Titicaca, Desaguadero River, Lake Poopó and Coipasa 'Salar'.

The surface area of the TDPS system is 143,900 km^2 and extends over the high plateau in the subregion of Puno (Peru) and the departments of La Paz and Oruro (Bolivia). The geographical characteristics of the basins that comprise the TDPS system are as follows:

a) Lake Titicaca: (*)

. Surface area of the basin	56,270 km^2
. Average surface area (lake)	8,400 km^2
. Average altitude of lake	3,809.34 masl
. Average volume	930x10^6 m^3

(*) *volumes/surface area are with reference to an altitude of 3,810 masl*

b) Desaguadero River:

. Surface area of the basin	29,843 km^2
. Length of shoreline	398 km
. Average gradient	0.45 m/km

c) Lake Poopó:

. Surface area of the basin	24,829 km^2
. Average area (1991)	3,191 km^2
. Average altitude	3,686 masl

d) Lacajahuira River
(connects Lake Poopó with Coipasa 'Salar')

. Length of shoreline	130 km
. Average gradient	0.2 m/km

e) Coipasa 'Salar'

. Surface area of the basin	32,958 km^2
. Average surface of lake	2,225 km^2
. Average altitude	3,657 masl

- **Surface water**

The Lake Titicaca Basin is located in an endorrheic basin constituted by a hydrographic system, in which Lake Titicaca is located to the north connecting in the south with Lake Poopó through Desaguadero River. The main elements of the hydrographic system of the Lake Titicaca Basin are Lake Titicaca itself and a number of small, medium-sized and large tributaries, and some of them have great economic significance.

The main tributaries that flow into Lake Titicaca are located in Peruvian territory: The Rivers Ramis and Huancané to the north, Coata and Ilpa to the west and Ilave and Zapatilla to the southwest. In Bolivia, the most important tributaries are: Huaycho, Suchez and Keka to the north and east; Catari and Tiahuanacu to the south. Among all the tributaries of the lake, the most important river is undoubtedly the Ramis, as it represents 26% of the tributary basin. Lake Titicaca is composed of Lakes Mayor and Menor; the latter is also called Huiñay Marca Lake. Desaguadero River begins in the southern area of this lake.

See figure 10. Peru-Bolivia TDPS hydrographic system map [Annex, page 90]

- Hydraulic characteristics of Lake Titicaca

Historical records of variations of Lake Titicacas levels exist from 1914 to the present. Various cycles of different durations are observed, a major cycle seems to have lasted 27-29 years and an intermediate one was of 12-16 years. The maximum lake-level variation during this period was of 6.37 m, with an absolute maximum of 3,812.51 m in April 1986 and an absolute minimum of 3,806.14 m in December 1943.

Apart from these interannual oscillations, the lake has an annual oscillation of about 1 m, reaching its maximum level during April-May and minimum in December-January. This indicates that maximum levels are reached 1-2 months after the end of the rainy season, while the minimum level is reached 4 months after the season of low rains.

Moreover, a marked persistence is observed in the interannual periods, both dry and wet. By way of example, during the dry period of 1924-44, the lake level remained below its usual average height of 3,807 masl for about 30 consecutive months, while during the wet period of 1986-87, for 21 consecutive months (from January 1986 to September 1987), the level exceeded its usual average height of 3,811 masl, which had not been exceeded in the previous 72 years. This characteristic, closely linked to the precipitations and river flow, results in serious effects with economic losses.

- Characteristics of the tributaries

The Ramis River Basin is the largest basin that flows into Lake Titicaca and one of the largest in the system (10.3%). Its altitude ranges between 5,828 and 3,815 masl in the northern and northwestern part of the system. The hypsometric curve indicates that this area is mature, very prone to erosion in the upper area and unstable in the lower area. The compactness rate indicates that it is a basin of high irregularity.

The Huancané River Basin is smaller and located at the northern corner of Lake Titicaca, at an altitude of between 5,162 and 3,820 masl. The hypsometric curve indicates that this area is mature, prone to erosion in the upper area and unstable in the lower area. It is a basin of high irregularity.

The Súchez River Basin is also small and located along the northeastern versant of Lake Titicaca, at an altitude of between 5,829 and 3,817 masl. The compactness rate indicates that this area is of high irregularity.

The Coata River Basin is the third largest basin among the Titicaca tributaries, although it is slightly bigger than the Huancané Basin. It is located at the northwestern corner of Lake Titicaca, upstream of Juliaca River (in Peru) at an altitude of between 5,475 and 3,830 masl. The hypsometric curve indicates that this area is mature, slightly vulnerable to erosion in the upper area and stable in the lower area. The compactness rate indicates that this is a regular area.

The Ilave River Basin is second in size among the Titicaca tributaries, although it is barely half the size of the Ramis Basin. It is located at the western and southwestern versant of Lake Titicaca, south of Puno, at an altitude of between 5,585 and 3,830 masl. The hypsometric curve indicates that this area is mature, slightly prone to erosion in the upper area and unstable in the lower area. The compactness rate indicates that it is a basin of high irregularity.

Huaycho: It is a small, rather irregular basin, located between Huancané and Súchez Basins, on the northeastern side of the lake, between 4,725 and 3,875 masl.

Illpa: This basin is located between the Coata and Ilave Basins, on the northwestern side of the lake, between 4,953 and 3,815 masl. The compactness rate indicates that it is an irregular basin.

Keka: This basin is located on the southeastern side of the lake, between 6,421 and 3,820 masl. The slopes of this basin are steep. Its compactness rate indicates that it is a regular basin.

Catari: It is the largest basin in this area. Occupying the southeastern side, it is situated at an altitude of between 6,088 and 3,819 masl. Here are located the cities of El Alto (La Paz) and Viacha. The compactness rate indicates that it is a basin of high irregularity.

See figure 11. Map of inflows to Lake Titicaca Basin [Annex, page 91]

- Mean water balance

According to the annual average flow of the main rivers of the Lake Titicaca Basin, the following conclusions are observed:

- Out of the five large tributaries flowing into Lake Titicaca, based on the flow volumes, the Ramis River leads with 76 m^3/s, followed by Coata River with 41 m^3/s, Ilave River with 38 m^3/s, Huancané with 20 m^3/s, and Súchez with 11 m^3/s. Accordingly, the aggregate flow of these five tributaries amounts to about 186 m^3/s, which represents nearly 85% of the total discharge water into Lake Titicaca, with the Ramis River alone responsible for the 40% of that amount. Furthermore, the Coata River discharges more water than Ilave River, the formers basin is just 60% the size of latters; this is due to the fact that the Coata has the largest precipation volume of all the tributaries.

- Of Lake Titicacas five largest tributaries, the Rivers Coata and Ilave have the highest interannual flow oscillation as is shown by the monthly maximum and minimum flow averages – of 789 times for Coata and 411 for Ilave, compared with 141 for Ramis. The maximum flows occur from January to May, while the minimums are observed between September and November.

- The overflow from the lake (to the Desaguadero River at International Bridge) barely reaches 35m^3/s, which represents only 19% of the inflow from the five major tributaries. This fact demonstrates the great volume of water lost within the lake, mainly due to evaporation. However, such variation has little significance, since the interannual variability at the International Bridge represents the highest variation among all the stations, taking into account that the average minimum flow per month is zero, and during the periods of low level of Lake Titicaca, the flow is reverted towards the lake (this is the reason for the negative flow rate figures) with the inflow from the upper basin of Desaguadero up to Aguallamaya.

- The total inflows to Lake Titicaca, including the direct rainfalls, were estimated at 436 m^3/s, during the period of 1920-92. This value is 7% lower than the one estimated for the period 1960-90 (471 m^3/s).

- January, February and March are the months of largest total inflow during the year, with 1083, 1264 and 902 m^3/s respectively. The extreme opposite occurs during the months of June, July and August, with 70, 58 and 71 m^3/s, respectively.

According to the data available during the period 1960-90, the preliminary mean water balance of the Lake Titicaca may be stated as follows:

Inflows from tributaries	= 201 m^3/s
Rainfall over the lake and other water sources	= 270 m^3/s

Evaporation	= 436 m^3/s
Outflows to Desaguadero	= 35 m^3/s
Drainage and other losses	= negligible

See figure 12. Schematic of Lake Titicaca hydrological balance [Annex, page 92]

The following table shows the data of surface area and volume of the lake with relation to their corresponding altitudes. It is observed that at the lakes mean altitude (3,810 masl), the volume contained is of 932 km^3, with a flooded surface of 8,400 km^2.

Table 2. MAIN HYDRAULIC CHARACTERISTICS OF LAKE TITICACA

ALTITUDE (masl)	AREA SURFACE (km^2)	VOLUME (mill m^3)
3,532.66	0.00	0.000
3,600	1,619.30	45,871.393
3,700	4,196.70	350,141.743
3,800	6,409.20	860,173.917
3,805	7,034.70	893,732.688
3,810	8,399.55	931,966.436
3,815	9,960.99	978,694.492

Source: Binational Master Plan.

- Groundwater

The groundwater resources depend mainly on the sedimentological characteristics of the aquifers (hydrogeology), on their hydrodynamic conditions and on recharge and discharge conditions.

The most important aquifers are located in the middle and lower basins of Ramis and Coata Rivers, in the lower basin of Ilave River and in a strip that extends from Lake Titicaca to Oruro, bordering the Eastern Range.

The water circulating through the aquifers moves towards the river and lake system, but is partly evaporated. The total volume of groundwater that goes into the system does not exceed 3m^3/s, which roughly indicates that the groundwater resources are not very abundant.

The water table morphology analyzed from the hydrological contour curves, shows that the ground water flows follow the direction of water reservoirs, the location of recharge areas and their base levels. As regards the tributary basins of Lake Titicaca, the water tables drain into Lake Titicaca with average hydraulic gradients of 1 to 0.1%. The same occurs along the Desaguadero aquifer. However, the ground flow that effectively reaches the surface water system is limited, because of the low transmissivity and low gradient. On the other hand, some rivers such as Ramis and Desaguadero considerably reduce their water volume flows in their lower valleys due to infiltration and posterior evaporation from the alluvial aquifers. The artesian water also flows to the surface water system, but the forms of the aquifers may be sharp-edged or closed without water contact, or in any event, very complex, and then, contribution to the surface system would be scarce.

According to the pumping tests, the hydrodynamic characteristics of the explored aquifers show that in some aquifers of the Peruvian sector, their transmissivities range from 120 to 5,600 m^2/day (1.4×10^{-3} to 6.5×10^{-2} m^2/s), while in the Bolivian sector, the range is from 1 to 750 m^2/day (10^{-5} to 8.7×10^{-3} m^2/s).

The values of water storage rates established for the Bolivian sector correspond to confined to semi-confined aquifers, and also open ones ranging from 10^{-2} to 10^{-10}.

Results of variable flow analysis show that the optimum yields of aquifers in the Peruvian sector range from 4 to more than 100 liters per second, with specific capacities of 0.3 to 5 liters/s/m. In the Bolivian sector, yields range from 2 to 75 liters per second, with specific capacities of 0.3 to 4 liters/s/m.

The states of confinement or semi-confinement in one or more levels of depth in the aquifers, lead to piece-metric levels reaching the soil surface or higher up to 2 meters-height, as in the Catari River Basin, in the Bolivian sector.

In conclusion, it may be stated that all groundwater systems lead to the hydrographic system, and from the hydrogeological standpoint, the Peruvian-Bolivian TDPS system is endorrheic. Neither Lake Titicaca nor the other components of the system have leaks. The aquifers in general represent a very limited part of the whole basin. However, during periods of high waters, over certain sectors a significant transfer of water is observed from Desaguadero to ground aquifers.

The water circulating in the aquifers moving toward the hydrographic system is partly lost to evaporation. The total volume of groundwater transferred to the surface water system does not exceed $3m^3/s$.

The data given above refer to renewable ground resources. The fossil or non-renewable resources contained in the sandy deep layers of Tertiary and Cretaceous formations are still unknown and their exploitation should be developed only as needed and in accordance with mining criteria.

- Precipitation

The maximum precipitation in 24 hours constitutes an indicator of storm events within the system. The statistical analysis of the available series demonstrates the following.

- There are two centres of high precipitation: Lake Titicaca and its surroundings and the middle of the southern area of the basin between the Mauri River and Lake Poopó. In both centres, the 24-hour maximum rainfall ranges from 70 to 95 mm for a period of return of 50 years. In addition, there are other minor isolated centres with the same values, especially in the upper basins of the Coata River (Lampa River) and Ramis River (Crucero River).

- The areas of lower precipitation are located along the eastern and southwestern coastlines of the basin, with 24-hours maximum rainfalls ranging from 50 and 60 mm. Intermediate values are observed in the rest of the system.

The maximum probable precipitation in 24 hours (estimated by Hershfield method) follows a similar regional pattern, although the values fluctuate from 250 to over 350 mm in the centres of high precipitation and from less than 150 to 250 mm in the centres of low precipitation that have been described.

See figure 13. Average annual precipitation in Peru-Bolivia TDPS System [Annex, page 93]

Extreme events:

- Floods

Flooding is the extreme event that poses the most serious problems by causing damage to the basin. During the second half of the 1980s, heavy rains during several consecutive years caused a strong inflow increase to Lake Titicaca, raising its water level steadily and flooding thousands of hectares in the riparian region (48,000 hectares were flooded in 1986).

This phenomenon, that reached its peak during 1986-87 and caused the lakes highest water level between the years 1920 and 1990, caused a large discharge increase by the Desaguadero River, which, added to the flow of its tributaries, resulted in serious floods along this river, especially in its lower section (Lakes Uru-Uru and Poopó), posing a threat even to the city of Oruro. Upstream of the International Bridge (origin of the Desaguadero River), the floods are linked either to the overflow of rivers or to the rise in the level of Lake Titicaca or else to the combined action of both causes.

See figure 14. Flood-prone areas [Annex, page 94]

Based on the longest series of precipitations, it has been estimated that for the rainy periods causing floods (November to March), the probability of occurrence (in the next 50 years) of another similar or larger rainy period than the major rainy record period (1985-87) is of 5.8%. If one considers the series of general inflows to Lake Titicaca, the probability of occurrence of another similar or larger rainy period than the one of 1985-87, has been estimated at 5.2%.

- Droughts

Droughts are also one of the extreme events that create the most serious problems in the area of the TDPS system of Peru and Bolivia. They affect the whole high plateau in general, and their characteristic is the general lack of water to meet the different needs (mainly for agricultural and domestic water uses) causing a great impact on various economic sectors. The analysis of this problem shall be carried out from the three complementary points of view: bioclimatic drought, pluviometric drought and fluvial drought, the latter two droughts especially pointing to the probable occurrence of historical droughts.

- Bioclimatic drought

Strictly speaking, a dry month is one in which the precipitation is less than PET. Now then, if for each month the number of years in which precipitation is less than PET/2 is counted and this value is divided by the total number of years being considered, the frequency of drought occurrence for each month is obtained. With these data, it is possible to determine the drought-free period (in months) with a certain frequency (50%, 75% etc.). Figure 1.21 shows the period free of droughts for some representative stations in the north, centre and south of the basin (see the characteristics and location of the stations in Table 1.14 and Figure 1.24).

By observing the charts, it can be concluded that in the north of the basin (Chuquibambilla and Huaraya Moho), the drought-free period is the longest (5-6 months with a probability of 50%), while in the south, barely a month is free of drought with the same frequency (Patacamaya and Oruro). An intermediate situation is observed in the central part of the basin (Ilave and El Alto).

- Pluviometric drought

This is in reference to the frequency of precipitations below a certain value, in general determined by the water needs of a region. In the present case, these reference levels have been deduced from the major historic droughts that the high plateau has had and that have caused huge economic and social losses. These historic droughts occurred in 1982-83 and in 1989-90.

Based on the series of accumulated precipitation during the months of November to March (period during which the major water demands for dry farming arise), there was the probability of similar drought periods in 1982-83 and in 1989-90.

- Fluvial droughts

Likewise based on the series of inflows and accumulated water volumes of the main rivers of the basin during the months of November to March (the largest agricultural irrigation demands occur in this period), one can assume there probably were similar drought periods in 1982-83 and in 1989-90.

- Risks of hail and snow

The high altitude, strong solar irradiation and strong convective phenomena, especially during summer, cause a high risk of hailstorms over the whole basin. The available data show that, in general, at altitudes exceeding 4,800 m there are more than 20 days of hail per year, particularly in the northern part of the System, although the highest frequency is recorded in Quillisani, located at 4,600 m. At lower altitude, and approaching Lake Titicaca, the number of days with hail decreases gradually to about 5. In the southern sector of the basin, the frequency of hail also seems to be less than 5 days per year.

Data related to frequency of snowy days is very limited. The only two stations that record snowfall are Puno and Caracollo, with frequencies of 3 and 1.2 days respectively, in a year.

The two phenomena (hail and snow) cause serious damages to agriculture.

Table 3a. PROBABILITIES OF HISTORICAL DROUGHTS FOR RETURN PERIOD OF 50 YEARS

Precipitation series from November to March (mm)

DROUGHT	BOLIVIAN SECTOR	PERUVIAN SECTOR	TDPS SYSTEM
1982-83	0.870	0.930	0.890
1989-90	0.370	0.430	0.470

Source: Binational Master Plan, 1993.

Table 3b. PROBABILITIES OF HISTORICAL DROUGHTS FOR A RETURN PERIOD OF 50 YEARS

Series of inflows accumulated from November to March (mm)

RIVER	DROUGHT 82-83	DROUGHT 89-90
Escoma	0.900	0.470
Huancané	0.900	0.470
Ramis	0.900	0.900
Coata	0.900	0.470

Ilave Abaroa (R. Mauri) Abaroa (R. Cosapa) Calacoto (R. Mauri) Ulloma (Desaguadero) Chuquiña (Desaguadero)	0.900 0.900 0.900 0.900 0.900 0.900	0.900 0.900 0.170 0.900

Source: Binational Master Plan, 1993.

- Frost and freezing frequency

Frost or freezing is a common event over the whole basin, although its frequency is quite irregular. The less affected area is the Lake Titicaca and its surroundings (including the lower valleys of the Rivers Ilave, Coata, Ramis, Huancané and Huaycha), where the number of frost or freezing days is less than 150 per year. Along the coastline of the Lake Titicaca, the frequency is less than 100 days. This frequency increases in all directions starting from the Lake Titicaca, although in the central strip of the basin to the south there are less than 250 days per year with temperatures below zero. Towards the border of the basin, the frequency increases up to 300 – 350 days per year, especially along the western border.

There are very few locations with periods that are completely free from frosts/freezes. Among them are: Isla del Sol with 7 months; Copacabana with 4 months; Puno, Huaraya Moho and Puerto Acosta with 2 months – all of them are near the lake – and Calamarca and Chuquiña, located on the Desaguadero River, with 1 month. The station of Huaraya Moho, near the lake, has recorded the longest period without frosts or freezes. The highest frequency of frosts or freezes occurs in winter (June to August, and in general, may be extended to May and September) while the lowest frequency occurs in summer (December to March). The map shows the distribution of the number of frost/freeze days over the whole basin.

See figure 15. Map of frosts and freezing periods *(Days per year)* **[Annex, page 95]**

Human impact on water resources:

- Current land use

With reference to the current use of the land in the basin, the following is observed:

- Agricultural and livestock-raising uses cover a total of 48% of the basin (including the aquatic areas). In this regard, 4.4% of the basin is used for crops and 21.7% for grazing, 7% for agriculture and livestock raising and 14.9% for agriculture, forestry and grazing. The largest area used for crops is located in Lake Titicaca basin, while grazing is highest in the Ramis Basin.

See figure 16. Map of current land use in Peru-Bolivia TDPS System [Annex, page 95]

- Forestry use covers barely 3% of the basin. Of this, 2.3% is covered by scrubby bushes, most of them spaced, and only 977 km^2 are covered by *queñoa* (Polylepis) forest.

- The rocky outcrops, sandy and stony grounds represent 33%, that is, one-third of the basins area. However, in most of such areas (in 96.2% of rocky outcrops and 96.4% of sandy and stony grounds) crops and/or grazing are observed, where there are bushy or herbaceous vegetation.

- Very eroded areas represent 2% of the basin.

- The perennial snow-covered and urban areas are not important on a basin-wide scale (only about 0.2%).

- **Inconsistencies between current use of land and the capacity of its utilization**

Comparing the values regarding the capacity of land utilization of the basin with those of its current use, the following inconsistencies are found:

- Arable lands apt for crops and/or grazing are scarce compared to the lands that are thus occupied, and this fact indicates an overexploitation of lands in the basin.

- Non-arable lands that are appropriate for permanent crops and extensive grazing for llamas and alpacas represent smaller areas than the lands effectively used on a regular basis for the grazing of these animals and partly for agriculture, indicating that there is also land overexploitation representing 16.7% of the land in the basin.

- The above shows that there are areas in the basin that are exploited beyond their capacities, representing more than one third of the basin land (35.2%).

- On the other hand, there are marginal and badlands unsuitable for agriculture with limited areas of bushes and shrubs. In fact, it is in these marginal and unsuitable lands that overexploitation is observed.

Such overexploitation of soil resources constitutes one of the most serious environmental issues in the high plateau. However, it should be noted that the lands exploited for crops and grazing have a considerably low productivity due to the rudimentary technology applied.
Low productivity is one of the reasons for such overexploitation, because in order to maintain certain given production volumes or levels, the use of a large extension of lands has been necessary. If a higher yield could be reached, the same or greater production would be possible in a smaller area.

- **Problem of water resources degradation**

As a result of human activity, mainly urban and mining, and the geological characteristics of the basin, the water resources of the basin show various levels of organic, bacteriological and physical-chemical pollution.

- **Organic and bacteriological pollution**

This basically results from the discharge of urban wastes into the basin. The most contaminated areas are:

- The Puno inner bay, where high concentrations of organic matter and coliforms are observed resulting from the discharge of wastewaters from the city sewage. This contamination has caused a process of eutrophication in the bay, with accelerated growth of aquatic lentils (*Lemna sp.*) producing large green spots on the waters surface. The treatment of a part of the Puno City wastewaters in an oxidation lake has not been sufficient to control the problem. Nevertheless, the high efficiency obtained in removing organic load (60-84%) and pathogenic microorganisms (80-100%), performed in two small experimental plants based on macrophytes (in

Chejoña and Chanu Chanu), offer possibilities of enhancing the treatment process and reducing pollution.

- Downstream of Coata River, due to the discharge of wastewaters of Juliaca.

- Lake Uru Uru, due to the discharge of wastewaters of Oruro and the disposal of this citys garbage at the lakeshore.

It is noted that if adequate measures on these issues are not taken, in the long term the bodies of waters described above will be seriously deteriorated.

- Salinity

This is the result of the basins inherent characteristics. The water salinity of Lake Titicaca is in general less than 1 g per liter.

- Pollution by heavy metals

Mining is the major source of water contamination by heavy metals. Water from the mines is very acidic and highly polluted with heavy metals. In addition, mine dumps and tailings left along the hillsides and riverbeds are conspicuous in the mining areas, particularly in Oruro. The mining waste contains in general large quantities of pyrite, which produces sulfuric acid when it oxidizes and comes into contact with water. This acid lixiviates the metals that are present, producing water similar to that from the mines. This process continues in general after the closure of mines, sometimes even more intense due to the lack of mine water and tailing piles management.

