After the change of government in 1989 the Ministry of Agriculture and Livestock was revamped, with greater emphasis on livestock farming and the environment. Amidst mounting concern worldwide for the latter, and the 1992 UN-sponsored Environment Conference in Brazil, the Ministry has become increasingly pro-conservation, embracing issues such as environmentally-sensitive development.

2.6 CURRENT STATE OF AGRICULTURE AND LIVESTOCK FARMING

2.6.1 Agriculture

Agriculture is a vital element of the Paraguayan economy, accounting for 27.5% of GDP in 1990. Of this 62.3% was crop farming. Development in this sector is generally achieved simply by expanding land area. In 1981 some 47% of workers were employed in the primary industry. The majority of exports come from the farming and livestock sectors, with cotton and soybeans alone making up 62.2% of total export volume in 1990.

At 20 million acres (49.2% of the total national land area), livestock pasture was the most common use of land in 1990, followed by cultivation farming at 4.39 million ha (10.8%). Virtually all the latter (4.23 million ha or 96.4%) was devoted to short-term crops such as cotton, soybeans and maize. Cultivated land is found predominantly to the east, while Chaco is mostly pasture or untouched land.

Due to changes in worldwide demand and government schemes to boost production, perennial crops such as "mate" tea, tung-oil, citrus fruits and coffee, traditionally the mainstay of Paraguayan agricultural production, have since the 1970's been rapidly usurped by exportable crops including cotton, soybeans, and wheat.

Cotton in particular is now a leading crop, grown throughout the country (with the sole exception of Chaco, where it is found in Boqueron only). Production rose rapidly under the 1978 Cotton Program, reaching 640,000 tons in 1990.

Soybeans have become another prime export earner under the Soybean Program, designed to capitalize on rising worldwide demand during the 1970's for livestock feed. Soybean production reached 1.8 million tons in 1990. In the main production areas of Itaipu (near the Brazilian border) and Alto Parana, mechanical cultivation is used in multi-cropping of soybeans and wheat.

Over the last ten years the most rapid growth has been seen in wheat, which has been heavily promoted by the government under the Wheat Program. Of a total 430,000 tons in 1990, 80% was produced in Itapua and Alto Parana via soybean multi-cropping. Self-sufficiency in wheat was achieved in 1989.

Export crops other than cotton and soybeans include tobacco, sugar cane, peanuts and castor beans, while crops grown for domestic use include wheat, maize, cassava, poroto and a variety of vegetables, as well as perennial crops such as "mate" tea, tung-oil, citrus fruits and coffee.

In the past, most of the land (and therefore economic power) in Paraguay was controlled by a handful of politicians and other influential figures. The majority of farmers were forced either to borrow land, work for others, or farm illegally on state-owned land. Agricultural reform officially began in 1883 with a law transferring state-owned land to farmers. Despite concerted resistance from major land-owners, a number of reforms followed, most notably the 1963 shakeup of the Agricultural Reform Institute to create the Farmer Welfare Institute (IBR), together with a new Agricultural Land Act clearly delineating land ownership rights for all citizens. These policies have brought farmers the benefits of land reform and made a major contribution to higher production levels.

Nevertheless, in 1989 the illegal entry and occupation by landless farmers of both state- and privately-owned land in the east became a major social controversy at the top levels of government. Landowners retaliated by felling and burning their forests to create grasslands, in a bid to deter the farmers and at the same time convince the government of their efficient use of landholdings. In some areas government troops were brought in to enforce removal operations. The situation is currently under control but with a number of serious unresolved issues remaining.

The growth of the landless farmer class can be traced to:

1. an influx of workers into the agricultural sector following the completion of the Itaipu Dam

2. a surplus of workers due to rising numbers of children born to workers on major livestock ranches

3. the rising population (2.9%) of small-scale (20 ha or less) farmers, which has created a 'latent unemployed' class in farming villages

Despite new land distribution measures enacted in response to an August 1993 uprising by landless farmers in San Pedro, the problem remains fundamentally unresolved, and the government is yet to put forward policies to deal with an estimated 40,000 landless households nationwide.

Of the 250,000 small-scale farmers in Paraguay, most grow crops for domestic consumption (not export) or household use only. The population growth of 2.9% has given rise to large numbers of both latent and potential (10 years old or less) unemployed in rural villages. In small-scale farming regions in the east, redistribution of land is severely limited by

restrictions on land acquisition under the present ownership system. The flow of idle workers to cites such as Asuncion, swelling the ranks of unemployed there, has created a major new social problem.

In an effort to boost production, stimulate small-scale farming and revitalize rural communities, the government is providing technological training and extension programs, expanded finance for farmers, and technological assistance and funding on a bilateral and multi-lateral basis. Further work is required however to redress problems such as the restrictions of the land ownership system and to organize extension programs.