In addition to the above, there are effluents from the concentration plants using flotation methods, containing heavy metals in solution, suspended mud with heavy metals and reagents used in the process. The pH, usually high at the end of the process (10-12), limits the metal solubility, and thus such metals are present as residual solids or attached to the suspended mud, where they may be naturally lixiviated. Processed water is discharged from the plant with solid waste as mud, either into a nearby stream or mine dumps. Once the suspended material is decanted, the water may be discharged into Nature or reused. However, the quality of this water may be very poor, with high content of heavy metals and solids in suspension, especially if the pH is low. The reagents used in general include sodium cyanide, copper sulphate, zinc sulphate, xanthate, foaming agents and others, part of which may be discharged into the tailings, especially if used in excess. Among these, cyanide and xanthate are particularly toxic for fauna and flora, although they (the reagents) may be easily degraded (by oxidation and hydrolysis respectively) if the discharge is kept for an adequate period in the tailings, which is not a usual practice in the mines of the high plateau.

Tin is a conspicuous metal all over the main water system, in concentrations that in general exceed the permissible limits for human consumption (0.002 mg/l), although the highest concentrations are found in Ilave River.

In addition, the concentration of heavy metals in sediments indicates that there are also pollution problems in the lower part of the Coata River and of its tributary the Cabanillas.

Furthermore, although it is not yet a significant problem, the natural leaks of oil and formation water (brackish water) in the peninsula of Capachica, specifically in the area of Pirim-Pusi to the northwest of Titicaca, may cause serious problems in future if adequate measures are not taken. The same is feared regarding the potential oil exploitation in this same region.

Water pollution has a clear impact in trophic chains of the TDPS System of Bolivia and Peru. Although there is little information, some concentrations of arsenic and mercury found in *pejerrey* fish (silversides - *Basilichtys bonaerensis*) from the Bay of Puno are very high (0.4 ppm of Hg), above the permissible limits for human consumption.

- Sources of contamination

The main sources of contamination are, as already mentioned, wastewater, industrial wastewater and mining drainage and waste in general.

Domestic contamination originates mainly in Puno, Juliaca and El Alto. The contamination of Puno Bay (Lake Titicaca) bay seems to have worsened, since 1992, when eutrophication indicators (Lemna and the water colour) were observed up to the first reed beds (*totorales*). Currently, indicators reach the floating islands. In the zone of Juliaca, the Coata is the affected river. Part of the wastewater from El Alto goes to Lake Titicaca through the Seco River.

Industrial contamination originates particularly in Juliaca and El Alto. However, contamination from mining comes from the entire basin.

Needs, uses and demands:

- Current use of surface water

The surface water use is mainly of two types: domestic and agricultural.

- Domestic use

Main uses are:

- *Urban use:* the estimated current rate of consumption in the main urban centres of the Altiplano (Puno, Juliaca, El Alto) is 1,322 l/s, of which 410 correspond to surface water and 912 to groundwater, distributed as shown in the table. If an average consumption *per capita* in Juliaca, El Alto, of 153 l/inhabitant/day is assumed, then the consumption by the rest of the basins urban population can be estimated at 467 l/s. The total urban domestic consumption is around 1,789 l/s.

- *Rural consumption:* there is no data available on this type of consumption. However, if a unitary consumption of 25 l/inhabitant/day is assumed, rural consumption could be estimated at 333 l/s.

The total domestic consumption in the whole basin then is near 2,122 l/s, of which 1,000 are used in Peru and 1,222 in Bolivia. However, this consumption cannot be considered as an actual loss, since the quasi-totality of it returns to the system as wastewater (nearly 80%).

- Agricultural use

According to studies of the Master Plan, there are approximately 19,444 hectares irrigated in the area of integration formed by Lake Titicaca, Desaguadero River, Lake Poopó and the Coipasa 'Salar', known as the Peru – Bolivia TDPS System, of which 8,484 are in the Peruvian sector and 10,960 in Bolivia. If average annual modules of 0.34 l/s/hectare are assumed for the Peruvian sector and 0.41 l/s/hectare for the Bolivian sector, which results from dividing the total estimated water demand by the total surface of the inventoried existing and proposed irrigation projects (see Tables 3.6 and 3.9) with water demand estimations (1,662.51 and 1,041.13 hm^3/year and 153,908 and 80,250 hectares for Peru and Bolivia respectively), the irrigation water use can be estimated at 7,379 l/s, 2,885 for Peru and 4,494 for Bolivia. The higher share of water used comes from surface sources. In contrast to domestic use, the water for irrigation does constitute a loss for the hydrological system, for it mainly goes into the atmosphere through evaporation and transpiration (only 25% is considered to return to the system, i.e. the actual consumption is 75% of the basins river flows in use).

- Other uses

Other water uses in the basin are industry, mining and animal consumption (livestock watering places). For industries located within or near the urban perimeter of the cities, their consumption is included in the relevant city's consumption. Statistics for the hydrological consumption by the (very few) remaining industries and the mines are not available. Nevertheless, it is estimated to be insignificant. Given the basins climate and the type of livestock raised, consumption in their watering places should not exceed 100 l/s. For the purposes of the present report, the volume used here should be a maximum of 1 m^3/s, corresponding mainly to cement plants and smelting facilities in Peru, particularly in the Oruro (Bolivia) zone. In all these cases it can be considered that the return to the system equals the domestic consumption return (80%), even if discharges generally are highly contaminated.

- Total use

In summary, the total volume of water used within the Peru-Bolivia TDPS system is around 10.5 m^3/s, of which 2.1 correspond to domestic, 7.4 to irrigation and 1 m^3/s to other uses. Of these, 4.3 m^3/s correspond to Peru and 6.2 m^3/s to Bolivia. This consumption is distributed approximately as follows:

Tables 4(a) and (b). CURRENT WATER USE IN THE PERU-BOLIVIA TDPS SYSTEM (L/S)

(a)

BASIN	PERU (l/s)	BOLIVIA (l/s)	TOTAL (l/s)
Titicaca	4.142	3.082	7.224

(b)

TYPE OF USE AND SECTOR	SURFACE WATER	GROUND WATER	TOTAL USE	NET CONSUMPTION (5)
1. DOMESTIC	1.210	912	2.122	424
PERU:				
Puno	849	151	1.000	200
Juliaca	25	151 (1)	176	35
Other urban locations	300		300	60
Rurals	334 (2)		334	67
	190 (2)		190	38
BOLIVIA:				
El Alto	361	761	1.122	224
Oruro	51	382	433	86
Other urban locations	34	379	413	82
Rurals	133 (2)		133	27
	143 (2)		143	29

2. IRRIGATION	7.294	85	7.379	5.534
PERU	2.800	85	2.885	2.164
BOLIVIA	4.494		4.494	3.370
3. OTHERS	1.000		1.000	200
PERU (3)	410		410	82
BOLIVIA (3)	590		590	118
GRAND TOTAL	9.504	997	10.501	6.158
PERU	4.059	236	4.295	2.446
BOLIVIA	5.445	761	6.206	3.712

(1) Estimated. (2) Assumed as surface water supply. (3) Estimation based on Peru/Bolivia proportion of domestic and irrigation uses (40.6% y 59.4%). (5) Actual system loss.

Irrigation water demand:

- Main problems identified

The main problems detected refer to imbalances between the hydrological resources supply and demand, to the irregularities of rainfall and rates of flow (droughts and floods), and to the degradation of resources caused by the discharge of domestic and industrial wastewater as well as drainage of mines. Given the low level of herbicide and plaguicide used by agriculture, contamination caused by these agro-chemical substances is considered insignificant.

- Lake Titicaca Basin

In the case of the Lake Titicaca Basin, the estimated total demand is 95.37 m^3/s, with a net consumption of 74.41 m^3/s. Now, even if the estimated input of the tributaries to the lake is 201 m^3/s, in reality it is not possible to use this entire flow rate, for the lake itself consumes the greatest part of it. The net output by the Desaguadero River, which is an indicator of the basins total yield, is only 35 m^3/s. Nevertheless, this rate of flow cannot be fully used, since the fluctuation level would be accentuated, resulting in minimum levels lower than the historical ones.

Table 5. SUMMARY OF WATER DEMAND FOR IRRIGATION IN THE BASIN

(in m^3/s)

BASIN AND COUNTRY	IRRIGATION PROJECT	IRRIGATION AREA (Ha)	GROSS DEMAND	IRRIGATION DEMAND
TITICACA BASIN	34	221,787	76.76	57.57
- Bolivia	6	19,370	7.94	5.96
- Peru	28	202,417	68.82	51.61

Source: Binational Master Plan and work of the author.

Consequently, the main limiting factor of the hydrological resources exploitation will not be the lack of water in the basins, but the restrictions imposed by the Lake Titicaca levels and in view of the lakes own survival. Simulation studies carried out within the Binational Master Plan framework have shown that the rate of flow potentially usable in the Lake Titacaca Basin could be between 20 and 25 m^3/s. The behaviours of the medium and minimum lake levels according to the different frequencies of appearances and for different extractions (basis of analysis: 15, 20 and 25 m^3/s) were measured. The minimum level for the protection of hydro-biological resources defined for Lake Titicaca is the height of 3,808.25 masl. Now, the curves registered indicate that the medium levels would not be very much affected by extraction and that this restriction (3,808.42 masl with a frequency of appearance of 98% for an extraction of 25 m^3/s) would always be respected. However, the minimum levels are indeed lower than the reference level, even in natural conditions. Moreover, differences between the various extraction alternatives are not very significant (between 5 and 16 cm for extractions of 20 and 25 m^3/s), so the decision as to the possible levels of extraction should consider other variables, for instance:

- Extraction of 20 m^3/s (with 82% guarantee) would require the confirmation that the majority of the inputs of the Desaguadero River, between the International Bridge and Calacoto, come from the tributary rivers of the sector.

- Extraction of 25 m^3/s (with 75% guarantee) would require additionally the confirmation that precipitation does not vary with the levels, as well as the fine-tuning of the hydrological balance of lake.

2. CHRONOLOGICAL HYSTORY OF THE BINATIONAL MASTER PLAN

1955-1957

The Declaration of the Presidents of Bolivia, Dr. Victor Paz Estensoro, and Peru, General Manuel Odría, and the 'Preliminary Convention for the Study and Use of the Water of Lake Titicaca' (*'Convención Preliminar para el Estudio del Aprovechamiento de las Aguas del lago Titicaca'*), signed between the Ministers for Foreign Affairs of Bolivia and Peru, Walter Guevara and David Aguilar, to carry out a diagnosis of the endorrheic basin of Lake Titicaca (1955). Following the year 1955 Declaration, in 1957 the 'Agreement for the Preliminary Economic Study on the Use of the Lake Titicaca Water Resources' (*Convenio para el Estudio Económico Preliminar del Aprovechamiento de las Aguas del Lago Titicaca*) was signed. Additionally, the legal regime of the lake was being determined and the highways Ilo – Moquegua – Desaguadero – La Paz were being built. These agreements were approved by the Peruvian Congress in 1955 and 1957, and by the Bolivian Congress in 1986. Both agreements came into force in 1987.

The agreement signed in 1957 set forth that:

'ARTICLE I: The Governments of Peru and Bolivia, in view of the recommendations of the Peru-Bolivia Joint Commission, and in view of the indivisible and exclusive joint ownership that both countries have over the water of Lake Titicaca, resolve to adopt a specific plan for preliminary economic studies on the joint exploitation of said waters, without fundamentally altering its conditions of navigability nor the fishing facilities, and without substantially affecting the surplus water volume product of the lake, which annually drains off through the Desaguadero River at the place called Concordia. The plan would also take economic indexes into account, as well as the intrinsic values of the water volume derived from it for industry, irrigation and other purposes.'

Comment:
This document constitutes the first joint agreement of the two countries to study the hydrological characteristics of the Lake Titicaca and proposes a joint management plan of said resource. It is within this framework that all future activities in the binational basin are being developed.

1965

The President of Bolivia, General René Barrientos, and the President of Peru, Fernando Belaúnde, resumed talks about the study of the Lake Titicaca Basin and decided to jointly request funding to build the Ilo – La Paz highway, by means of a note addressed to the President of the Inter-American Development Bank, Mr. Felipe Herrera. (This step was taken through an official letter sent by the President of Peru, Fernando Belaúnde, to the President of the Inter-American Development Bank, Felipe Herrera, which letter was personally delivered by the Ambassadors of Bolivia and Peru in the United States of America, Julio Sanjinés and Celso Pastor, respectively).

Comment:
It is underlined that the concern and consideration for the Lake Titicaca issue occurs at the highest level of authority in both countries. Furthermore, with this request, one can assume that the concept that the Lake Titicaca Basin issue is linked to the development of its area of influence. This area includes, among other things, the La Paz – Puerto de Ilo corridor on the Pacific Ocean side (Department of Moquegua in Peru).

1967

The request to the Inter-American Development Bank was reiterated by official correspondence addressed, in Washington, by the governors of the Bank for Bolivia and Peru, the Minister of Economy of Bolivia, Mr. Rolando Pardo, and the Minister of Finances of Peru, Sandro Mariategui, on 28 April 1967.

Comment:
The vision of generating a joint development as a result of addressing the issue of the Lake Titicaca Basin between Peru and Bolivia has become a constant element in the actions of both governments.

1974

Seven years later, under the offices or mandates of Mr. Julio Sanjinés as Ambassador of Bolivia in Peru, and General Hugo Banzer, as President of Bolivia, and General Juan Velazco, President of Peru, conversations were resumed to undertake the Lake Tititcaca studies. The agreement on the construction of the Ilo – Desaguadero highway was reiterated by means of correspondence exchanged between the Secretaries of State Alberto Guzmán for Bolivia and Miguel Angel de la Flor for Peru.

Comment:
Consideration of the Titicaca Basin continues at the highest level of authority, with the participation of both countries Presidents, confirming the political willingness expressed in the documents signed by the secretaries of state.

1975

In the framework of the celebration of the six hundredth anniversary of the founding of Bolivia, during the visit of General Francisco Morales Bermúdez, Prime Minister of Peru, to General Hugo Banzer, President of Bolivia, conversations continued for the study of the lake and particular attention was given to the concession of free zones for Bolivia in Matarani and Ilo.

Comment:
In the framework of the relations established for the consideration of the Lake Titicaca Basin, specific management actions of binational interest in the area were initiated through discussions on the establishment of free zones for Bolivia in the ports of Ilo and Matarani.

1976

Under the CAF (Andean Development Corporation) presidency of Mr. Julio Sanjinés, several projects were initiated, with CAF financing for the establishment of an integration process in the border zone between Bolivia and Peru, starting with a study sponsored by SELA (Latin American Economic System), with Ambassador Carlos Alzamora as Executive Secretary. The study related to the trout culture in cages in the Lake Titicaca, to be implemented by PESCA-PERU and the Corporation for Development of La Paz.

Comment:
The work regarding trouts in Lake Titicaca became the first joint action regarding a common hydro-biological resource. This strengthened the policy adopted by the governments of Peru

and Bolivia, whereby the coordinated and horizontal participation of institutions in both countries was to be fostered.

1976 – 1979

As a priority project, the bathymetric survey of Lake Titicaca was sponsored in order to determine its area and depth. This was done through hydro-acoustic methods employed by the Hydrographic Services of the naval forces of both countries. The work was carried out during research cruises undertaken from 1976 to 1979.

Comment:
The bathymetric survey of the lake, as an essential tool for further studies, succeeded in involving institutions such as the armed forces, traditionally jealous about sharing information. This undertaking facilitated the joint treatment of data and reports produced by each country on the Lake Titicaca Basin.

1976 – 1983

During these years hydrometeorological information exchange took place between the SENAMHI of Peru and Bolivia, and institutions belonging to the Peruvian and Bolivian air forces.

Comment:
This is another important aspect, for hydrometeorological information is vital for any hydrological study. Likewise participation of and interrelations between the two SENAMHI institutions in these countries was achieved.

1980 – 1983

Following the bathymetric survey, a diagnosis of the fishery resources of Lake Titicaca was carried out by IMARPE-Peru and Bolivias *Universidad Mayor de San Andrés* (University); this was financed by the CAF.

Comment:
The Lake Titicaca fishery resources evaluation, using electro-acoustic techniques was the first joint experience of this kind carried out between the two countries. Trained experts from both countries participated and thus the first ichthyological evaluation for the entire lake was successfully completed.

1981

The border project of CORDEPUNO (Puno development corporation) and the Prefecture of La Paz, was financed by the CAF.

Comment:
This project resulted in the participation of two local development institutions of the boundary departments of Puno in Peru and La Paz in Bolivia.

1985

The hydrometeorological study of the Lake Titicaca was carried out, with UNDP funding, through a mission undertaken by engineers Julio Sanjinés and Vega Sedano for Peru. At that time, Messrs. Edgar Camacho and Luis Percovich were Ministers of Foreign Affairs for Bolivia and Peru, respectively; and the architect Fernando Belaúnde and Dr. Hernando Siles were the Presidents of Peru and Bolivia, respectively.

Comment:
It was the first joint hydrometeorological study carried out in the Lake Titicaca Basin. Furthermore it summarized most of the studies that had been carried out on the Lake individually by each country.

1985

The proposal of a mathematic runoff model was presented to the governments of Bolivia and Peru to determine the hydrological balance; the model was to be produced with UNDP funding. It was proposed by engineers Roger Berthelot from the UNDP, J. Sanjinés from Bolivia and Luis Vega Sedano from Peru. (It was rejected for lack of resources from Bolivia.)

Comment:
Here, in a preliminary manner, the hydrological balance of the basin was determined and actions were proposed in order to establish jointly the management of the water resources by both countries.

1985

Because of the flood in Puno and Oruro, technical assistance was requested individually and separately by Bolivia and Peru from the European Union; the latter sent a technical evaluation mission.

Comment:
Extraordinary floods occurred in the Lake Titicaca and the Desaguadero River in the 1984-1985 period. They affected various cities as well as the areas production and infrastructure. This worried the governments of Peru and Bolivia, who sent separate requests for support to the European Union. The latter sent a technical evaluation mission.

1986

Approval by the Bolivian Congress of the 1957 treaty.

Comment:
This an aspect that should be mentioned, because, even though the Peruvian Congress had approved the 1957 Lake Titicaca treaty almost immediately, Bolivia did not do so until 1986 due to various internal criteria on the matter. With the approval of Bolivia, the legal framework for the joint approach to the basin was consolidated.

1986

Presentation of a joint Peru-Bolivia proposal to the European Union to study the Peruvian and Bolivian tributaries, the annual precipitation, and the effluent through the Desaguadero River. The Ministers of Foreign Affairs at that time were Dr. Guillermo Bedregal for Bolivia and Mr. Alan Wagner for Peru.

Comment:
Based on the mission report of the European Union, the Governments of Peru and Bolivia jointly requested financial and technical support to undertake the joint study of the Lake Titicaca Basin, in compliance with what had been accepted in the 1957 Agreement.

1987

PAIF (*Proyecto de Apoyo a la Integración Fronteriza Perú – Bolivia*) is a project aimed at integrating the Peru-Bolivia border. It is funded by the Inter-American Development Bank, with the objective of studying transport, energy, tourism, fishery, agriculture, industry and commercial border exchange projects based on the Border Project initiated by the CAF in 1981.

Comment:
This constitutes an important contribution to the efforts toward integration and the joint work of both countries concerning the high plateau area. It 'rescues' the horizontal collaboration between institutions and experts from both nations, at the same time generating binational information on the subjects of transport, energy, tourism, fishery, agriculture, industry, and commerce; and it proposes joint development approaches.

1987

Creation of the Joint Bolivia-Peru Subcommissions (*Subcomisiones Mixtas Boliviana-Peruana*) for the execution of EC Projects and of the Integrated Hydrometeorological Study of Lake Titicaca.

Comment:
This is one of the most important executive actions of the Peruvian and Bolivian governments towards institutionalizing the joint management of the Lake Titicaca Basin, towards acquiring the funding and organization needed for the execution of the Binational Master Plan for the Peru-Bolivia TDPS System. The Joint Subcommission is presided over by the Ministers for Foreign Affairs of both countries and integrates the basin-related institutions. The Subcommission streamlines decision-making efforts.

1987

Fishery projects, incorporating SUBCOMILAGO and promoting OLDEPESCA.

Comment:
Fishery projects are carried out jointly in Lake Titicaca on trout resources and with the participation of SUBCOMILAGO. The latter was recognized and validated as the appropriate body for addressing basin-related issues.

1987 - 1988

Signing of financial and technical support agreements with the European Community and the governments of Peru and Bolivia, for the integrated study of the Peru-Bolivia TDPS System.

Comment:
These agreements provided the material basis for the request of the governments and for the economic base necessary to assure the execution of the Peru-Bolivia TDPS System Binational Master Plan.

1989

Creation of the Peruvian and Bolivian Offices for the execution of the Master Plan studies, and for the supervision, monitoring and support needed for the international enterprise selected for this purpose. A main Office was created in La Paz, Bolivia, and a support Office was set up in Puno, Peru, supervised by one Peruvian Co-director, one Bolivian Co-director and one European Co-director. The effort was supported by one expert from Peru, one from Bolivia and one from the European Union.

Comment:
The management organization was thus institutionalized to carry forward the Master Plan studies. The governments of Peru and Bolivia set up a binational structure with strong participation by the cooperation fund, represented by BDPA-SCETAGRI Consulting. This structure appoints the European Co-director and the technical assistant. Setting up the La Paz and Puno Offices ensures the flow of information in both countries on the Peru-Bolivia TDPS System, as well as the monitoring actions regarding field and technical activities. The tripartite Co-direction enables a suitable decision-making approach in the interests of both countries. This organization prepares the terms of references for the studies of the Peru – Bolivia TDPS System Master Plan.

1990

The European Community invited enterprises or consortia to submit tenders for the execution of the Master Plan, with 12 European enterprises competing. The work was awarded to a consortium formed by INTESCA of Spain, CNR of France and AIC Progetti of Italy.

Comment:
The transparency and impartiality of the selection process was thus ensured, as it was carried out directly by the European Community. The fact that the consortium selected for the execution of the studies was European ensured that the Master Plan would bring together and pursue the common interests of both countries, without any orientation towards the benefit of Peru or of Bolivia.

1991

The Tripartite Co-direction worked out the Specific Administrative and Technical Guidelines (IATE, 'Instrucciones Administrativas y Técnicas Específicas'). A contract was signed between the INTECSA/CNR/AIC Progetti consortium and the European Community for the execution of the studies of the Peru-Bolivia TDPS System Master Plan. The consortium began its activities in October with the creation of its offices, acquiring the presence of European experts, and hiring national technicians from Peru and Bolivia, as well as auxiliary and service personnel.

Comment:
The elaboration of the IATE was important, because it defined and oriented in detail the goals and activities of the Master Plan. Thus, the consortium had the necessary guidelines and orientation for carrying out the work.

The fact that the Terms of Reference explicitly stated the obligation of the enterprise in charge of the studies to hire national technicians ensured that the approach to the Master Plan was in accordance with the national contexts. Furthermore, it enabled the selected consortium to become acquainted with the hydrological, economic and social situation of the area of study, while technicians from both countries had access to the new progress in the various fields of work. It also gave this trained staff the possibility of participating in further execution phases of the Master Plan, facilitating its implementation for the benefit of both countries.

1991 – 1993

Execution of the Master Plan and approval by the Governments of Peru and Bolivia.

Comment:
During its four years of execution, the Master Plan benefited from the participation, on a temporary basis, of diverse European and national experts and technicians. As well the opinions of related institutions from both countries and from the population were welcomed towards the final phase of the document. Discussions and comments were kept strictly to the technical level, leaving political aspects aside. The governments of Peru and Bolivia approved the Master plan by an exchange of notes proposed by their Ministers of Foreign Affairs.

1990 – 1992

Participation of the Bolivia-Peru SUBCOMILAGO in the construction of the Ilo-Desaguadero road, and that of the Ilo Free Zone, with support from the United Nations.

Comment:
As well, the organization created the positive approach of both governments on binational matters that helped to secure the funding and construction of the Ilo-Desaguadero Highway, currently in service, as well as the granting by Peru, in favour of Bolivia, of a concession for the establishment of a Free Zone in Ilo. This strengthened the integration policy of both countries.

1993

Creation of the Binational Autonomous Authority for the Lake Titicaca Hydrological System – the Desaguadero River, the Lake Poopó and the Coipasa 'Salar' (ALT) System – by an exchange of notes signed by the Peruvian and Bolivian Ministers for Foreign Affairs.

Comment:
Thus the decision of both governments took force towards continuing their joint actions in the framework of the Peru-Bolivia TDPS system. The ALT is established by an *ad hoc* committee composed of a president elected by both Ministers for Foreign Affairs, Mr. Julio Sanjines, a noted Bolivian who had been fostering actions on the Titicaca Basin for many years, as well as by Peruvian Bolivian Directors, namely Messrs. Anibal Pacheco and Mario

Revollo (both engineers), who were part of the tripartite co-directorship in charge of the studies. Thus, continuity in the actions was achieved. The major tasks of the *ad hoc* committee were, with the support of international experts and the United Nations ECLAC, to elaborate the ALTs bylaws and manage different financial programmes in support of the ALTs actions. Support was obtained from the Andean Development Corporation (CAF) for project execution, from the Organization of American States (OAS) for the environmental diagnosis, and from the International Atomic Energy Agency (IAEA) for the study of evaporation through isotopic techniques.

1994

The ALTs statutes and financial and economic regulations were approved and the institution began operating.

Comment:
The statutes and the financial-economic regulations were approved first of all by an exchange of notes signed by the Ministers for Foreign Affairs of both countries. Afterwards they were approved by the Peruvian and Bolivian Congresses, and the corresponding laws were issued by the Presidents of both countries, thus aquiring the highest level of authority for these two normative ALT documents. In June, the ALT Executive President was appointed – of Peruvian nationality, compensating for the fact that the ALT headquarters were located in La Paz – Bolivia, as set forth in the statutes. The office was organized with similar participation of Peruvian and Bolivian professionals mainly in executive positions, thus promoting internal equity.

3. PERU-BOLIVIA TDPS SYSTEM MASTER PLAN

3.1 Previous actions

3.1.1 Funding agreement

The first step towards achieving execution of the Peru-Bolivia Hydrological System Master Plan (of Lake Tititcaca, Desaguadero River, Lake Poopó and Coipasa 'Salar' – or TDPS System) was to secure the necessary European Union funding. This was achieved through Agreement ALA/86/3 between the European Community and the Republic of Peru, which was signed on 11 September 1987. As well, Agreement ALA/87/23 between the European Community and the Republic of Bolivia was signed on 14 July 1988.

These agreements have the following main characteristics:

- They establish two programmes, one for the work to be undertaken nationally in each country, and the other of work to be executed by Peru and Bolivia in a coordinated manner.

- The goal of the programme of studies is the execution of the Peru-Bolivia TDPS System Master Plan through a contract with a specialized consulting firm.

- The Agreement with Peru was established by a total amount of 6 million (6,000,000) ecus, 3.35 million were allocated to the works programme, 2.15 million to the studies, and 0.5 million for incidental expenses. Funding was thus established at 5 million by the EC and 1 million by the government of Peru.

- The Agreement with Bolivia established a total amount of 5.5 million ecus (5,500,000), 2.3 million were allocated to the works programme, 2.7 million to the studies and 0.5 million for incidental expenses. Funding was thus defined as 5 million by the EEC and 0.5 million by the government of Bolivia.

- An important allocation was set for operating costs (400 thousand ecus in the case of Peru, and 600 thousand ecus in the case of Bolivia).

- Co-direction by a national co-director and a European co-director was established for the studies programme.

- Technical determination and approval of the studies is under the exclusive responsibility of the internal organization led by the national and European co-directors. Payments were to be made directly by the respective office of the EEC, after approval by the co-directors

- A duration of three years was established.

- Evaluation of the study proposals would be delegated to the EEC; the latter deciding on the most suitable one and submitting it for the approval of both countries (Peru and Bolivia).

One should bring out the agreement that the development of the studies programme was not only to be coordinated between both countries, but also to be executed in a joint manner. Therefore, a triumvirate was established for this purpose, composed of a Peruvian co-director, a Bolivian co-director, and a European co-director; thus ensuring unified leadership, criteria and methodologies for the Master Plan. Additionally, the provision of a budget enabled the establishment of a suitable team, and the logistics and personnel needed, for accompanying, monitoring and supervising the Master Plan studies. In this context, in addition to the co-directors, specialized professionals also participated as technical advisors: one for Peru, one for Bolivia and one for the EC. An office was established in La Paz, Bolivia and another one in Puno, Peru, thus guaranteeing support in the form of documentation and information, as well as for establishing the necessary contacts with institutions and individuals. This facilitated the contracting work of the consulting firm.

The agreements duration of three years provided the adequate time span for developing all the basic studies for the Master Plan, considering the vast area to be covered and the hydrological complexity of the Peru-Bolivia TDPS System.

The decision that the call for bids and the drawing up of the shortlist of candidates be done by an EEC delegation – enabling also participation of European enterprises – guaranteed impartiality in the studies execution, and strengthened mutual trust, for consultants were not involved in any of either countrys interests. This was a vital aspect for the conduct and execution of the work, as well as for the acceptance of the works results.

The decision that supervision should be the exclusive responsibility of the co-directors facilitated suitable decisions taken in the context of the local and immediate reality. Co-directors were freed from directly making payments to the consulting firm, thus avoiding possibilities of incorrect favoritisms towards it or from the consulting firm towards the co-directors.

In short, thanks to the detailed elaboration and methodological strategy selected for executing the programme of studies, the funding agreements became the guiding document for action, avoiding misinterpretations that could have led to the hindering of activities.

3.1.2 Terms of reference

The elaboration of the terms of reference for the execution of the Master Plan studies was another vital prior element. To this effect, a parity commission was created, formed of technical experts from Peru and Bolivia, who worked jointly to elaborate the terms of reference. It should be mentioned that every aspect was approached from an essentially technical perspective. This overcame the differences that came out between the delegations or the participating professionals, whose points of view were logically in coherence with their respective national interests.

The terms of reference initially presented the characteristics of the region regarding hydrological, production, soil, social and economic aspects, providing the proponents with a thorough knowledge of the environment. It was thereby defined that the Master Plan should consider the whole endorrheic basin of the Peru-Bolivia TDPS System, with special emphasis in the Lake Titicaca Basin, considering its significance within the System. It was established that the base studies should be binational in order to achieve an analysis and study of the base parameters in a complementary and interrelated manner. The Plan was defined as a document for planning regional economic development linked to the management and best possible use of its hydrological resources. The objective was to find the optimum balance between prevention and protection from floods, and production uses, without causing a loss or a decrease in the quality of water, or affecting the ecosystem. It should become an organizing instrument for the management of the Peru-Bolivia TDPS System, definitive to the greatest degree possible for the Lake Titicaca normative and flood-control programmes. It should also be preliminary to the various types of exploitation.

The terms of reference indicate the need for undertaking specific ground studies in different fields such as: socio-economics, hydrology, hydrogeology, geomorphology, fluviomorphology, topography, bathimetry, climate, hydrochemistry, contamination, etc., in order to provide all the system information needed to enable an adequate proposal for the Master Plan.

It also indicates the development of mathematic models for hydrological studies of the main basins as well as a global model of the whole Peru-Bolivia TDPS System, enabling simulation of diverse scenarios, in accordance with the systems management proposal. This is an important aspect: that of updating the Master Plan with the best information available, resulting in a Plan that will be dynamic.

An important element in the terms of reference was the requirement for presenting development project and activity proposals of a binational as well of national nature; including the presentation, in the form of financial portfolios, of two irrigation projects for Peru and two irrigation projects for Bolivia. This was thought to facilitate short-term financial management and execution of the Master Plan, and its immediate development once the document was finished and approved. In this context, a proposal of the management and execution organization of the future Master Plan was also to be put forward, in order to avoid the possibility that this effort by Peru and Bolivia for the joint management of the Peru-Bolivia TDPS System should remain only at the document level. These elements enabled further agreements for the joint management of the basin within an environment of integration by both countries.

Finally, it should be underlined that the terms of reference specified that the consulting firm in charge of the development of the Master Plan should, without fail, foresee a budgetary percentage for the representative participation of national technical entities pertinent to the studies, as well as of individual professionals from both countries. This was conceived in order to take advantage of local experience and knowledge, thus facilitating the access to information and promoting technological transfer and the training of technical staff from Peru and Bolivia.

3.1.3 Strategy

Establishing strategies for the elaboration phase of the Master Plan was an important step for its adequate development. It also diminished the possibility of greater conflicts caused by lack of prevision. Among the strategies was the agreement that the level of management should be mentioned: it should be at the highest level of authority in each Ministry of Foreign Affairs, coherent with both governments priorities in the elaboration of the Master Plan and their contribution to the integration of the document in question. These concepts were not necessarily conceived by government officials of lower rank in the two countries.

The elaboration of the document was conducted and oriented above all in a technical fashion, in order to avoid introducing concepts that could distort the established objective, or generating conflicts within the working teams regarding subjects of particular interest for either of the countries. This would have hindered the development of the study and the presentation of proposals. It is more feasible to have agreement and coinciding ideas in proposals and solutions if approached from a technical viewpoint.

It was considered and decided that, given the sensitivity of the hydrological resources subject – which is of particular interest to both countries and over which a great number of criteria and sensitivities could arise, at the levels of the regional authority and of the population – the elaboration of the Master Plan should follow the guidelines proposed by the technical team appointed for this purpose by both countries. Only after having been formulated and approved, the Master Plan proposal should be submitted for the consideration of other authorities and of the population of both countries, in order to obtain their contributions and impressions. This avoided conflicts that could have arisen from different classes or origins, whose vision could have been rather influenced by aspects of a political or chauvinistic order, distorted by subjective opinions not necessarily based on adequate knowledge and technical support.

The governments of Peru and Bolivia organized the Master Plan support and supervision structure. A binational technical team was formed, which on the one hand would facilitate gathering data from prior studies, maps, reports, among other things; and, on the other hand, would supervise, follow up and orient as needed, thus guaranteeing permanent follow-up of the studies. This would imply that the objectives targeted by both countries would be reflected in the Master plan. To this effect, the operation of this structure should be ensured of adequate funding resources.

3.1.4 Call for bids

The international call for bids process – conducted directly by the European Union by delegation of both countries – was performed in accordance with the terms of reference submitted by the two countries, and involved the participation of 12 European enterprises. The result was submitted by the European Union to both countries, with a shortlist of the three enterprises that ranked highest according to the EU qualification process. In this context, both governments had a favourable opinion of the enterprise ranked first. The contract was awarded to the consortium formed by INTECSTA from Spain, CNR from France and AIC Progetti from Italy. It is pointed out that this procedure avoided pressures and interests within any of the countries that could distort the call for bids process.

3.2 Master Plan preparation

3.2.1 Specific administrative and technical guidelines

The supervision team was made up of a Peruvian Director, a Bolivian Director and a European Director. They prepared specific administrative and technical regulations and guidelines (IATE) based on the terms of reference, on the consortium offer as well as on observations by the supervising team. The specific administrative guidelines were presented in May 1991.

On 2 July 1991, the co-directors and the technical team (Tripartite Supervisory Group) submitted, to the consortium representatives, the Specific Administrative and Technical Guidelines (IATE, approved by the presidents of SUBCOMILAGO) for developing studies.

3.2.2 Initial activities

The consortium began their activities on 15 October 1991, setting up their offices in La Paz, Bolivia, and an auxiliary office in Puno, Peru.
The office equipment included computers, office informatics, telecommunications, as well as drawing and field equipment. Technical, general, and service personnel were hired from both Peru and Bolivia.

3.2.3 Technical follow-up to the study

The personnel in charge of the studies were supported in specific matters by the headquarters of the consortium enterprises.

Diverse missions were sent by the European Community while the studies were being conducted; one of them was carried out by Prof. Jean Jacques Peters, and Drs. Alain Teyssonniere de Gramon and Harold Ter Hear.

The European Community appointed the French consulting firm BDPA-SCETAGRI to technically assist the tripartite supervision of the studies, with the support of a European co-director and technical advisory service personnel.

Joint meetings were held between the study offices personnel and the consortium technicians, to clarify terms of reference issues related to the preparation of the Master Plan.

3.2.4 Objectives of the study

According to the terms of reference, a Binational Global Master Plan should be established for control, conservation and sound use of the multiple resources of the TDPS System – mainly hydrological and hydrobiological resources – without jeopardizing the ecology of the region, and considering the possibilities of joint or separate use of these resources by Bolivia and Peru. In order to achieve this, the following should be accomplished:

- Study the problem of floods and droughts associated to the possible occurrence of extreme hydrological and climate events; estimate the negative socio-economic and ecological effects on the TDPS System by assessing the damage caused by these phenomena.

- Analyze the different alternatives for preventing and controlling floods and droughts, considered jointly with sound hydrological use, by determining criteria for the management and control of this resource, in association with economic, social and ecological aspects. For this, simulation models were to be used, that should facilitate the choice of the most practical alternatives within the guidelines established by the Master Plan.

- Carry out an integrated study to determine the volumes of water that could be used in the TDPS System without affecting the average rate of flow through the Desaguadero River and its interrelation with the control and prevention of floods and droughts, bearing in mind that neither the TDPS Systems ecology, nor other activities such as navigation, fishery and tourism, etc. should be affected.

- Develop the best alternatives in project identification; classifying them by their binational and national characters, as well as establish the technical and legal framework for the execution of priority flood and drought control and prevention projects, and for the sound use and management of the Lake Titicaca resources.

- In cases where the limited available information hinders reasonably reliable conclusions, an evaluation of achieved results should be presented, as well as the corresponding quantitative and qualitative orientations.

- A methodology for refining the Master Plan should be presented, in accordance with the best hydrometeorological information and other pertinent data that can be obtained through a plan of action defined for the study, of no less than 30 years.

The field and office-conducted studies and work, based the Binational Global Master Plan, for the TDPS System hydrological resources use, were organized by the consortium in coordination with the supervising team. Results of each of the studies are presented as separate documents in 23 Annexes.

3.2.5 The Master Plan preparation

The general organization chart of the TDPS System studies is presented below. Also presented, together with the basic studies, are their respective interrelated activities, as well as complementary and specific studies, alternatives for new projects, and, as the final result, the Binational Global Mater Plan elaboration. This consists of:

- Executive Summary

- Volume A

- Volume B

- 23 Annexes, five corresponding to the portfolios of the selected projects: the regulatory work, as well as the irrigation projects of El Choro and Chilahuala (Bolivia), Ilave and Lagunillas (Puno-Peru), according to the following outline:

  Diagnosis
  Diagnosis of damages caused by extreme events
  Geomorphology study
  Climatology studies
  Hydrology studies
  Hydrogeology studies
  Hydrochemistry and contamination study
  Fluviomorphology study
  Soil and erosion study
  Natural environment study
  Fishery development diagnosis and study
  Bathymetry and topography
  Water use and management in protected crops and optimization of greenhouses
  Water use and management in bofedales and optimization of the use of camelidae
  Irrigation projects and water needs in the TDPS System
  Water management in Lake Titicaca affluents
  Mathematic models for the TDPS Hydrological System
  Hydraulic management works in the TDPS System
  Bid folder for the regulatory work
  Bid folder for the Lagunillas irrigation system
  Bid folder for the Ilave irrigation system
  Bid folder for the Chilahuala irrigation system
  Bid folder for the Choro irrigation system

- **Data collection activities**

The gathering of available information such as existing data, studies and projects, has served as technical backup for the elaboration of the Master Plan.
In general, data-gathering activities included:

a) Selection of the meteorological observing networks, data collection and analysis (precipitation, temperature, evaporation, wind, etc.)

b) Selection of the hydrometric network (gauge point, river streams, Lake Titicaca levels). Control of the transport of solid materials and water quality. Diagnosis on the current state of seasons by means of field recognition, and elaboration of inventory cards with their characteristics.

c) Studies and projects in the fields related to climatology, hydrology, hydrogeology, hydraulics, socio-economics, agriculture, fisheries, etc.

d) Cartography, topography and thematic maps (geology, vegetation, soil, etc.)

Important contributions were made by the data collections of the libraries of the Lake Titicaca Special Project (PELT) of Peru and the Operative Unit of Bolivia (UOB) – where almost all the information from the different areas of study was organized – as well as of the SENAMHI (National Service of Meteorology and Hydrology) from Bolivia and Peru, and various other institutions in both countries.

The PELT and the UOB developed libraries with duplicated information filed equally in each of them. As well there were data bases created in the studies offices and in the whole TDPS System.

The existing information from all the topics studied has been revised and processed by the consortiums professional experts, in accordance with the most advanced (at the time) methodologies and mathematic models.

A general scheme is presented in the chart below:

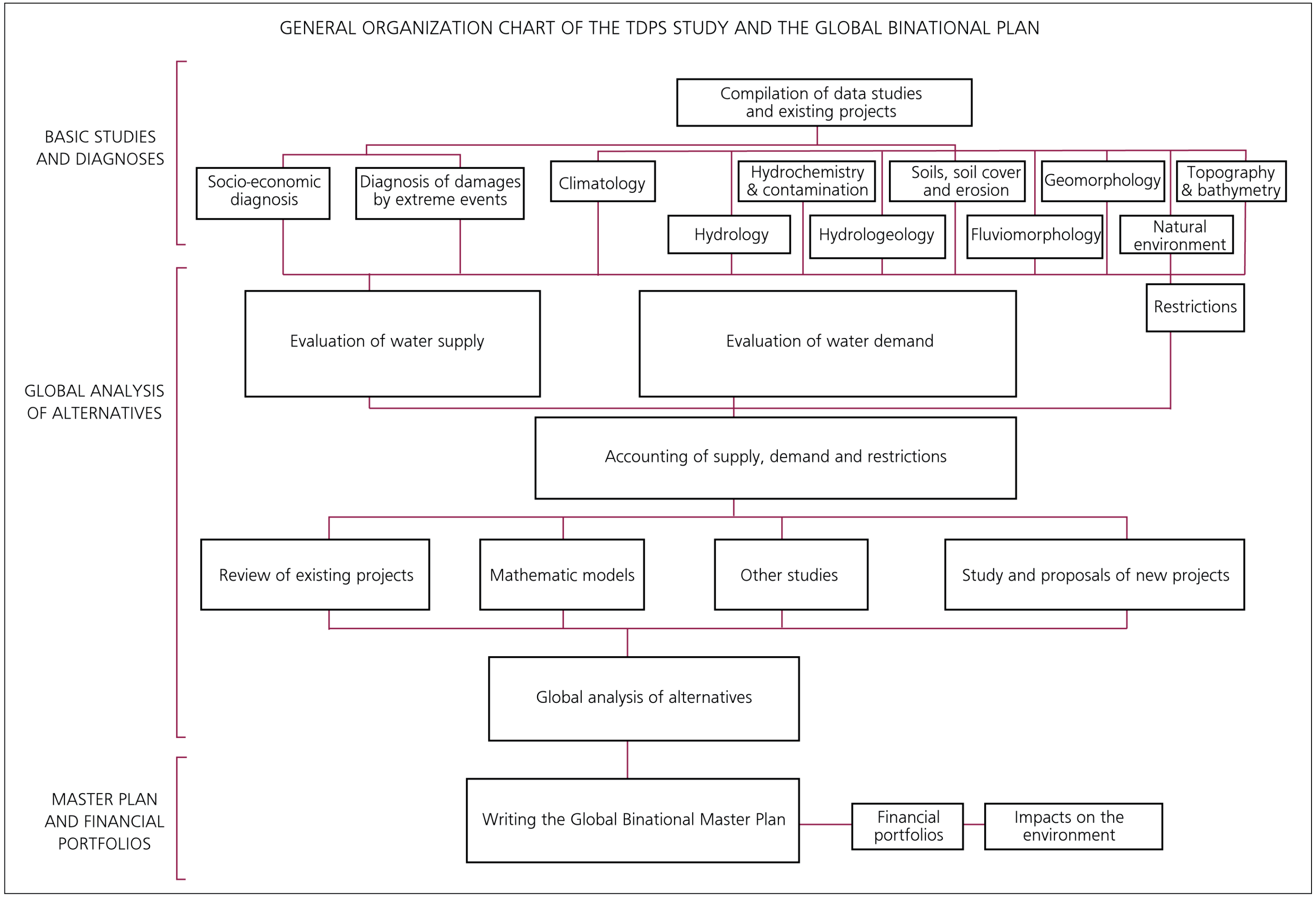

Figure 17. General organization chart of the TDPS Study and the Global Binational Plan

- **Development of the study**

As a strategy for the development of the Master Plan, it was pointed out that, judging by previous experiences, the expected results are limited when actions are conceived and undertaken in an isolated manner. Therefore, the work was done jointly by specialists, as well as by local and government authorities, with the active participation of the beneficiaries through seminars and workshops. The reaction was positive, for the participants were acquainted with the Master Plan themes, as well as with both countries willingness to jointly manage the Lake Titicaca Basin. Also the prior diffusion of the study objectives helped to achieve the finalization of the Global Master Plan. The Plan constitutes an instrument to achieve the rational use of the hydrological and hydrobiological resources in the Peru-Bolivia TDPS System, oriented towards making sustainable development possible in the Peru and Bolivia Altiplano.

The Master Plan was elaborated with the following orientations:

a) The use of water in irrigation projects, without jeopardizing other natural resources such as soil, vegetation, fishery, aquatic vegetation, among others, in order to promote the socio-economic development of the Altiplano.

b) Encouraging the governments of Peru and Bolivia to prioritize the investments needed for the execution of the work proposed by the Master Plan.

c) The projects to be defined should be sectoral with specific and module actions due to the varied conditions of the Altiplano.

d) Due to drought occurrences in the Altiplano, importance should be given to irrigation and hydrobiological projects. This means efficient water management, which should depend mainly on the binational work proposed.

e) Participation of the projects beneficiaries could be achieved if they receive previous training for offering support to the projects execution.

f) For economical-financial evaluations, the generation of social benefits should be taken into account.

g) The projects proposed in the Master plan should be constantly evaluated. This task corresponds to the Binational Authority.

The development programmes should contemplate generically the following aspects: rational use of hydrological resources to protect and prevent floods in the surrounding area, protect and mitigate extreme climate events, develop hydrobiological resources, recover and preserve the environment (erosion, sedimentation, salinization) and agricultural development.

It should be considered that the Master Plan emphasizes the updating and improvement, particularly the constant supervision, of the projects, with up-to-date and increased data. This should enable the improvement of available criteria for hydrological resources use. In this respect, mention has been made of the proposal for the improvement of the Master Plan, which most closely related to reality could have been named improvement and updating of the Master Plan. Actions foreseen are the following:

a) Technological transfer for the application of the models that have been used in the elaboration of the Master Plan.

b) Activities for widening and improving climate information such as:
- Setting up of new meteorological networks
- Setting up of evaporimetric stations
- Widening of the network for measuring global radiation G
- Setting up of an automatic meteorological network at Lake Titicaca

c) Increased hydrometric knowledge which shall include the following:
- Improvement of the existing hydrometric network
- Application of new techniques
- Programme for measurements and network maintenance

d) Improvement of mathematic models, as:
- Hydrological balance model for Lake Titicaca
- Affluent basins model
- Desaguadero River basin model
- Desaguadero River stream model

e) Programme for widening and improving knowledge on sediment transport and Fluviomorphology

f) Setting up of geographical information system (GIS)

g) Programme for classifying and selecting projects by means of multi-criteria analysis

h) Increasing the data base and bibliographic information, initiated by the PELT

By accomplishing these actions the following results are expected:

- Adjustment of the Lake Titicaca hydrological balance;
- Improvement of available hydrological knowledge about the system, particularly in zones with scarce available data;
- Improvement of regulations for the management of hydrological resources;
- Assist in the selection of viable projects; and
- Greater utility of executed projects and of available information.

Undoubtedly, one of the most important conclusions obtained in the studies carried out within the Master Plan, was the quantification of the supply and demand of hydrological resources in the TDPS System basin. It is the starting point for programming their use in accordance with decisions by the relevant authorities from Bolivia and Peru for the selection of irrigation projects. An advance in this sense is that the Master Plan included the tender proposal folders of the irrigation projects of El Choro and Chilahuala in Bolivia and Lagunillas and Ilave in Peru.

To achieve the simulation of the basins hydrological resources behaviour through the different parameters, as well as the of the Systems behaviour in general, diverse mathematic models were put into practice, such as:

- *Hydrological models*
  The programme used by the consortium was called SACRAMONTE, aimed at transforming rain into runoff for determining the rate of flow by basin.

- *Rate-of-flow models for Lake Titicacas affluent rivers*
  The programme used was MIKE11, designed for modeling water levels and the propagation of freshets in the Ilave and Ramis Rivers (Peru), in order to determine excesses and flood areas.

- *Runoff models for the Desaguadero River*
  The programme was: CRUETDPS, designed to model water levels and propagation of fleshets in the Desaguadero River, determining the hydraulic capacity of Lake Titicacas output and determining possible adaptations of the rate of flow (by lockgates, dredging).

- *Hydrological balance model for Lake Titicaca*
  The programme TDPSMOD was used to learn about the terms of the hydrological balance of the lake and in determining the usable rates of flow in sustainable conditions, without affecting the ecosystem.

- *Management model of Lake Titicaca affluents*
  The name of the programme is SIM-V. The goal is optimizing the measurement of the works in the lakes affluents with a view to its future use in exploitation projects.

- *Model for the generation of synthetic series*
  The model is called ESPIGOST, through which synthetic series are generated of the contributions to the lake for a database creation.

- *The Desaguadero River basin model*
  The programme is called TDPSMOD, for analyzing improvement alternatives for the Desaguadero River Basin.

The Master Plan studies were concluded in 1993.

3.2.6 Role of the Master Plan in the regions development

One important orientation of the Master Plan is to define the water and other resources management, as well as the management of the ALT, in support of the Peru-Bolivia Altiplano area, thus emphasizing its role as promoter of the social and economic improvement of the local population.

3.2.7 Master Plan approval

The preliminary version of the Master Plan was revised between the 13 and 18 September 1993 by professionals from both countries involved in the subject. For this a workshop was organized at Puerto Pérez (Bolivia), where a document was elaborated with the comments of the different working groups, which were as follows.

The 8th meeting of the Peru-Bolivia Joint Subcommission for the Development of the Lake Titicaca Integration Zone (SUBCOMILAGO) was held in La Paz in November 1995, at the Ministry of Foreign Affairs. During this meeting, it was agreed to approve the Binational Global Master Plan for the Protection-Prevention of Droughts and Sound Use of Resources in the TDPS System.

The document was signed by Harry Belevan, Ambassador of Peru in Bolivia, and President to the Peru section of SUBCOMILAGO, and Jaime Aparicio, President to the Bolivia section of SUBCOMILAGO.

On 6 November 1995, both governments approved the Master Plan in Bolivia through exchanged note SERIC-SPE-DGA-2006 and in Peru through exchanged note No RE 6-27. (NB: The Spanish term 'notas reversales', which was used in the original text, refers to an exchange of [diplomatic] notes.)

4. CREATION OF THE BINATIONAL AUTONOMOUS AUTHORITY OF LAKE TITICACA, DESAGUADERO RIVER, LAKE POOPÓ AND COIPASA 'SALAR' HYDROLOGICAL SYSTEM

Agreements reached in the IVth ordinary meeting of the Peru-Bolivia Joint Commission for the development of the Lake Titicaca integration zone (SUBCOMILAGO), held in Lima on 27 November 1992, set the way for the Ministries of Foreign Affairs of both countries to agree on the creation of a binational entity in charge of executing the Lake Titicaca, Desaguadero River, Poopó Lake and Coipasa 'Salar' (TDPS) Binational Master Plan (through exchange notes 6/36 and SBAP DGA/2400, approved on 12 December 1992).

Later, on 18 May 1993, through exchanged notes DGAP-DAS 67/09, of the Peruvian government, and SBAPE/DGA/1012 of 15 June 1993, issued by the Government of Bolivia, the name of the entity was formally recognized as the Binational Autonomous Authority of Lake Titicaca of the TDPS System Basin (ALT).

Through the same reversal notes, the nature, domicile, duration, and functional dependencies of the entity mentioned were defined as well as its objects, functions, personnel management scheme, economic-financial regime, legal responsibility of the institution, mechanism for conflict settlements, the modality for approval of the bylaws, the authorities and other matters.

In order to introduce the established definitions, in the exchanged notes of May and June 1993 and in documents that facilitate their application, the ALT bylaws were elaborated, as well as the Financial and Economic Management Regulations, with the participation of international and national consultants from both countries. Technical support was received from the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), and financial support from the Andean Development Corporation (CAF).

Another important milestone in the 1993 agreements was the creation of an ad hoc committee, headed by a president and appointed by the Ministers for Foreign Relations plus two directors, one from Peru and the other from Bolivia.

On 29 May 1996, through exchanged notes SERIC-SPE-DGA-609 and RE-6/75, the afore-mentioned documents were approved and entered into force. It is noteworthy that both countries committed themselves to incorporate or adapt these instruments within their respective legislations.

Given the importance of the ALT for Bolivia and Peru as an organization for integration, and in order to give it the adequate legal standing, the Congress of the Republic of Peru, through Legislative Resolution No. 26873 of 10 November 1997, and the Honourable National Congress of the Republic of Bolivia, through Law Nr. 1972 of 30 April 1999, approved and ratified the agreements which were subscribed to in exchanged notes by both nations, regarding the creation and functioning of the Binational Autonomous Authority of Lake Titicaca, Desaguadero River, Poopó Lake and Coipasa 'Salar' Hydrological System (ALT).

The operation of the ALT is regulated firstly by its statute. This instrument, in force since 1996, defines the ALT as an entity of international public law, with full management autonomy in the technical, administrative, economic and financial field and scope. It depends functionally on the Ministries of Foreign Affairs of Bolivia and Peru. Regarding its permanence, the ALT is an entity of indefinite duration. Its headquarters were established in La Paz, Bolivia, and it is headed by a Peruvian Executive President.

In order to legally authorize the establishment of the ALT headquarters in La Paz, a Headquarters Agreement between the ALT and the Government of Bolivia was signed on 15 April 1996. The agreement states the ALT shall enjoy the privileges accorded by the Republic of Bolivia to international organizations regarding the management of property, immunities and personal privileges.

The statute defines the main functions of the ALT which enable the latter to achieve the general objectives of the Authority: to promote and conduct programme actions and projects; to elaborate and ensure compliance of zoning, management, control and protection regarding water management in the TDPS Hydrological System in the framework of the Binational Global Master Plan of the TDPS Hydrological System, hereafter referred to as the Master Plan.

The statute defines as Master Plan all the work undertaken under the 'Peru-Bolivia TDPS System Binational Global Master Plan'. However, the Master Plan should also be understood as all the work that shall follow, which shall enrich and complete aspects contained within the Original Master Plan. The geographical area of influence should also be established, as well as the obligation of coordinating actions with the responsible entities regarding aspects of influence of the TDPS Hydrological System.

5. HOW DOES THE ALT OPERATE?

5.1 Transitional stage

The notes exchanged for the creation of the ALT provided for the establishment of an ad hoc committee to organize the institutions complete operation, create its basic governing documents such as its statute, and the economic and financial regulations, and to pursue financial support from international organizations. These tasks were achieved from 1993 to mid-1996: the Statute and the Economic Financial Regulations of the ALT were elaborated; financial support from the CAF was obtained for the Statutes elaboration and for studies of development projects for the Peru-Bolivia Altiplano, and support was received from the OAS for a programme on environmental macro-zoning of the Peru-Bolivia TDPS System, from the International Atomic Energy Agency (IAEA) for the evaluation study (using isotopic techniques) of the evaporation in Lake Titicaca; and from the Global Environmental Facility (GEF) for the binational project for the conservation of biodiversity in the Peru-Bolivia TDPS.

5.2 The ALT structure

According to its Statute, the ALT has an Executive President, who is the highest administrative and technical authority of the institution. The Executive President is appointed by exchanged notes signed by the Ministers of Foreign Affairs of Bolivia and Peru, and has two directors, also appointed by exchanged notes from the Foreign Affairs Ministers, one being Peruvian and the other one from Bolivia. One of the directors is in charge of the systems hydrological resources and the other one is in charge of the Master Plan. Advisory and support units for administrative, planning and legal matters are appointed by the Executive President. For those actions at the national level related to the Master Plan, there is the Lake Titicaca Special Project in Puno, Peru, with just one functional dependency on the ALT and an administrative and technical dependency on the National Development Institute (INADE), which is the Peruvian entity in charge of Special Projects, and the Operational Unit in La Paz, Bolivia, also with only one functional dependency on the ALT and an administrative and technical dependency on the Ministry of Sustainable Development.

The ALT staff are subject to a special regime, independent from civil service regulations in either country. They are under the direct and exclusive authority of the Executive President. Regarding their property and economic and financial regime, it is regulated by the ALT Economic and Financial Management Regulations, aimed at the administrative and financial management of resources obtained from governmental support or other funding sources, such as personal incomes, non-refundable cooperation from national and international organizations, donations and/or subventions, credits and capital goods, assets, property coming from national and international agreements. It should be stressed that operating costs, as well as both countries investments are covered by the two countries in an equitable manner.

As of 1996 the ALT started to organize itself and hired personnel in accordance with the rule of equal contributions from both countries under the parity principle as applied to government officials from Bolivia as well as from Peru.

The general lines of the ALT structure are presented below:

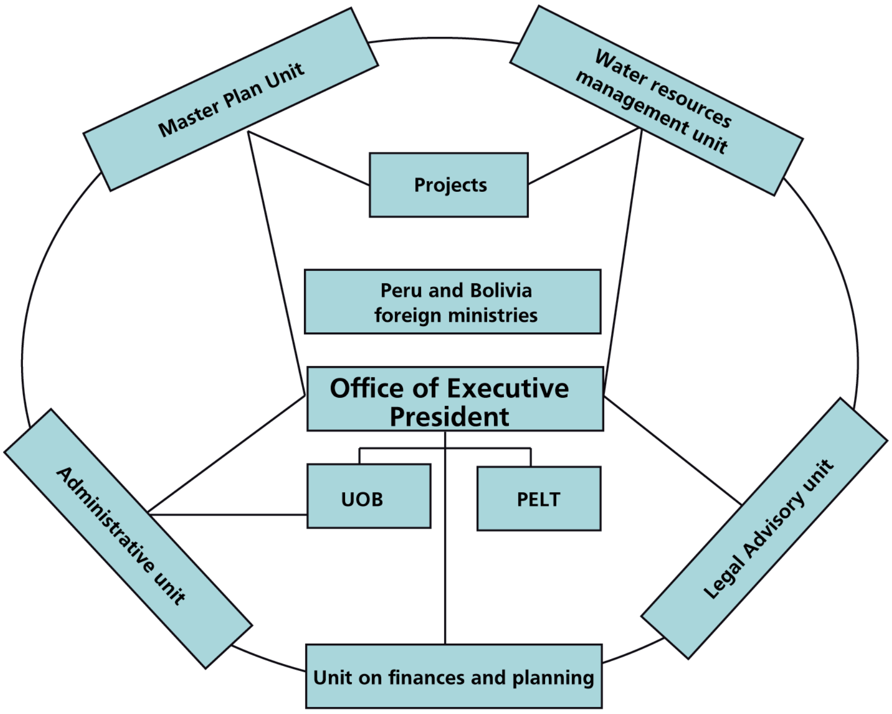

Figure 18. The ALT structure

5.3 Appointment of the ALT Executive President

The Executive President of the ALT was appointed by exchanged notes in June 1996, which meant the beginning of the institutions full operation. Both directors, the one from Peru and the other one from Bolivia were also appointed by exchanged notes, and the ALT structure was established as well, particularly taking the principle of staff parity from both nationalities into account, especially in directorial positions.

5.4 Financial resources allocation by Peru and Bolivia

In order to ensure the ALTs operation, both countries agreed by exchanged notes to an annual equal allotment to cover the expenses of a minimum approved structure. Regarding project execution, funding was considered within the countrys particular interests. In this context, it was agreed that work would proceed on the Desaguadero River regulating lockgate and the dredging in the Desaguadero River in its initial section as follows: Desaguadero (International Bridge) – Nazacara works were financed in equal parts by both countries.

5.5 Popular participation in ALT activities

Workshops and seminars are organized on a permanent basis and oriented toward both civil groups and rural organizations, to provide them with information on the ALTs role and the basic guidelines of the Master Plan, and to try to encourage their participation in the relevant ALT activities. In this context, regarding fishing activities, coordination and exchange between fishermen from both countries is being fostered in order to organize and make uniform this activity following the concept of sustainable use of the resource.

Moreover, through coordination with other municipalities, their active participation is being promoted, as well as that of the local population, in the execution of diverse projects hence supporting local community development.

5.6 International cooperation projects execution

While operational, the ALT conducted various international cooperation projects, namely:

5.6.1 Regional programme for institutional strengthening of the management and conservation of the Peru-Bolivia TDPS System natural resources

By an agreement signed between the Andean Development Corporation (CAF) and the ALT, on 31 January 1997 a total of US$ 239,000 was contributed by the CAF and US$ 321,000 from the ALT for this programme, carried out up to 30 May 1998 and achieving the following objectives:

- *Institutional consolidation.* Through contact with diverse international institutions, elaboration of the ALT Statute with the participation of international experts, the ECLAC, and national experts as well as an international seminar on basin management, as a Medium- and Long-Term ALT Development Plan was developed.

- *Project formulation and evaluation.* Development of situational diagnosis of projects on the Peru-Bolivia TDPS System, multi-criteria methodological schemes for project prioritization, analysis of homogenous projects, fishery development projects for Lake Titicaca, management and development projects on the lower basin, integrated use of the shores of Lake Titicaca, use of hydromorphic areas – wetlands (bofedales) management, diagnosis of natural resources in the Altiplano.

- *Hydrological models.* Hydrogeological studies were undertaken in the basins of the Ilave and Berenguela Rivers and in the Juli, Pomata y Yuguyo sectors, as well as of the pilot area of Chchillapi. Hydrogeological examination for drinking water supply for the Llapa Lapani community study on the water quality of the Maure River basin. Hydrometry of rivers of interest for the Peru-Bolivia TDPS System, sedimentation sampling during the rainfall period, hydrochemical evaluation of the Desaguadero River, Lake Poopó, and Lake Uro Uro. Simulation of new scenarios in the hydrological balance model of Lake Titicaca.

- *Financial management.* Various actions were taken to promote the Project 'Basic Hydrometeorological Network for the Peru-Bolivia TDPS System', and the latters registration as one of the pertinent bodies of Peru and Bolivia.

5.6.2 Environmental Management Plan of the Peru-Bolivia TDPS System

The Plan was developed under an agreement signed between the Organization of the American States, the United Nations Environment Programme (OAS, UNEP) and the ALT, between 1955 and 1999. Various studies and documents were made, which resulted in the following volumes:

Volume 0: Environmental Diagnosis of the Titicaca-Desaguadero-Poopó-Coipasa Salar System (TDPS).

Volume 1: Promoting the use of sound technologies for sustainable agriculture and cattle raising in the Peru and Bolivia Altiplano.

Volume 2: Preliminary management plans for the binational reserve: Natural Integrated Management Area of Titicaca-Mauri (Bolivia) and Aymara Lupaka Reserve Zone (Peru); Strategy for strengthening TDPS protected areas.

Volume 3: TDPS Biological Resources: Sustained Development Programme of totorals (cattail thickets). Promotion of fishing in Lake Titicaca. Biodiversity in the TDPS.

Volume 4: Pollution control in the Peru-Bolivia TDPS System: Diagnosis and proposals for control.

Volume 5: Socioeconomic diagnosis of the TDPS.

Volume 6: Complementary studies and programmes; proposal for the strengthening of community development in the Peru-Bolivia TDPS System area. Proposal for the promotion of tourism in the Peru-Bolivia TDPS System. Climatology. Microbasin management in the Peru-Bolivia TDPS System.

Volume 7: Programme for the institutional strengthening of the TDPS environmental management. Economic, institutional, and legal strengthening.

Volume 8: Peru-Bolivia TDPS System environmental zoning (13 maps and explanatory synthesis)

5.6.3 Analysis of Lake Titicaca evaporation through isotopic techniques

In the Lake Titicaca isotopic balance, the terms for the hydrological balance of the lake were obtained by means of isotopic techniques, deuterium and $O_{16.}$ The study was carried out, which in turn included further detailed studies on the state and distribution of contaminants on the shores of Lake Titicaca.

This project, like the preceding one, was conceived and developed in coordination with the entities in charge of nuclear technology in Peru and Bolivia: IPEN and IBTEN, respectively. The Peru-Bolivia TDPS System Binational Autonomous Authority (ALT) and the Titicaca Lake Special Project (PELTPUNO) also participate.

The national counterparts who cooperated in the study had the following tasks.

- Water sample collection in the humid as well as low water level periods
- Sediment sample collection
- Measurements simultaneous to sampling
- Obtaining hydroclimatological parameters
- Chemical analysis of heavy metals (IBTEN), water samples and sedimentation collected.

- Analysis and interpretation of laboratory results
- Displacement of technicians and support staff

The International Atomic Energy Agency (IAEA) contributed with:

- Equipment and reactive substances

- **General objective**

The objective of this study was to contribute to the sustainable development of the Lake Titicaca Basin through the use of nuclear techniques, as well as stating in a general manner the technical progress made that served as a basis for the future formulation of a 'Strategic Plan for the Control of Contamination in Lake Titicaca'. The Plan also had as its goal to quantify the levels and types of contamination in the different zones of this basin, and subsequently to foresee measures for the conservation of environmental quality in the Lake Titicaca ecosystem and its natural resources.

- **Specific objectives**

1. Selection of affluent water sampling spots, mainly in currents that flow across the population areas and the Lake Titicaca coastal zone.

2. Identification of the spatial distribution of anthropogenic contamination in the lake surroundings.

3. Evaluation of the water quality and sedimentation in the lake and its affluents, by quantifying the degree of contamination of anthropogenic origin and its actual and potential impact in Lake Titicaca as receptor body.

4. Compile and generate a database aimed at increasing the current state of knowledge in the surrounding area concerning the natural environment and pollution.

Nineteen sampling points were defined, basically considering the mouths of the affluents to Lake Titicaca.

5.6.4 Biodiversity Conservation in the Peru-Bolivia TDPS System

Project Biodiversity conservation in the Lake Titicaca-Desaguadero-Poopó-Coipasa 'Salar' (TDPS) Basin was approved for co-funding by the GEF (Global Environment Facility) Council on 15 February 1995.

The project was proposed for a period of seven years, with a total funding of US$4M (four million US dollars). Part of the funding would be covered by GEF ($3.11M) and the rest by a third funding source, to be governed by the Peruvian and Bolivian governments ($0.89M), supported by the UNDP.

Between September and December 1998 the governments, the executing agency (ALT) and the UNDP as implementing agency (IA) signed the project documents for Bolivia and Peru (Bol/98/G31 y Per/98/G32).

The documents state that the development objective of the project is the conservation and sustainable use of the Titicaca-Desaguadero-Poopó-Coipasa "Salar" (TDPS) System Basin through the design and implementation of community biodiversity, sustainable use and restoration activities, by:

a) Developing sustainable management plans for the three key ecosystems (cattail thickets [totorals], tholars [type of bush, which protects against erosion] and wetlands), to be adopted by the local TDPS communities.

b) Management of indigenous species (*suri*, *pisaca*, the lake giant frog, and native fish of the *Orestia* genus) based on technical knowledge, and commercializing them in accordance with sustainable harvest plans.

c) Establishing a planning, monitoring and evaluation framework for activities and future investments in the TDPS system, from the ecosystem perspective, and for the strengthening of local capacity.

Results:

Main results:

- Ecosystems

- Regarding *totorals* (cattail thickets), determination of their biological characteristics, as well as development of knowledge on quantities, volume and location. Planting techniques were put into practice, and other uses such as crafts and ethnotourism, development of manuals, training workshop organization and the *Totora* (cattail) Management Plan.
- Regarding wetlands, establishment of the soil and water characteristics; determination of the biomass, density and location; determination of the animal load; expansion of knowledge on the social and economic situation; establishment of sustainable management guidelines; and development of a manual on sustainable management of the wetland.
- Regarding tholars, the establishment of biological characteristics, development of knowledge concerning the social and economic situation; determining biomass, quantity and location; creating capacities for animal load; validating techniques for other uses, such as medicine, textiles, dyeing; elaboration of a Technical Manual on the Sustainable Use of the Thola; organization of training workshops.

- Species

- Regarding the *pisaca*: systematizing available information, determination of biological characteristics; creation of a pilot hatchery, validating incubation of eggs in captivity; design of cage system for breeding, elaboration of a Management Manual for the *Pisaca.*
- Regarding the *suri*: systematizing available information, determination of biological characteristics, creation of a pilot hatchery, validating incubation of eggs in captivity; design of cage system for breeding, elaboration of a manual for *suri* management and re-introduction.
- Regarding the lake frog: systematizing available information, determination of biological characteristics, establishment of quantity and location, validation of techniques for raising them in captivity, achieving reproduction in captivity, determination of other uses and economic value, elaboration of a manual for the sustainable management of the frog; organization of training workshops.

- Regarding indigenous fish: systematizing available information, acquiring knowledge on the behaviour of introduced species compared to indigenous ones; validation of technology for artificial breeding of the *mauri,* the *boga*, *suche*, *ispy* and *carachi*; proposal of fishery regulations; elaboration of technical manuals for the *mauri*, *ispi* and *carachi*; organization of training workshops.

- Protected areas :

- Study on extending the limits of the Titicaca Reserve. Study and proposal for the creation of the Titicaca-Mauri Reserve; development of diagnosis on flora and fauna and cultural inventory of the Reserve; organization of training workshops.

- Institutional:

- Diagnosis of the biodiversity situation in the Peru-Bolivia TDPS System; elaboration and proposal to the countries of the Biodiversity Management Plan for the Peru-Bolivia TDPS System.

The Project was concluded in September 2005. The general outline follows:

See figure 19. Chart of Biodiversity Project focus [Annex, page 96]

5.7 Master Plan projects

5.7.1 Lake Titicaca regulation works

• Background:

1. With the exchange of Notes N° 6/06 of Peru, dated 3 February 1997 and SNIC-SPEX-DAM-107 of Bolivia, dated 18 February 1997, the respective governments agreed on the execution of the 'regulation works project on Lake Titicaca'.
2. On 12 March 1997 under Of. Dec./c/056/98, the Prefecture of the Department of La Paz, and on March 13, 1997, under Of. N° 546-97-INADE-1101/GPSS, the INADE delivered a favourable statement with respect to the bidding conditions related to the regulation works project on Lake Titicaca, with a basic budget of US$ 6,252,640.05.
3. On 27 March 1997, under Presidential Resolution N° 29/97, the final assessment is approved.
4. On 2 and 3 April 1997, a public notice related to the International Call for Tenders (*Licitación Pública Internacional*) N° 01-97-ALT, is published in Bolivia and Peru for the execution the 'Regulation Works of Lake Titicaca'.
5. On 15 May 1997, proposals from contracting companies were received.
   Eight (8) bidders submitted their proposals.
6. On 8 June 09, 1997, under Presidential Resolution N° 064/97, the project related to Buena Pró was awarded to the consortium CEFOISA - E. Reyna C. S.A. Contratistas Generales Asociados, for the amount of US$4,853,296.45
7. On 1 July 1997 the agreement was signed, and on 21 November 1997 the contractual term was initiated.
8. The Buena Pró project was assigned to the consulting firm PCA-SERCONSULT, for the supervision of the work.
9. The work was concluded on 16 November 2001.

- **Justification**

The Lake Titicaca Regulation Works Project was a theme of the portfolio with respect to the Master Plan; based on this, the final assessment was carried out in four months. The execution of this project was the initial action in compliance with the recommendations included in the Master Plan, to allow the control of Lake Titicaca outflows and consequently, the mitigation of its extreme water levels caused by droughts and floods. This was to optimize the conservation of the hydrobiological resources and the utilization of water resources of the TDPS System, meeting the irrigation water needs along the axis of the Desaguadero River, to assure its equal utilization by Bolivia and Peru.

- **Description of works**

The regulation works were constructed in the Desaguadero River Basin, which constitutes the international border between Peru and Bolivia.

The regulation system consists of four Vagon-type gates, each one having its corresponding cofferdam, 9 m in width and 6 m in height. The whole electro-mechanical system was installed in a structure of reinforced concrete, composed of four pillars, supported by a base of reinforced concrete, which in turn is supported by 600 piles of 0.45 m by 0.45 m, with variable lengths of between 18 and 27 m. The whole structure weighs 28,000 tons.

The regulation structure is connected to the abutments of the International Bridge, by channeling (embanking) dams of 270 m in length, on both shorelines. In addition, the urban areas of the towns of Desaguadero in Peru and Bolivia were protected with lateral dams of 120 m and 1,300 m length.

The regulation structure consists of the following construction types: foundation construction by prefabricated piles, reinforced concrete structures, electro mechanic system, channeling dams both for lateral protection and complementary works.

By monitoring Lake Titicacas water levels, the flood effects on the lakeshore areas and the flood-prone areas of Desaguadero River should be mitigated.

Achieving the objectives of the regulation gates in the Desaguadero is dependent on the complete execution of the dredging works in the Desaguadero River in its initial section (Desaguadero-Nazacara, which is 65 km in length). For this reason, the operational works are interdependent.

Finally, the cost of the regulation work was US$ 7,200,000, of which the supervision cost US$ 1,000,000.

5.7.2 Dredging of Desaguadero River in its initial section

- **Background**

The assessment of the Desaguadero River dredging works, 65 km long in the initial section (Desaguadero-Nazacara), was carried out by ALT experts (1998).

This project, as set out in the Master Plan, was binational only up to 7 km distance from Aguallamaya, with an assessed capacity of 570,000 m^3, which was later corrected due to the detection of altimetric errors that caused the change of the dredging length from 7 km to 65 km, and from 570,000 to 3,500,000 m^3 of dredging, which resulted in a cost of US$ 11,500,000.

The dredging works started in September 1999, under direct administration, with the financial contributions of Peru and Bolivia, through the Institute of National Development (INADE) and the La Paz Departmental Prefecture, respectively.

Later on, five national biddings were called to carry out the dredging works under contract.

- **Justification**

Sedimentation of the Desaguadero River bed, in its initial section, results from suspended matter carried by run-off in waters discharged by the main tributaries of this river. The eroding effects of precipitation cause the sedimentation.

The formation of alluvial cones at the converging points of the Desaguadero with its tributaries, and the resulting sedimentation on its bed, is caused by its low gradient (1.59 cm/km). Under the final dredging project, it will be of 8 cm/km (0.00008 m/m). The first 40 km of Desaguadero River is actually a lake, of up to 5 km in width; in the Master Plan it is called Aguallamaya (which is also the name given to the town located there), where one of its main tributaries, called Jacha Jahuira, discharges on the left shore of the lake. The lake ends at this point, and the Desaguadero River bed is thence well defined, with an average width of approximately 50 m. In flood season, the alluvial cone of Jacha Jahuira River, at its confluence with the Desaguadero, obstructs the free flow of this river, causing a damming up further upstream, even causing the reversal flow of water, so that the Desaguadero River becomes another tributary of Lake Titicaca. This phenomenon used to occur before the execution of the dredging works in this 40 km section.

If the Desaguadero River bed of is not kept clear, the regulation gates will not meet the objectives, and vice versa; therefore, the dredging works are essential to allow the free flow of the regulated water from the lake, and permit the water to be used for the irrigation projects to be developed in Bolivia, using the corresponding water volumes that are assigned. It should be noted that on the Peruvian side, waters of the tributaries are used, whereas the Bolivian users take their water from Desaguadero River.

- **Description of the Desaguadero River dredging**

The first 40 km of Desaguadero River, which constitute Lake Aguallamaya, has the following hydraulic design characteristics: a gradient of 1.59 cm/km (0.0000159 m/m), slopes of 1:5 (1 vertical and 5 horizontal), and a base of 20 m. The initial point is at the bottom level of the Desaguadero regulation gates, which has an absolute altitude of 3,806 masl. From Aguallamaya up to Nazacara, the features are as follows: a gradient 1.59 cm/km (0.0000159 m/m), a base of 20 m, a slope of 1:2. A final design is being prepared, from Aguallamaya to 98,000 kilometers, trying to adhere to the dimensions of 3,500,000 m^3 and to a cost of US$ 11,500,000.
The Desaguadero River dredging works are being carried out with two hydraulic dredgers fitted with extra-long arms with a range of 19 m, which work from the river shores, and for the unreachable portions in the middle of the riverbed, they are placed on pontoons or barges. The contractor works with a dredger fitted with cutters and suction pumps.

- **Current Progress**

For the administration, the advance is US$ 6,480,000 and for contracts it is US$ 1,800,000, totaling US$ 8,280,000. This corresponds to 72% of the advanced funds.

The usable volume of water is limited to 20 m^3/s for each country, so as to keep the hydro-biological resources within acceptable limits. This volume should have been reviewed, with updated information on the corresponding variables. It also depends on the success of the Desaguadero River dredging works. The results here are interdependent on the Lake Titicaca levels and the operating rules of the regulation gates. Also, it should be taken into account that the success of the Desaguadero dredging works depends on the results of the basin and soil conservation management that is applied in the short term in the basins of the main Desaguadero River tributaries. Otherwise, according to the erosion rates recorded to date, within a period of about 15 to 18 years, the same volume of dredged sediment (3,500,000 m^3 at the cost of US$ 11,500,000) will have accumulated again.

As a result of the dredging activities carried out, benefits have been obtained in the form of a reduction in floodplains, meaning that agricultural and infrastructure losses have been avoided, as is indicated in the following table.

See table 6. Desaguadero River. Comparison of losses with and without dredging [Annex, page 99]

With regard to river dredging, for the elimination of sediments generated from the eroding effects of rainfall, one should consider, on a priority basis or simultaneously, relevant assessments of erosion monitoring and protection of the basins of their tributaries. With the execution of the erosion mitigation works recommended in this study, the investment made in the dredging works will be justified. Otherwise, sedimentation will occur again on the dredged riverbed. Moreover, by determining the sediment accumulation rate, the annual cost for dredging may be calculated and budgeted as an item of maintenance.

5.7.3 Studies of 'Partidor de La Joya' (Oruro-Bolivia)

The study related to the La Joya bifurcation works, the implementation of which took about seven months, was carried out at a cost of US$ 18,000.00.[1]

Relevant activities were carried out in accordance with the provisions under the Terms of Reference of the contract with the Lake Titicaca Binational Autonomous Authority (ALT) for the elaboration of the engineering aspects in relation to the tenders for the La Joya Water Regulation Works Project, foreseen in the Bolivia - Peru Global Binational TDPS Master Plan.

In the La Joya sector, the Desaguadero River is separated into two branches, where the water flow is naturally distributed in a disproportionate manner, causing irregularities in irrigation, with damaging consequences. These works will allow the Desaguadero River water to be directed to the right and left branches. The left branch will flow into Uru Uru Lake and the El Choro irrigation area, while the right branch will serve to drain the sediments and floods.

The final design was produced by the ALT, based on the proposal set forth in the Global Binational Master Plan, defining a set of optimum works for the derivation of required water flow. It was composed of the following elements:

- Damming up the left shore
- Retaining wall along the right shore
- A lateral spillway (overflow) in the retaining wall of the right shore
- Monitoring work in the Desaguadero River bed

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1 NB: 'partidor' = a mechanism, device or agent that divides, distributes or channels.

- Catchment work in the left branch and Soledad Channel
- Conduction channel for the flow of the left branch and Soledad Channel.

5.7.4 Basin studies

Considering that the sedimentation problem of the Desaguadero River must be studied in order to know the sedimentation rates of the rivers main tributaries, and based on such values, monitoring studies must be programmed with regard to the erosion caused by the rainfall, as well as developing management of the basins and deviation construction in the confluences of the tributaries. Budget provisions for the maintenance of Desaguadero dredging works should also be taken into account.

First, an agreement was signed by the directors of the hydraulic laboratory at the Universidad Mayor de San Simón, for the development of a sedimentation study in Lake Aguallamaya. Then, a second agreement was signed, for the elaboration of a study of the Llinqui River Basin. And finally, the agreement is being executed for the study of sedimentation influence in the Desaguadero River caused by the eroding action of rainfalls in six tributary basins.

The ALT is also studying erosion-monitoring measures in the Jacha Jauría River Basin, which measures include the digging of the infiltration trenches, planting terraced crops and contour belts, application of forestation programmes, design of flow-speed control structures in ravines and basin rivers, etc. These control measures will mitigate the eroding actions of the rainfalls, and the resulting accumulation of sediments that are deposited over the Desaguadero River bed.

6.0 OTHER PROJECTS IN THE MASTER PLAN FRAMEWORK

The ALT has been executing several development and support projects since 1996, among which the following are noted:

6.1 Study on erosion and sedimentation in the Llinki River Basin

This study was carried out by the Cochabamba Hydraulic Laboratory, Bolivia, and was submitted towards the end of 2004. The study indicates that preliminary analyses of sedimentation and filling that occur in Desaguadero River in the initial section, strongly suggest that most of the solid matter comes from the Llinki River Basin, and is mainly responsible for the obstruction of the main river, preventing the controlled drainage of Lake Titicaca water overflow and resulting in over-elevation of the water level. Thus great harm comes to the people living in the vicinity of Lake Titicacas shores.

The basin under study was called 'Alto Desaguadero' (upper Desaguadero), as referred to in the TDPS Global Master Plan (1993). This area is located in the northern part of the high plateau and in the surrounding mountain ranges, covering part of the high plateau in the department of La Paz, Bolivia, and a mountain ridge in the department of Puno, Peru, an area of 5,168,995 km^2 between latitude 16°16-17°22 to the south, and longitude 68°54-69°39 west, as shown in the figure.

Thanks to the study, knowledge has been increased regarding the processes and variables related to erosion and sedimentation of the Llinki River Basin, and it was possible to estimate the corresponding rates of such processes. As well, the following results were achieved:

- Thematic maps of the area under study were drawn up, such as maps indicating gradients, use of soils, vegetation, floodplains, and eroded areas.

- Setting up and operation of the projects GIS.

- Describing the sub-basins characteristics in order to determine the origin, transport and discharge of sediments.

- Identification of the areas most vulnerable to erosion and issuing recommendations of the most convenient and efficient hydraulic structures to be installed in order to monitor and prevent erosion.

See figure 20. Llinki River sedimentation and erosion map [Annex, page 96]

6.2 Utilization of the Mauri River water benefiting both countries

The Mauri River starts in Peruvian territory and ends as it flows into the Desaguadero River in Bolivian territory. Both countries agreed to study and analyze the best manner of water usage for their benefit. In the case of Peru, its interest lies in the assignment of water use to the Department de Tacna.

Based on the studies carried out by the ALT related to the projects in the Mauri River Basin, which is mainly located under the jurisdiction of the Municipality of Charaña, Pacajes Province in the Department of La Paz, the following projects were implemented:

- Irrigation project of Charaña

- Project on the improvement and extension of the system of potable water treatment for the people of Charaña
- Water harvesting project – Khotañas municipality of Charaña
- Forestation project on *"espina de mar"* (plant species group), Charaña municipality
- Interconnected Charaña – tripartite electrification project, Charaña municipality
- Digging of an exploration well – to be used to meet the basic potable water needs of the Charaña population
- Construction and installation of 43 shallow wells with hand pumps in the six Ayllus (agricultural communities) of the Charaña municipality
- Trout farming pilot project – Charaña municipality
- Project related to animal health campaign – Charaña municipality
- Water intake (bocatomas) in the Caquena River

See figure 21. Water intake in Bocatoma River, Caquena [Annex, page 97]

6.3 Final study of Botijlaca–Campero–Rosario road

A final study was carried out on the 106 km-long Botijlaca-Rosario road.

The study concerned the improvement of the section indicated, filling the present roadway with gravel or ballast, except for the Coro Coro stretch, where an alternative road of Sucre was considered. A geometrical improvement, following the design standards, was provided by the National Road Service. El Botijlaca-Coro Coro stretch is part of route 1511 of the departmental network, whereas the Coro Coro-Campero stretch belongs to routes 1519-1515-1450 of the municipal network.

Nine (9) bridges will be constructed, namely:

1. Chulluma, at 3.8 km from Botijlaca.
2. Komankollo, at 7.08 km from Botijlaca.
3. Colorado, at 9.4 km from Botijlaca.
4. Calajahuira, at 23 km from Botijlaca.
5. Viscachani, at 27.9 km from Botijlaca.
6. At 45.8 km from Botijlaca.
7. At 62.4 km from Botijlaca.
8. At 90.4 km from Botijlaca, before arriving at Rosario.
9. Rosario, at 92.6 km from Botijlaca.

These bridges are 4 m in width (one lane), sidewalks of 0.7 m and kerbs of 0.25 m in height

6.4 Electrification projects

The ALT carried out electrification studies to support the communities living in the area where the Desaguadero River dredging was to take place.
- Rural electrification in the towns of Ayllus Chijcha, Chijcha, Parina Arriba, Parina Baja, Aguallamaya, Janqujaqi Baja, Hiruitu Urus, San Pedro de Tana, and in District 4 Jesus de Machaca, the town of Viacha.

- Rural electrification in the agricultural communities of Ayllu Yaru Ingavi – Chouqe, in the jurisdiction of Jesús de Machaca, the town of Viacha.

6.5 Rainwater drainage studies in the city of Juliaca

The city of Juliaca, which is the second in importance in the Department of Puno, Peru, is located in the plains, which have serious rain drainage problems. Thus finding a solution for rainwater drainage is essential.

Problem: Temporary and long-term flooding of the city, causing a deterioration of quality of life.

Population: 192,596 inhabitants

The immediate cause of the flooding problem due to rainfall in the city of Juliaca is that the: 'Rain drainage system is insufficient'

The existing drainage system has 20.12 km of drains. This is only 20% of the coverage that is necessary.

Actions taken are as follows:

- A profile study was carried out and approved by the sector of Housing and Construction, and communicated by resolution N° 384-2003-Vivienda-OGPP on 6 June 2003.

- A pre-feasibility study was prepared and submitted to the OPI of Housing and Sewerage in October 2003, and reformulated by Letter N° 041-2004-ALT/PDAPCJ, dated 17 November 2004, for submission to the sector.

- Letter Nº 037-ALT-2005/PDAPCJ, dated 12 March 2005 submits the pre-feasibility study, raising the corresponding observations.

See figure 22. Photo of flood in Juliaca, Puno (Peru) [Annex, page 97]

6.6 Project on the wise use of Lake Titicaca shores

The objective of the project is the implementation of integral programmes of productive development in the shore areas of Lake Titicaca and other bodies of water, promoting the wise use of shore land, with the expansion of regional agricultural limits and giving the farmers the possibilities of economic alternatives to improve their socio-economic situations.

The Integral Use of Lake Titicaca Shores Project, on 5 November 2003, was defined as priority and requested by the Municipal Government of Tiwanaku, together with the authorities of the sector itself.

The project was approved and the financing agreement was signed between the Administrative Agency of the National Basins Programme (PPPNC) and the Binational Autonomous Authority of the TDPS Water System (ALT) on 3 February 2004.

Furthermore, action towards insuring the coverage of the total cost of the project was coordinated between the Farmers Academic Unit (*Unidad Académica Campesina*) of Tiwanaku – Bolivian Catholic University (*Universidad Católica Boliviana*) and the Municipal Government of Tiwanaku. This was for co-financing of part of the projects total cost.

The project is situated in the Tiawanaku Basin, located in the community of Huacullani, Tiwanaku Municipality, Department of La Paz.

The achievements are as follows:

1. Construction of 64 green houses for 254 beneficiaries, each green house corresponding to 4 families, and just 2 families remaining for one green house. The work progress to date is 100%.

2. Construction of irrigation channels for open field crops to be irrigated by pipes of 4", for an area of 12.16 hectares, of which 11 hectares are for Andean crops. This area is located between altitudes of 3,812.42 up to 3,811.36 masl with 100% completed.

3. Construction of raised fields for crops, over an area of 10 hectares, located at altitudes between 3,811.36 and 3,810.00 masl, with 100% completed.

4. Plantations of aquatic flora – totora (reed beds) in an area of 8 hectares in the community of Huacullani, with 100% completed.

Moreover, a training programme for the handling of solar tents and crop production was carried out under an agreement between the Academic Farmers Unit (*Unidad Académica Campesina*) – Bolivian Catholic University (*Universidad Católica Boliviana*) and ALT. This consisted of 12 modules in 6 months.

See figure 23. Photos of project on wise use of shores [Annex, page 97]

6.7 Binational Development Plan for the Peru-Bolivia Border Zone

The Binational Authority of the Water System of Lake Titicaca, Desaguadero River, Lake Poopó and Coipasa 'Salar' (ALT) and the Andean Community (CAN) have taken the initiative to execute a Border Development Plan between Peru and Bolivia in the Desaguadero River Basin, following the principle of integrating the two neighbouring countries considering that they share the same basin, customs, and that their cultural aspects are very much alike, and naturally their problems. In this framework, the relevant agreement was subscribed to by both countries.

The purpose is the formulation of a Binational Development Plan of the Peru-Bolivia Border Zone as an instrument for the planning and promotion of the socio-economic progress of their communities.

The document 'Diagnosis and Generation of the Binational Development Plan of the Peru-Bolivia Border Zone", has six sections. In the first section, the objectives, justification, methodology and delimitation of the basins are set out. The second section is entitled: 'Biophysical diagnosis' and includes seven chapters that describe the area in general (geology, geomorphology, climate and hydrology).

The third and fourth sections are entitled: 'Socio-economic diagnosis of the Peruvian and Bolivian sectors'. All the sections of this document and chapters with validated maps are included.

In the fifth section of the document, the FODA (feature-oriented domain analysis) of the area is included under each basin and description of characteristics, obtained through workshops and consultations with the people. As well, the potentialities and limitations of the study area are determined.

The sixth section, entitled 'Binational Development Plan of the Peru – Bolivia Zone', describes in detail the project proposal under each basin and thematic area, each with its characteristics and costs.

This study constitutes a contribution to the plans established between Peru and Bolivia for the Border Integration Zone (ZIF) of the Desaguadero River.

See figure 24. Map of Binational Boundary Hydrological Project development [Annex, page 98]

6.8 Eco-economic macrozonification of the Peruvian-Bolivian TDPS System

To map the Peruvian-Bolivian TDPS System thematically, data both from the field and in offices were used and were supported by a Geographic Information System (GIS), to produce maps related to soil coverage, population, altitudes, gradients, geomorphologic and irrigation areas. This allowed the combined analysis of the relevant parameters for the purpose of planning and proposing actions that will benefit the people of the area.

Studies were completed under an agreement between the ALT and Special Binational Project of Lake Titicaca (PELT) with the participation of the Bolivian Operative Unit (UOB). The Specialized Automated Studies Project (PEAE) of the Institute of National Development (INADE) was also consulted. The entire TDPS Basin water system was covered. Included were all the departments of Puno in Peru, La Paz and Oruro in Bolivia. This was carried out with the assistance of the Binational Authority of Lake Titicaca (ALT).

This study was presented in the city of Lima in the presence of the representative institutions of Peru and Bolivia, such as the Ministries of Foreign Affairs, Institute of National Development (INADE), Ministry of Agriculture, etc. Also present were Congressmen and labour representatives. The study results were finally submitted to the Ministry of Foreign Affairs for dissemination through them to other institutions. The report was also prepared in electronic and digital format for dissemination as appropriate.

6.9 Study of the fluvio-morphological behaviour of Aguallamaya Lagoon

As the hydraulic behaviour of a river is not static, the solid matter in suspension is dragged along by the water flow and by the forces acting in the bottom of the river. Such sediments are dragged from the upper parts of the main tributary basins and deposited (due to its low gradient of about 1.6 cm per km) on the bottom of the Aguallamaya Lake.

Thanks to data collected by experts of the Hydraulic Laboratory of Cochabamba – Bolivia (using the DELF 3D model), knowledge of the morphological evolution of Aguallamaya Lake has been improved. In addition, such research recommends projecting the ideal path of the dredging works. As well, after determining the erosion rates, it has been pointed out that if adequate erosion monitoring measures are not taken in the Desaguadero River, sedimentation will reach a volume similar to the level attained before the present dredging within an estimated period of 18 years.

Hence, the research recommends the implementation of a continuous monitoring and supervision system.

6.10 Plan of solid waste treatment in the city of Desaguadero

With the financial assistance of the Andean Community (CAN), the ALT developed the plan of studies related to the solid waste treatment in the city of Desaguadero, for both the Peruvian and Bolivian sides, recommending the joint management of this environmental problem. In this context, the relevant diagnosis was made by conducting a cadastral survey of both populations and determining the garbage volumes for a horizon of ten years as well as making a proposal for the waste management and the development of the corresponding sanitary landfills. The report of these studies was submitted at a special ceremony to the mayors on each side of the Desaguadero.

6.11 Programme for improved potato seed

The ALT contacted and agreed with the International Potato Centre (*Centro Internacional de la Papa*), established in the city of Lima, Peru, with the purpose of improving potato seed germplasm, developed for high productivity and the extreme climate conditions of the high plateau, and to test and validate such seeds in the high plateau. Based on the results achieved, the ultimate purpose is to promote the growth of such varieties in order to improve the social and economic conditions of the rural peoples of the region. At present, the project is in the validation phase in coordination with institutions such as the *Instituto de Investigación Agropecuario* (INIA, Agricultural Research Institute) in Puno, Peru and the Catholic University, Military University of Engineering and the University of Oruro in Bolivia.

The ALT took the initiative regarding this binational activity. As well, this programme is also related to the use of water resources and soil, to be implemented in the Peruvian-Bolivian high plateau with the application of traditional technologies such as cultivating crops in raised fields (camellones).

7.0 FAVOURABLE EXPERIENCES IN THE ALT FRAMEWORK

The establishment of the ALT has made possible the adequate management of the water resources of the Peruvian-Bolivian TDPS System, mainly as regards the management of Lake Titicaca, and orienting and directing its use binationally.

The Master Plan, when considering the supply and demand of available water resources, delimited the use of this important resource at a regional level, eliminating excessive or overly large expectations, even facing the realities of other regions.

The ALTs activities have confirmed the atmosphere of confidence existing between the two countries since the development of the Master Plan. This allowed an extensive and transparent exchange of information and molded a common idea and single objective regarding the management of the basin. These factors consolidated the integration between Peru and Bolivia, not only at governmental level, but also at institutional and individual levels among the various stakeholders of the region in relation to issues concerning Lake Titicaca. All of these previously mentioned factors form the basis for facilitating future actions and agreements between the two countries, in various common regional matters.

Having a document like the Master Plan orients and determines long-term objectives and serves as an important tool. It permits regional activities to be carried out with objectives that are defined and previously set forth and approved by both governments. Therefore, the ALT, in developing the Master Plan, was guided by clarity in the direction of its actions and investments. This has allowed the ALT to orient and carry out joint actions with other institutions committed to such regional works, facilitating in this way the promotion of allocated activities and projects.

The creation of a binational institution physically based in the region, has allowed opportunities for dialogue, for access to information on relevant issues, as well as an increasingly improved knowledge of the reality and needs of the people and the status of natural resources. These advantages allow the enhancement of the Master Plans proposals, giving place to dynamic attention to environmental problems, as well as an integral management of the various resources of the region from the standpoint of an adequate management of the two essential elements: soil and water.

The ALTs various activities, have allowed the exchange of technical experiences between institutions and professionals of both countries, thus enhancing the knowledge of participants and building capacity for the benefit of institutions and individuals.

Having brought about joint efforts of persons and institutions of both countries, synergies were created among them, and they continue acting together in different activities, even in actions not related to ALT, strengthening in this way the human and technical assets of the region.

It should be noted that, thanks to the nature of the issues dealt with by the ALT, people of different cultural and social levels are involved, and thus individuals of different social strata and walks of life are coming together, and the programme facilitates their actions and their understanding of the objectives.

The action of the ALT in itself has attracted the attention of the people and institutions regarding water and environmental issues, and it encourages their participation and commitment to find solutions to problems related to these issues.

The ALT in some cases has become an instrument of technical analysis of binational interest, facilitating the decisions taken by both countries through their Ministries of Foreign Affairs.

In order to prevent difficulties with the local people due to the lack of information about the ALTs objectives, workshops and seminars have been organized, but they are still insufficient. This action is limited mainly by the lack of financial resources for such purposes.

Although the Statute of the ALT establishes that its top authority is the Executive President, it also provides for the participation of the individual directors for policy, support, advice and consulting; this allows the institution to have a collegiate management, with a sharing of responsibilities.

The hydro-meteorological data, processed by the relevant institutions of both countries (SENAMHI) and by ALT, has turned out to be insufficient, since this kind of information is needed in real time on the Peruvian-Bolivian TDPS System. Such data are currently not being processed. And yet the methodology is to collect information from each station on a monthly basis for annual processing. This requires the development of a Basic Automated Hydrometeorology Network, to fall under the direct management of ALT, connected through satellites and allowing instant readings at the required moment.

The presence in the Peruvian-Bolivian high plateau of common ethnic groups – such as the Aymara, Uros, Puquina – as well as the similarity in the cultural identity of the regions people, have facilitated the binational actions of the ALT and underlined the Master Plans objectives.

The binational identification regarding the management of the Peruvian-Bolivian TDPS system, has avoided the threat of unilateral decisions that would have generated future conflict between the two countries. This was favoured by the fact that they have been traditionally united as brother countries by their interlinked histories and common interests.

8.0 OPINIONS OF BOTH COUNTRIES AUTHORITIES

In order to assess the perceptions of the Peruvian and Bolivian authorities regarding the issues of the Master Plan and the ALT, interviews were carried out as follows: in Lima, officials of the Ministry of Foreign Affairs, Ministry of Agriculture, Institute of National Development (INADE), National Institute of Natural Resources (INRENA), National Council of the Environment (CONAM) and Congressmen who represented the Region of Puno; in the city of Puno, officials of the regional government, municipality, Departmental Office of Agriculture, Association of Engineers; and in the city of La Paz, officials of the Ministry of Foreign Affairs, Ministry of Sustainable Development (MDS), Prefecture of La Paz, the army of Bolivia and in the city of Oruro, officials of the prefecture and Technical University of Oruro were interviewed. The following opinions were gathered:

Information on the Master Plan and the ALT is insufficient, so that it is difficult to have a general knowledge of their objectives.

The binational management established by the governments of Peru and Bolivia related to water resources of the Peruvian-Bolivian TDPS System was considered to be appropriate.

The establishment of binational management for environmental issues in the Peruvian-Bolivian TDPS System was also considered appropriate.

The need for coordination of the ALT with local institutions was pointed out, so that they might participate more effectively in support of the ALTs activities.

9. CONCLUSIONS AND RECOMMENDATIONS

C. It is necessary to disseminate, at all levels, an agreement on international water management for common knowledge of the objectives set.

R. To carry out studies and the projects recommended in the Master Plan, the ALT should create a working group of experts in information dissemination, training and extension work who should, beforehand, visit the beneficiary populations and those places constituting their working environments, and coordinate as is needed in order to avoid opposition from authorities and/or from the general population, often foreseen and calculated to extract some benefit.

C. Sector institutions of each country should take part actively in the agreements made for the joint management of the basin.

R. Within the ALT structure, a Technical Committee composed of representatives of those institutions involved in Master Plan and ALT subjects should be created in each country for periodical analysis of different aspects, taking decisions, and making commitments in a joint manner.

C. It is important to regulate those actions involving the operational entity in charge of implementing agreements.

R. The ALT should complete and update administrative as well as technical regulations in order to have an adequate operative framework.

C. It is important to achieve collegiate participation in the management of an international organization dealing with subjects of national interest.

R. Those responsible for the management should actively participate in the decisions taken by the authority and should not rely solely on the Executive President. Therefore, the Executive President and those responsible for management should create a board of directors.

C. The Master Plan should constitute a dynamic document updated permanently.

R. The ALT should consider and prioritize activities for updating the Master Plan in order to handle the variables and parameters that propitiate an adequate ALT strategy regarding the management of the Peru-Bolivia TDPS System.

C. External control mechanisms should offer adequate guaranties to the institution itself as well to the tutelage.

R. Regarding yearly external audits, the ALT should establish terms of reference giving the auditors adequate independence and clearly stating the scope of their work, which should adequately coincide with ALTs technical and administrative management.

C. The hydrometeorological data and information available to the ALT have been insufficient and out-of-date for the purposes of the institution.

R. The ALT, supported by the governments, should take the necessary managerial steps vis-a-vis the international organizations concerned for implementing the

Automatized Hydrometeorological Basic Network (*Red Básica Hidrometeorologica Automatizada*). The network is connected by means of satellite signals, so as to have access in real time to the parameters needed.

C. The organizations operation was affected by the variations and timeliness of the countries financial support.

R. The governments of Peru and Bolivia should authorize a prioritization in their respective annual budgets vis-a-vis the corresponding bodies, in order to ensure adequate funding for the activities foreseen in compliance with the recommendations of the Master Plan. Otherwise, it would be tantamount to ignoring the efforts made to obtain the funding for the Plans development, and to jeopardizing the achievements of the studies final goals and the work performed to date.

C. The binational management of the Titicaca Lake Basin required parallel treatment and understanding of legal, technical, social and economic matters.

R. All similar endeavours aimed at the management of an international hydrological basin should work first toward political decisions at the highest possible levels, to be able then to proceed in parallel on legal, technical, social and economic matters.

C. During the development of the Peru-Bolivia TDPS System Master Plan, the technical theme was given priority over other concepts, thus permitting advancement in the diverse subjects considered.

R. During the elaboration of a binational management plan of an international basin, technical aspects should be given priority over other considerations.

C. Given its technical and scientific nature, the ALT develops dynamic studies on hydrological and hydrobiological resources, proposes equitable distribution of water between Peru and Bolivia, looks after these Peru-Bolivia TDPS System resources and, above all, fosters a comprehensive outlook towards the integration between the two countries. The ALT analyses and does research on a permanent basis regarding the operational rules of the regulation structures lock gate system, simulating in different exercises the various rates of the flows in Lake Titicaca by means of simulation models. This is done in order to adapt the control systems operation to the variations of the lake levels, so that the different rates of supply will meet the annual water demands and availability as stated in the Master Plan. This activity constitutes a monitoring mechanism to avoid the extreme maximum and minimum levels that have occurred in the lake, which is one of the reasons for the ALTs creation.

R. In similar cases, particular attention should be given to the technical and scientific knowledge of the basin under study in order to launch actions that will result in the best possible management conditions to be proposed for the hydrological system.

Evaporation in the lake is a very important factor in calculating the hydrological balance. It is the most important variable towards describing this phenomenon quantitatively and the most difficult one to calculate by means of conventional methods such as evaporation pans and their variants. This is due to the heterogeneity of the physical conditions in the 8,400 km^2 covered by the lake, in addition to the extreme meteorological conditions.

R. It is imperative to continue, with international technical and financial assistance, the research initiated in order to obtain consistent values and refine the hydrological balance of the Peru-Bolivia TDPS System.

C. The ALT, in its nine years of operation, has evolved from the elaboration of its statutes, regulations and legal devices, to acquiring knowledge on the physical, meteorological, socio-economic, and other related factors of the Peru-Bolivia TDPS system environment. It has worked in coordination with competent national authorities and been technically guided by the studies done for the elaboration of the Master Plan and its recommendations. Peruvian and Bolivian professionals, working jointly and motivated by the particularities of this great geographical scheme with a lake so important for the development of the Altiplano inhabitants of both countries, have succeeded in combining ideas, projects, needs and expectations vital for channeling requests for support to international entities.

R. To encourage the participation of the Foreign Affairs Ministries towards obtaining international financial support aimed at strengthening the ALTs activities.

C. The methodology in the elaboration of the Master Plan and in the creation of the ALT demonstrated that the concept adopted for the Lake Titicaca Basin management is effective and that the experience can be replicated in similar realities.

R. The basic elements to be taken into account when implementing the joint management of a basin similar to the Peru-Bolivia TDPS System:

- Reach political agreement at the highest level possible
- Create a binational organization to be in charge of the subject at the very beginning
- Technically manage programmes
- Make agreements and exchange information in a transparent manner
- Ensure funding for those activities required by the studies
- Favour the participation of an impartial entity to develop the study and the proposal
- Obtain approval of the studies by the cooperating countries at the highest possible level
- Create a joint structure from the participating countries for the basin management
- Develop and approve an adequate regulatory framework for the institution
- Ensure funding for institutional operation, to be provided by the participating countries.

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Figure 1. Lake Titicaca Basin general location map

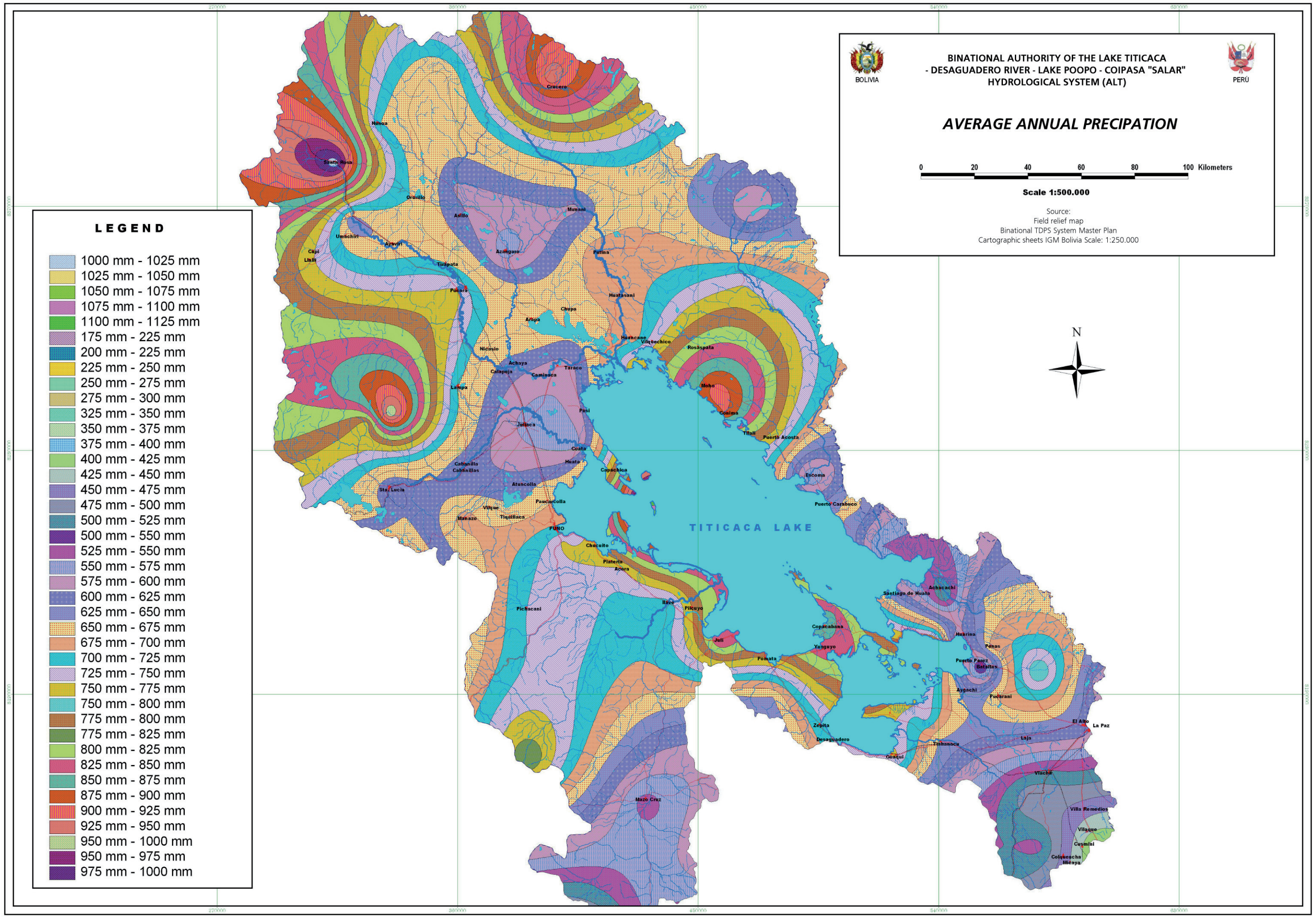


Figure 2. Average annual precipitation map

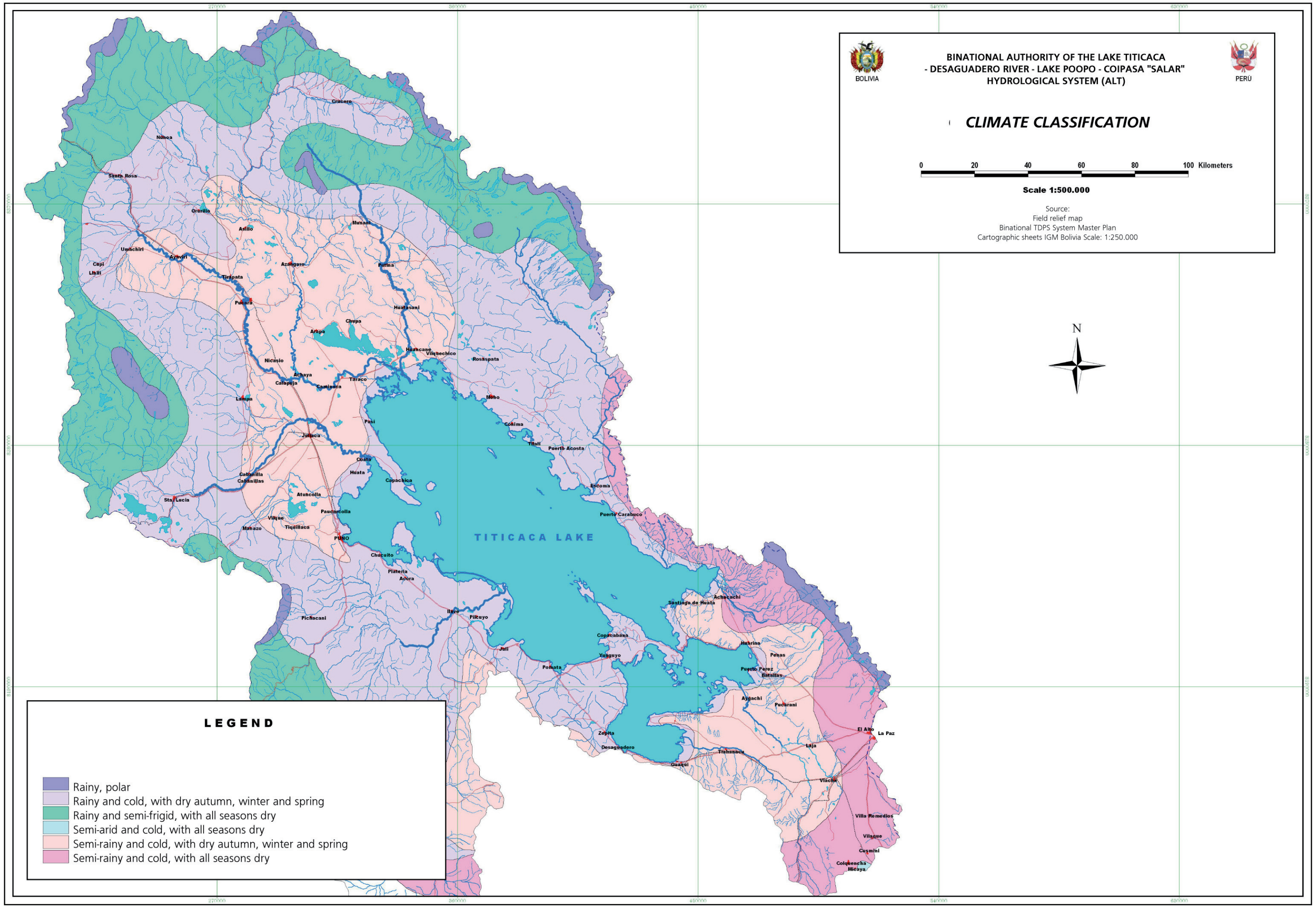


Figure 3. Climate classification map

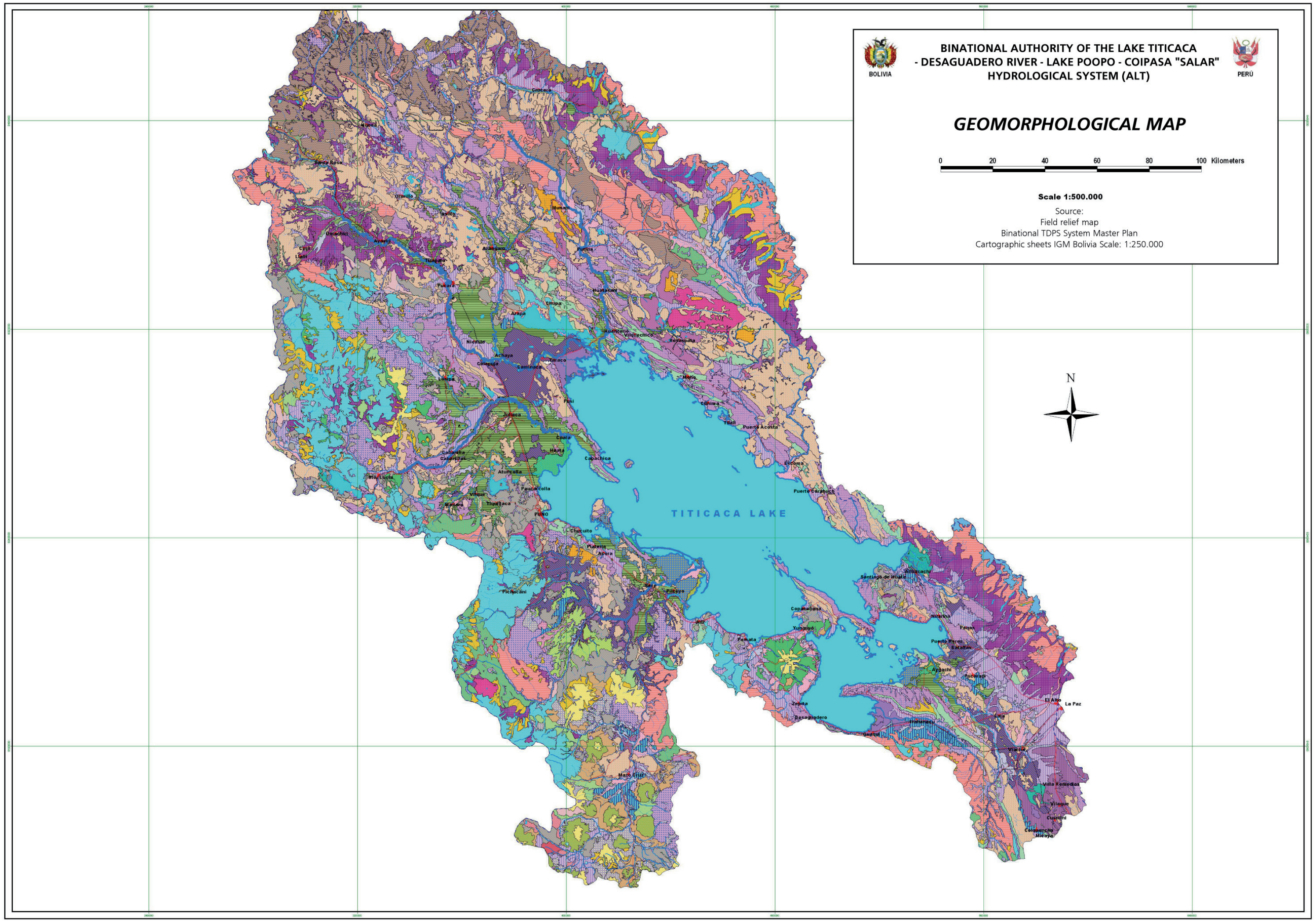


Figure 4. Geomorphological map of the area

LEGEND

- Rocky outcrops.
- Hydromorphic areas.
- Hills composed (or structured) of sedimentary substrata in dissected and substantially fractured forms, with elongated and sharp crests and variable slopes.
- Hills composed of sedimentary substrata in rounded forms and medium slopes, colluvial cover locally thick and substantially fractured ('cortada').
- Volcanic hills in dissected and substantially fractured forms, variable slopes.
- Volcanic hills in rounded forms and medium slopes, colluvial cover -- locally thick and substantially fractured.
- Satellite cones.
- Cones and volcanic 'aparatos' (type of formation) of the first order of relative minor slope (moderate to strong) and generally with major proportion of material.
- Cones and volcanic 'apparatos' of second order rising up much more, of greater breadth (scope) and dissection, steep slopes sometimes covered in snow.
- Colluvial and alluvial deposits.
- Colluvio-fluvial deposits.
- Sand deposits.
- Fluvial deposits.
- Glacio-fluvial deposits.
- Muddy macrophite.
- Undulated shallow bottoms.
- Rarely flooded.
- Periodically flooded.
- Island.
- Lake.
- Lagoon.
- Fluvio-lacustrine plain.
- Lacustrine plain.
- Flood-prone lacustrine plain.
- Plateau of lava and ignimbrites with original surface recognizable but degraded and dissected and with outcrops of Tertiary sedimentary substrata, dissected and considerably fractured.
- Plateau of lava and ignimbrites with subhorizontal surface slightly inclined and/or undulated, conserved and only slightly fractured, with a subparallel drainage and moderately linear erosive laminae concentrated in the 'canales'.
- Plateau of lava and ignimbrites with a considerably dissected surface with rocky outcrops.
- Plateau of lava and ignimbrite subtrates, covered with a layer of tuffs and 'interstratified' sediments. Irregular surface; undulated and with fractures of fine drainage; moderate to severe laminae and linear erosion.
- Volcanic plateau with subhorizontal or slightly inclined surface, conserved and slightly fractured.
- Volcanic plateau strongly dissected, dense drainage, slightly inclined.
- Sedimentary mountains structured by irregular forms, dissected and considerably fractured with elongated and sharp crests, glaciated sides of very high and steep/sheer tops ('cirros').
- Sedimentary mountains structured by medium to high rounded and steep-sloping forms, abundant colluvial cover, moderate to severe laminae and linear erosion in 'carcavas' (gullies) over the colluvial mantle.
- Sedimentary mountains structured by medium to high rounded and steep-sloping forms, abundant colluvial cover, moderate to severe laminae and linear erosion in 'carcavas' (gullies) over the colluvial mantle.
- Volcanic mountains of irregular, dissected and strongly fractured forms, slopes of very high and glaciated tops.
- Volcanic mountains of rounded forms, medium to high slopes; uniform, with dense colluvial cover.
- Moraines.
- Snow-covered.
- Snows.
- Beaches and sand bars.
- Beaches and stony bars.
- Important river.
- Main river.
- Surface of conserved 'puna' erosion originated in the intense Miocene period of erosion with processes of peneplane formation.
- Surface of dissected 'puna' erosion, similar and associated with the above-mentioned but with more dissection and undulation.
- Dissected and inclined structural surface, covered by a mantle of tuffs and 'interstratified' sediments; irregular undulated surface with outcrops.
- Inclined structural surface, considerably altered, sedimentary.
- Inclined structural surface considerably dissected (volcanic).
- Inclined structural surface considerably dissected (volcanic).
- Inclined sedimentary structural surface.
- Inclined volcanic structural surface.
- Lacustrine terrace with conserved undulated surface with numerous small depressions, slightly fractured.
- Lacustrine terrace with conserved flat surface, slightly fractured.
- Lacustrine terrace with degraded and completely obliterated surface with outcrops of Tertiary sedimentary substrates.
- Lacustrine terrace with undulated surface with numerous depressions, slightly fractured.
- Lacustrine terrace with ondulated surface with numerous small depressions, slightly fractured.
- Lacustrine terrace with ondulated surface with numerous small depressions, slightly fractured.
- Dissected lacustrine terrace.

Figure 4. Legend for the geomorphological map of the area

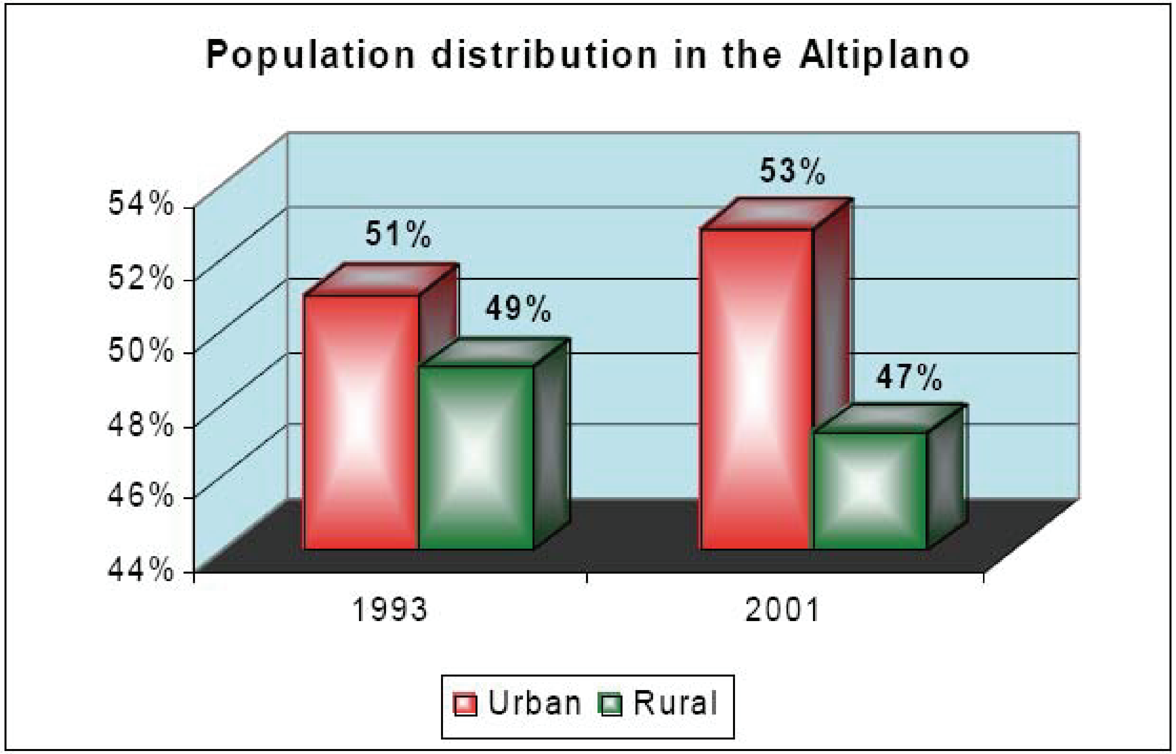


Figure 5. Population distribution in the Altiplano

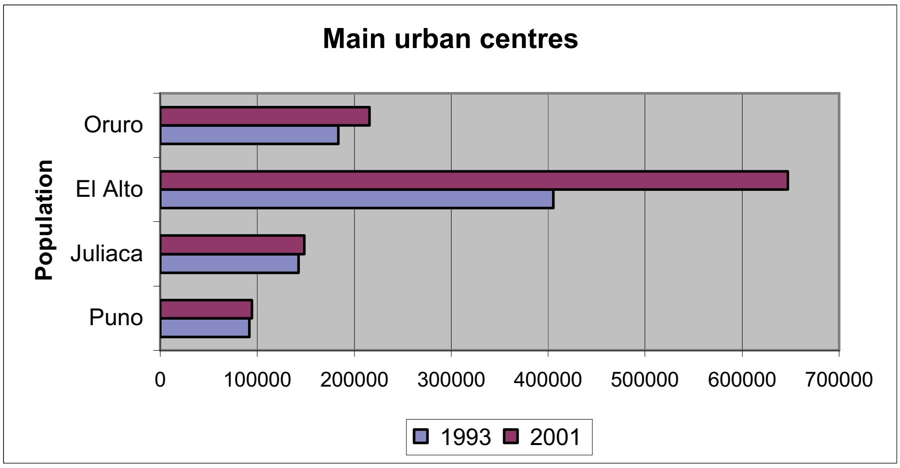


Figure 6. Main urban centres

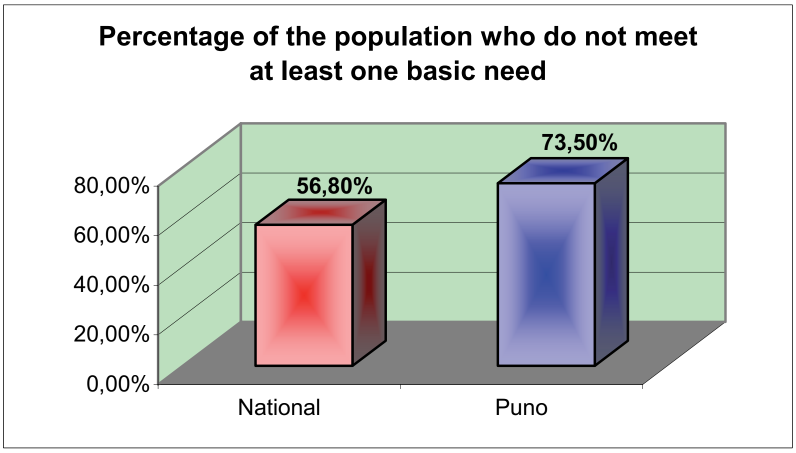


Figure 7a. Population not meeting at least one basic need (Peru)

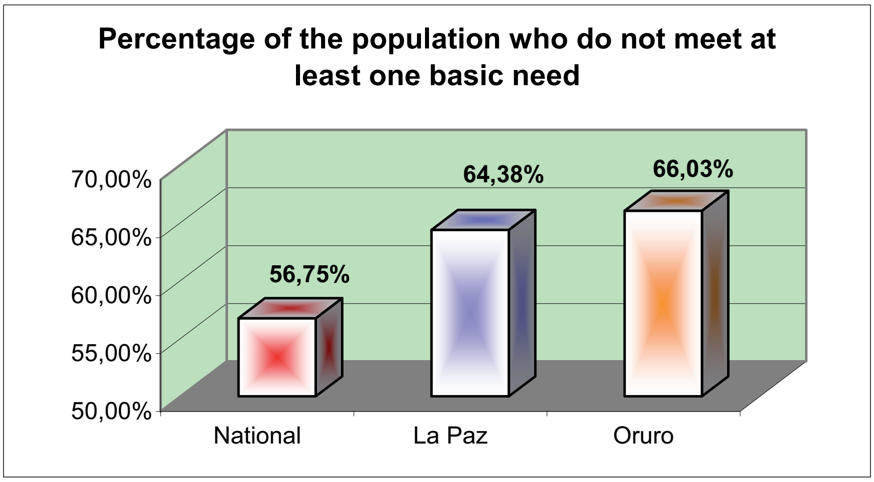


Figure 7b. Population not meeting at least one basic need (Bolivia)

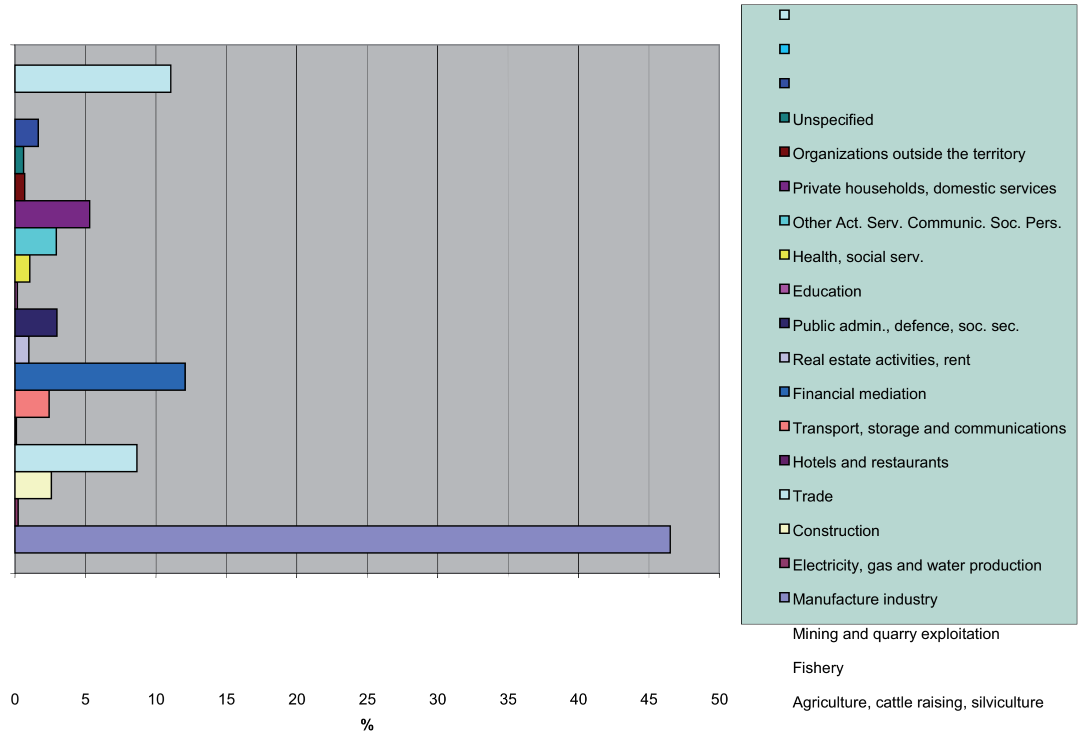


Figure 8a. Economically active population (EAP), Puno (Peru)

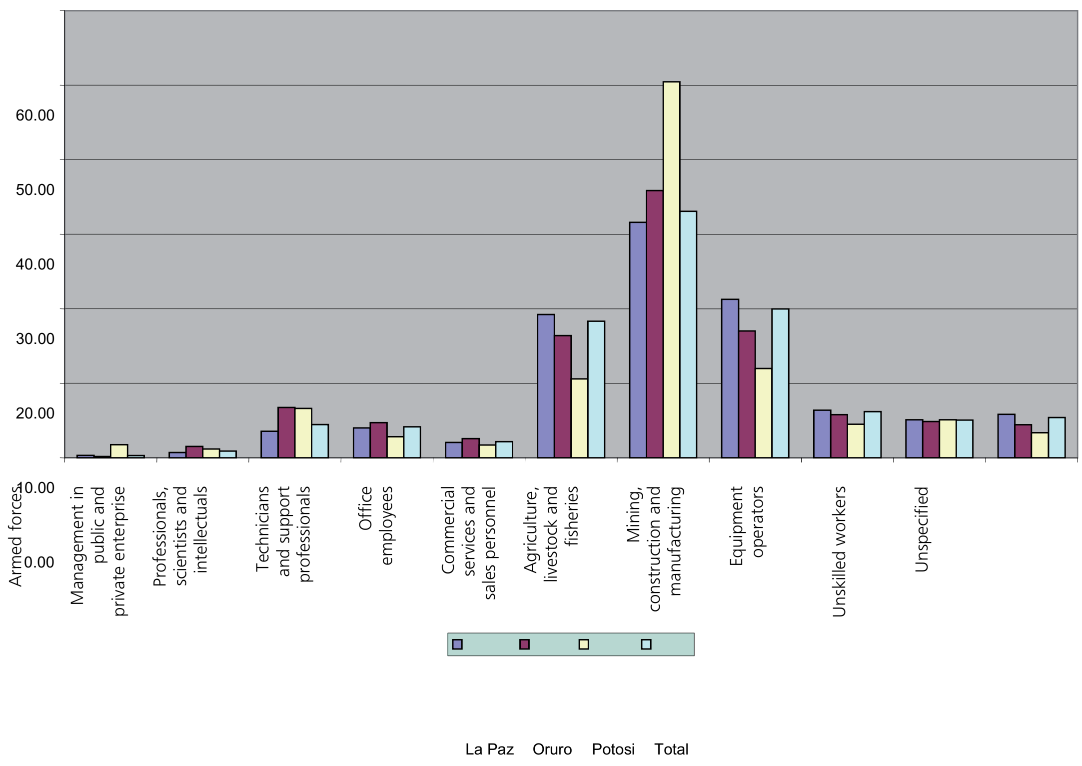


Figure 8b. EAP in La Paz, Oruro and Potosi (Bolivia)

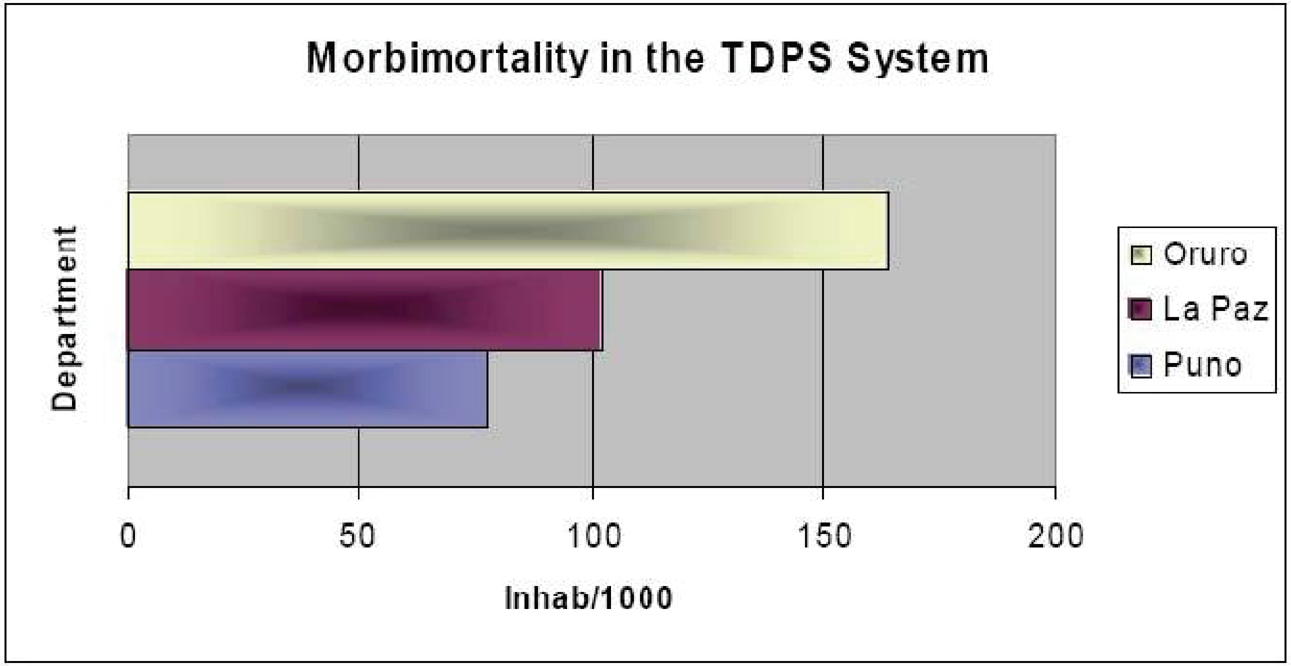


Figure 9. Morbimortality in the TDPS System *(Note: morbimortality = a combination of morbidity and mortality rates.)*

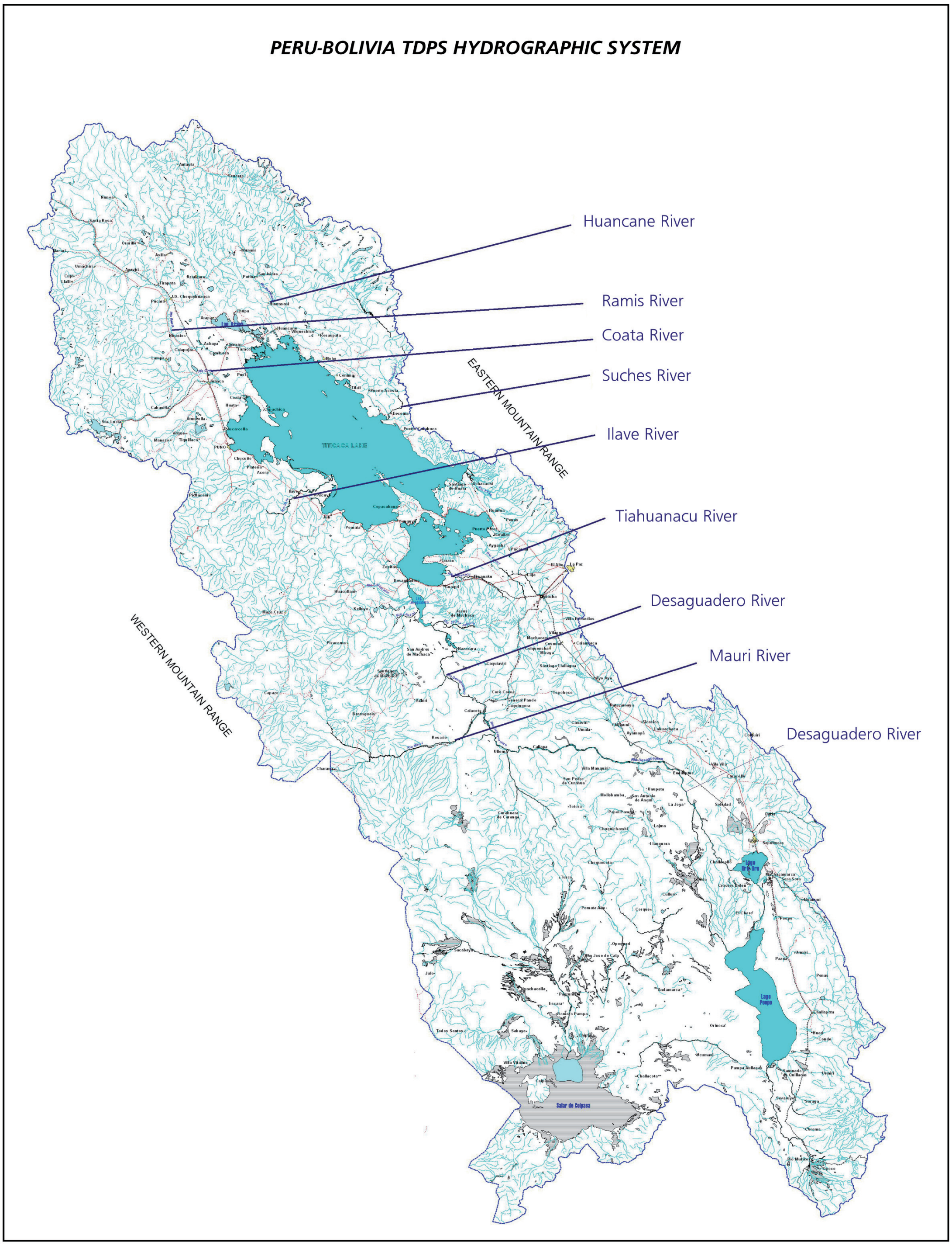
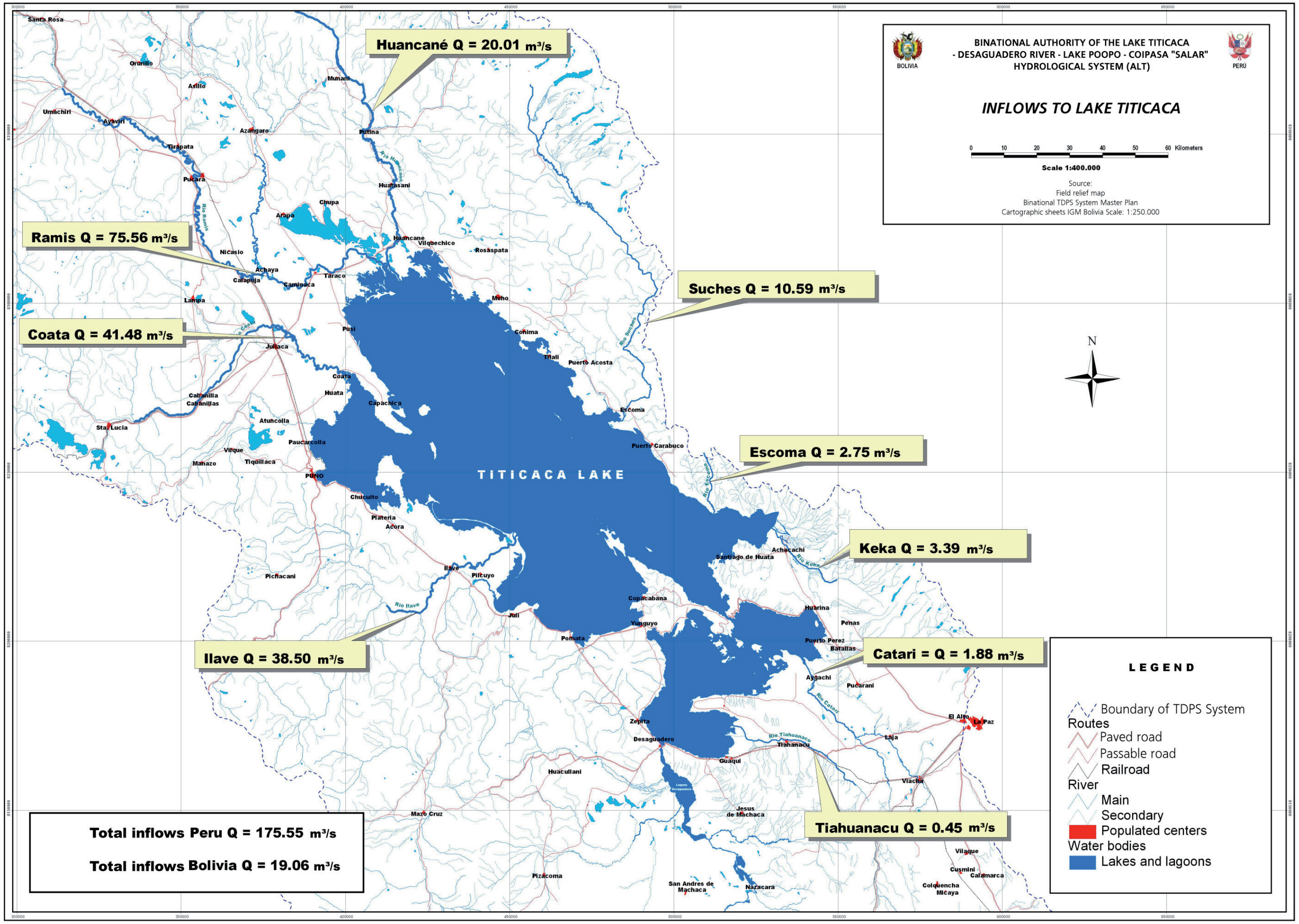


Figure 10. Peru-Bolivia TDPS hydrographic system map

Figure 11. Map of inflows to Lake Titicaca Basin



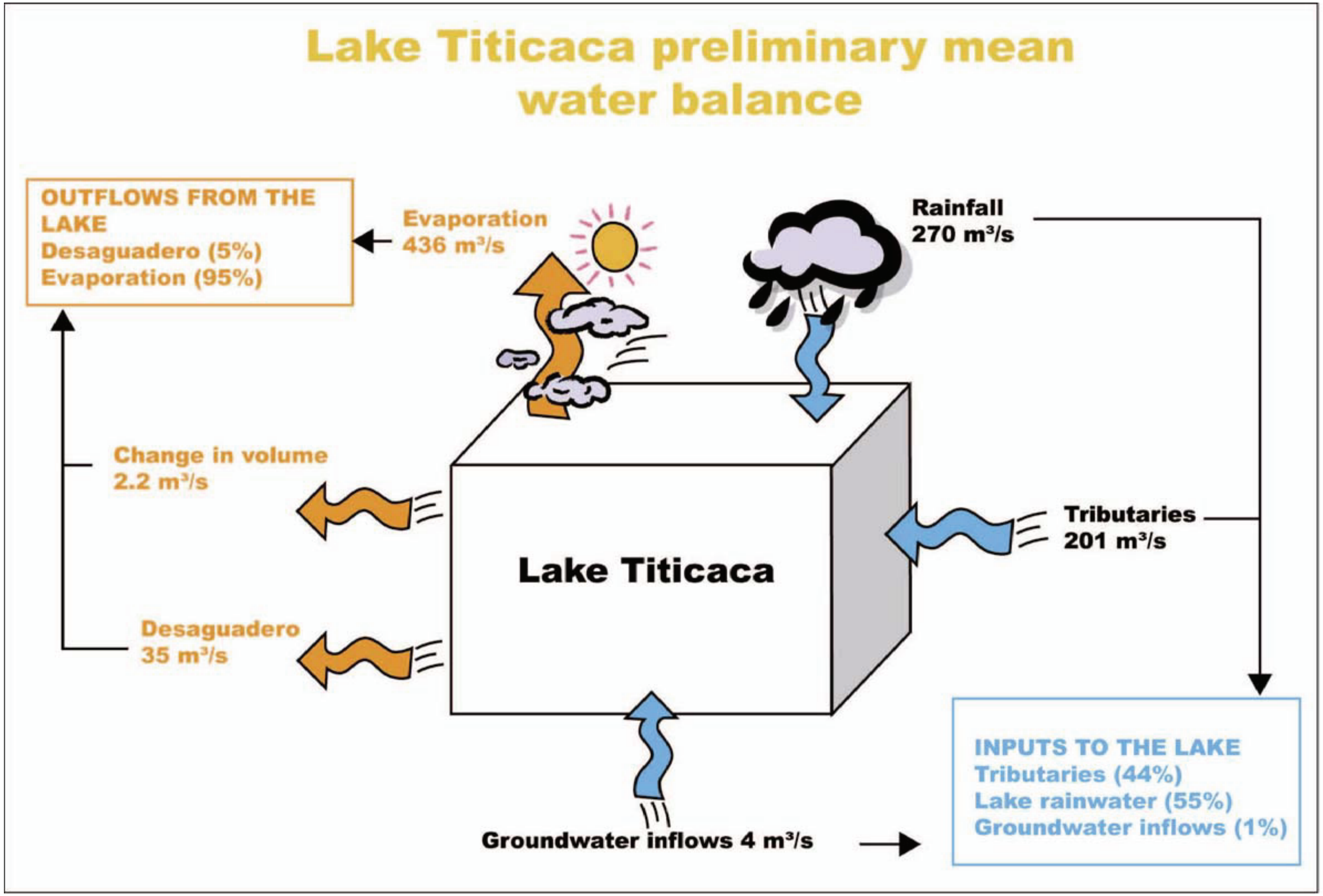


Figure 12. Schematic of Lake Titicaca hydrological balance

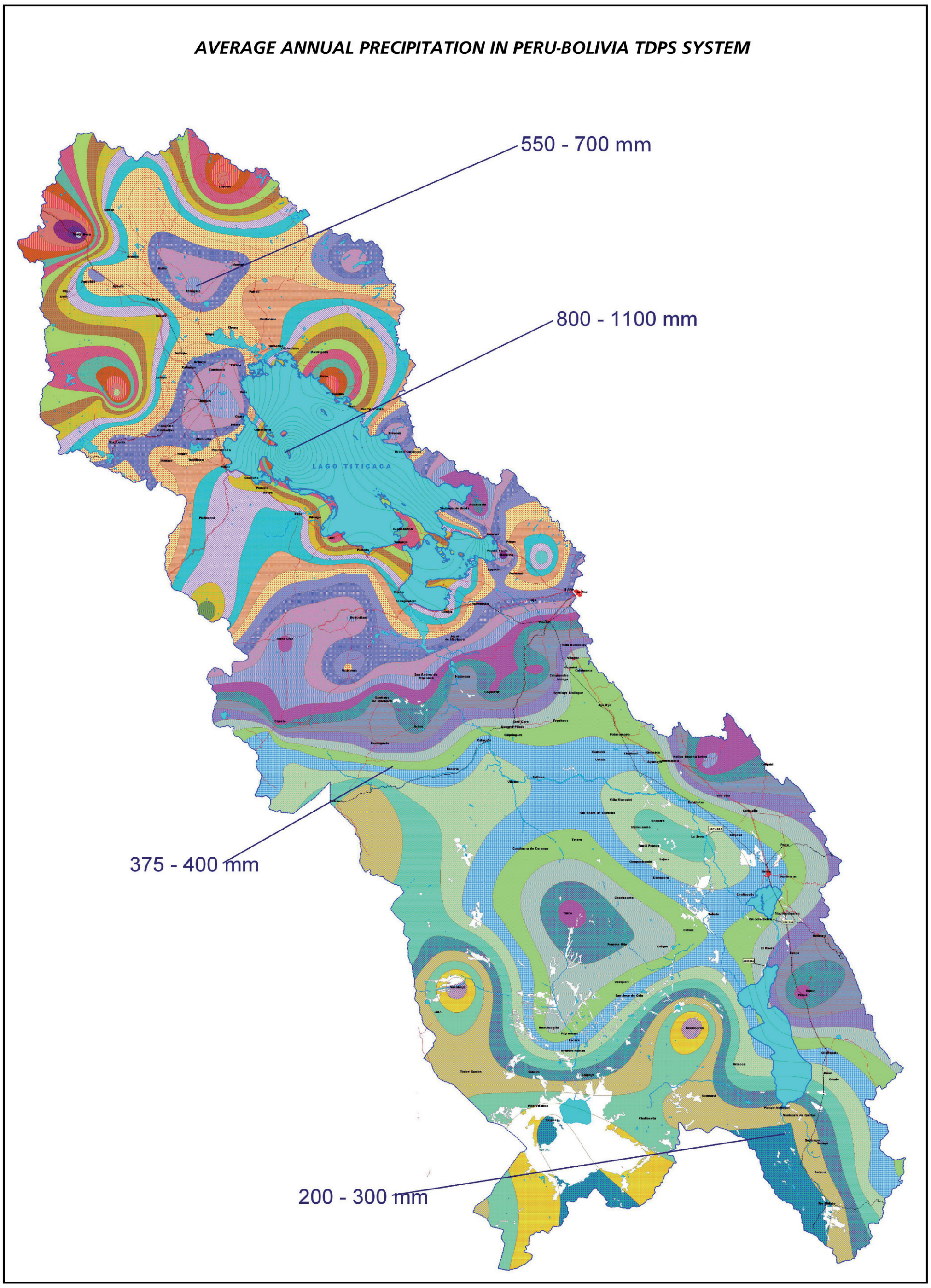


Figure 13. Average annual precipitation in Peru-Bolivia TDPS System

Figure 14. Flood-prone areas

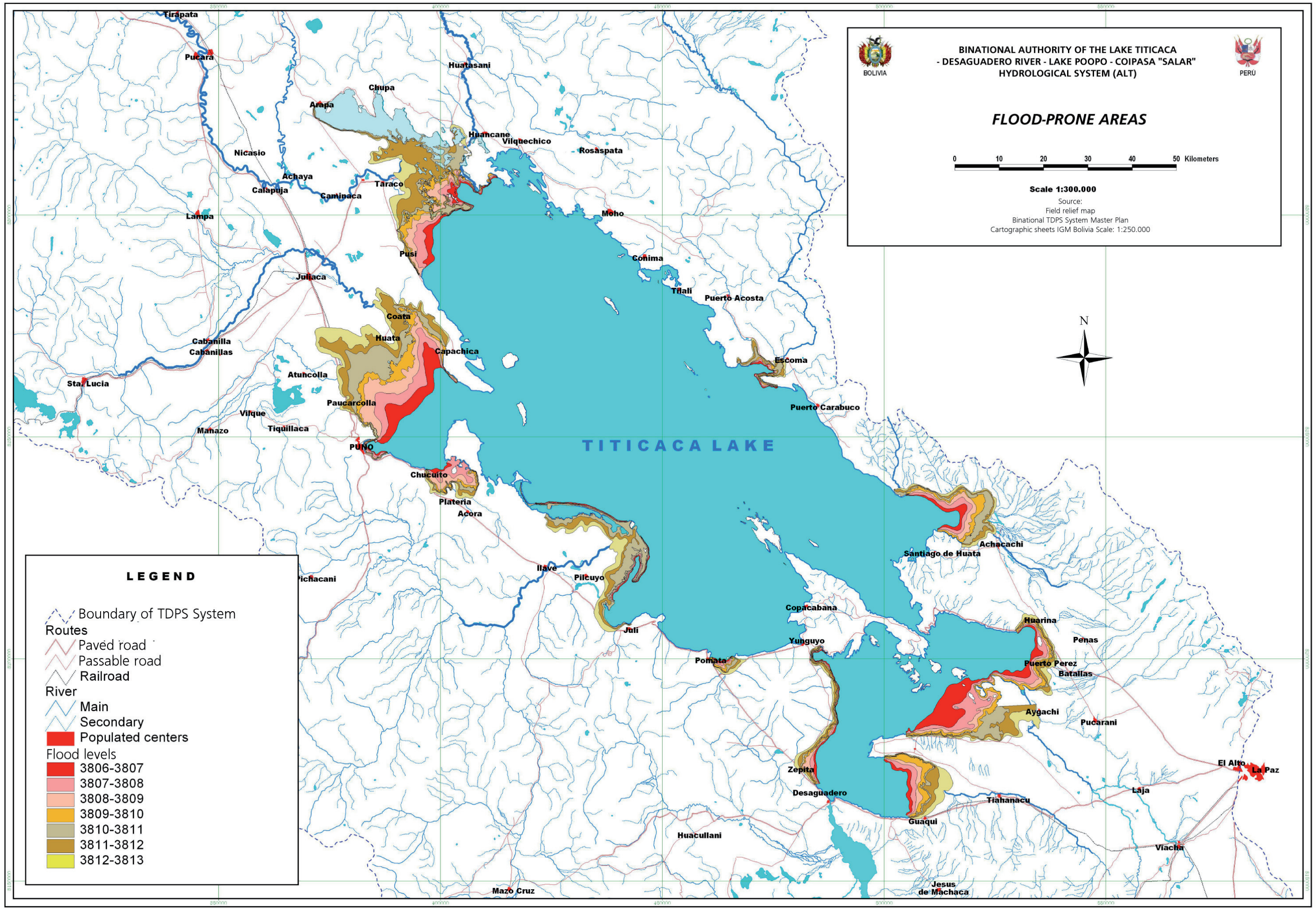


Figure 16. Map of current land use in Peru-Bolivia TDPS System

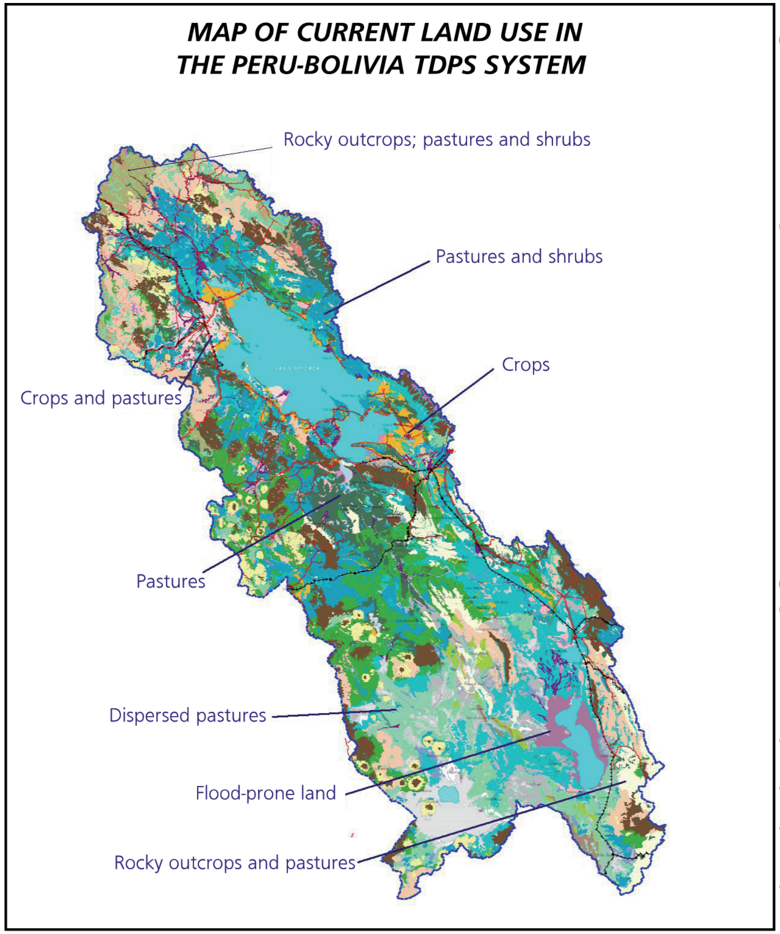
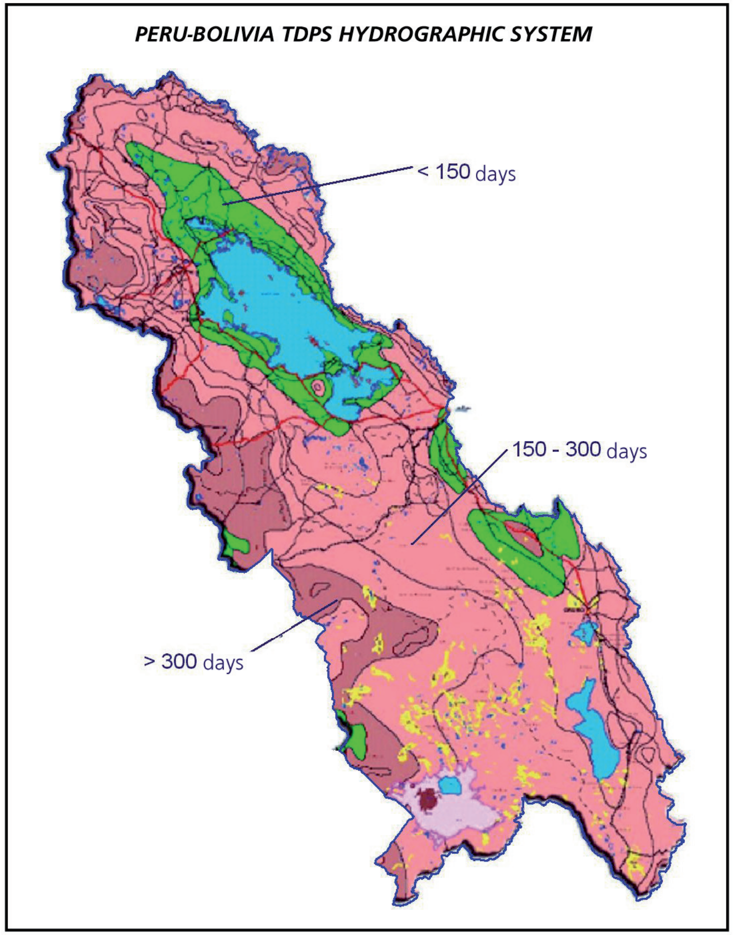
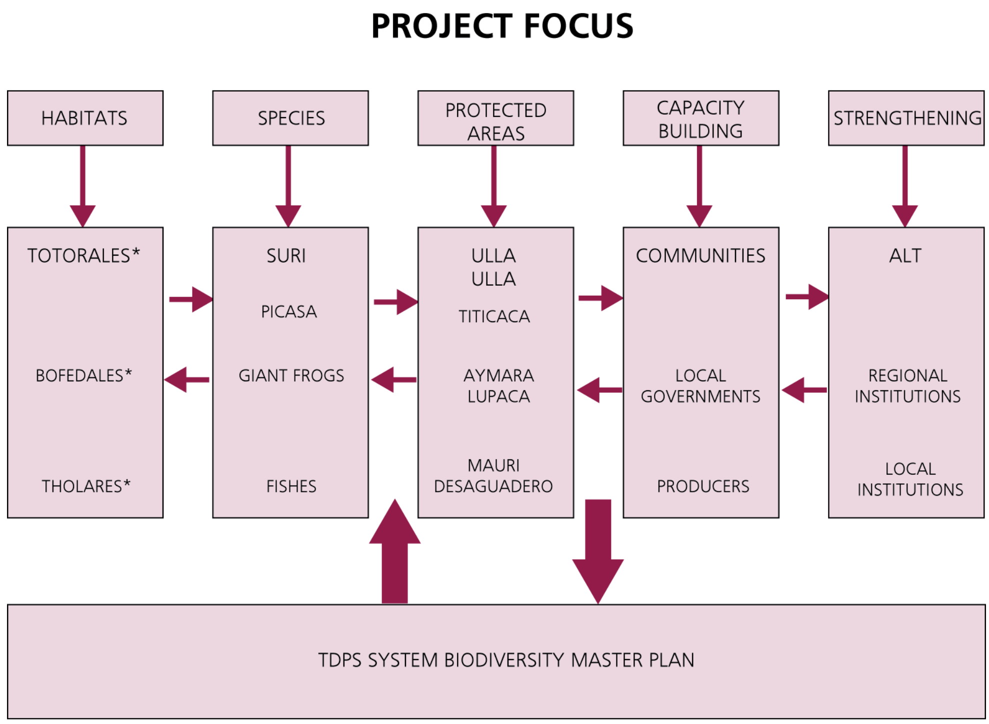


Figure 15. Map of frosts and freezing periods *(Days per year).*





*** Totorales: cattail thickets**
Bofedales: type of wetlands
Tholares: type of bush formations

Figure 19. Chart of Biodiversity Project focus

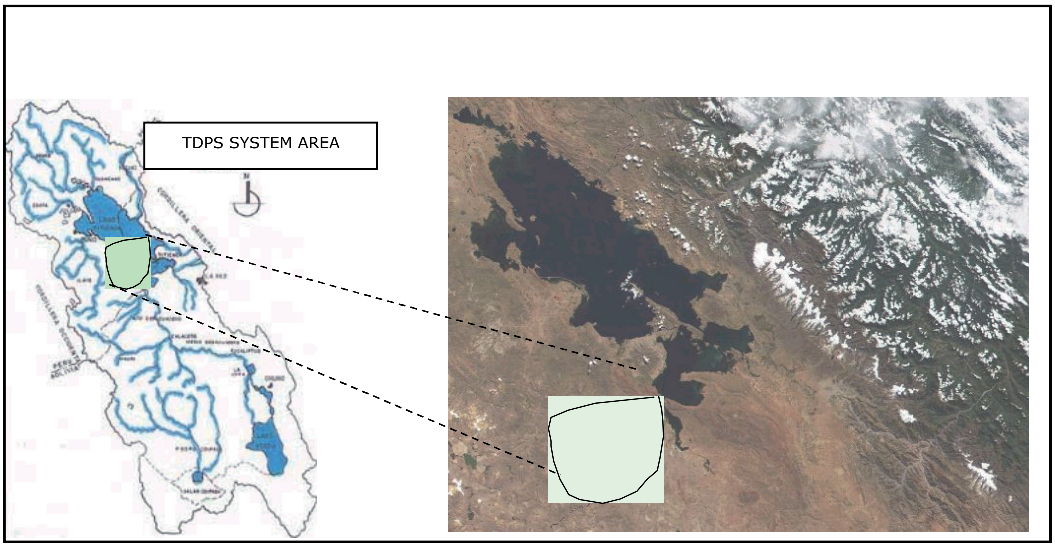


Figure 20. Llinki River sedimentation and erosion map

Figure 21. Water intake in Bocatoma River, Caquena

Figure 22. Photo of flood in Juliaca, Puno (Peru)

Completed installation of slow-drip irrigation

Entrance to a group (battery) of greenhouses

Greenhouse in production

64 greenhouses divided into three groups

Figure 23. Photos of project on wise use of shores

Figure 24. Map of Binational Boundary Hydrological Project development

Losses in Dredging
2003 – 2004
1st approximation
figures in million dollars

Year	No Dredging		Dredging		Diffe-rence
	Height	Loss	Height	Loss	
2002	3810.81	10´0	3810.41	-	10´0
2003	3811.55	28´0	3810.91	14´0	14´0
2004	3811.94	37’0	3811.10	19´0	18´0
Total		75´0		33´0	42’0

Table 6. Desaguadero River. Comparison of losses with and without dredging

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Constitution of UNESCO (excerpt)
London, 16 November 1945

The Governments of the States Parties to this Constitution on behalf of their peoples declare:

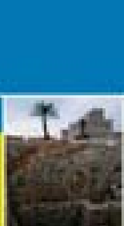
That since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed;

That ignorance of each other's ways and lives has been a common cause, throughout the history of mankind, of that suspicion and mistrust between the peoples of the world through which their differences have all too often broken into war;

That the great and terrible war which has now ended was a war made possible by the denial of the democratic principles of the dignity, equality and mutual respect of men, and by the propagation, in their place, through ignorance and prejudice, of the doctrine of the inequality of men and races;

That the wide diffusion of culture, and the education of humanity for justice and liberty and peace are indispensable to the dignity of man and constitute a sacred duty which all the nations must fulfil in a spirit of mutual assistance and concern;

That a peace based exclusively upon the political and economic arrangements of governments would not be a peace which could secure the unanimous, lasting and sincere support of the peoples of the world, and that the peace must therefore be founded, if it is not to fail, upon the intellectual and moral solidarity of mankind…




Co-operation on the Lake Titicaca

Isaac Martínez Gonzáles and Rolando Zuleta Roncal in collaboration with Aníbal Pacheco Miranda and Julio Sanjinés Goitia

International Hydrological Programme

World Water Assessment Programme