Although social problems associated with landless farmers and small-scale farming are more common to the east, the same is true within the study area, particularly among landless farmers dwelling on state-owned highway land along National Highway 9 (see 2. above) and small farm settlements on the Rio Pilcomayo.

2.6.2 Livestock farming

Livestock farming has always been an important part of life in Paraguay, with its abundance of land. Animals are not affected by adverse weather conditions to the same extent as crops such as cotton and soybeans. Despite recent progress in crop farming, some 20 million ha (49.2%) is still devoted to livestock, and this area is steadily increasing.

Livestock farming is a key industry on a par with agriculture, accounting for 28% of all farms and 8% of the national GDP (1990 estimates). As of 1991 there were 7,627,000 head of beef cattle - the most important animal to the national economy and the most efficient in terms of land usage - as well as 1,004,000 pigs, 320, 000 horses, 357,000 sheep, 102,000 goats, and 11,233,000 chickens.

Beef cattle farming on natural grasslands is relatively unproductive in terms of area but highly productive in terms of human labour. While farm (and herd) sizes vary from several hectares up to tens of thousands of hectares according to region, actual profitability depends more on individual farm management skill, with quite a large discrepancy between either end of the scale. Livestock raising by feed lots is rare.

Cattle were first brought to Paraguay in the 16th Century by the Spanish, who progressively introduced a number of European breeds. In 1840 there were said to be some two million head of cattle under livestock farming. Today's Criolla is the result of natural selection of European breeds within the Paraguayan environment.

From early this century European breeds including Hereford, Shorthorn, and Aberdeen Angus were re-introduced in an attempt to improve existing stock. Since the 1940's, zebu species such as Nelore and Brahman have been used to create climatically adaptable and disease-resistant hybrid species.

Beef cattle are generally put out to pasture in natural grasslands of up to 500 ha for an entire year. According to overall average indices of efficiency, fatting, and breeding rates plummet during winter due to the lack of protein and of actual feedstuffs. Technical assistance, particularly from Japan and Germany, is beginning to show positive results in areas such as breeding and animal hygiene.

There are two types of beef slaughterhouse in Paraguay: packers, where beef is processed for exporting, and ordinary slaughterhouses which supply the domestic market. The latter are often badly run-down with no cooling facilities, poor water supplies and inadequate waste water disposal systems.

On the natural grasslands where beef cattle are raised, the winter season poses difficulties for grass production: growth is inhibited, volume of available grass decreases, and protein content falls, affecting animal body weight. Grassland development and improvement is absolutely vital to alleviate the problem. More emphasis is being placed on varieties such as colonia, salinas, pangola, setaria, and bracchiaria, while feed crops are being introduced to compensate for natural grasslands during winter. Planting of ripe-cutting feed crops is gradually on the increase, although as yet not commonplace.

The main dairy farming districts are located near Asuncion and in the Mennonite settlements. Most milk cattle in Paraguay are crosses between traditional cattle and combined dairy/beef breeds, with a heat-resistant milk type bred from Holstein and Brahman recently appearing in larger numbers.

Although beef was traditionally the mainstay of the national diet, the number of pigs and chickens has risen considerably in recent years. Pork comes mainly from Alto Parana, Itapua, San Pedro, Caaguazu, and other areas in the south-east. The above four provinces make up 58% of total national pork production. Chicken farming is concentrated around cities, especially Central, Caaguazu, Itapua, and Cordillera, which account for 52% of chicken production.

Apiculture has recovered from a one-time incursion of African bees from neighbouring Brazil to the point where there are now around 20,000 swarms, mostly in Departamento Central. Honey production in 1990 was 820 tons. It is hoped that the current annual consumption level of around 200 g per person can be boosted in future.

2.6.3 Forestry

Forests covered 43.9% of Paraguay in 1985 but only 37.2% (15.1 million ha) in 1990. In the last two years the rate of attrition has doubled from 200,000 to 400,000 ha per year, leading to predictions that forests may disappear altogether in another twenty years. In most cases forests are being felled not for agriculture but to provide livestock pastures.

The forestry industry consists mainly of transporting logs and collecting firewood for lumber. Some 1.8 million m^3 of lumber is processed annually. Another 72,000 m^3 of quebracho colorado are harvested to provide tannin, and 350,000 m^3 of smaller logs used to make livestock fencing and posts. Although prohibited by law, it is estimated that logging to Brazil is of the order of 600,000 m^3 per year.

The incidence of useful varieties such as cedro, ybyra pyta, ybyraro, petereby, lapacho, guatambu, incienso, and peroba is said to exceed no more than 5-10% in Paraguay's natural forests.

2.6.4 Importance of agriculture and livestock farming

Agriculture is still Paraguay's principal industry, providing its most lucrative exports and employing a large part of the populace. Production in this sector is linked directly to wage levels, and is thus a major issue for the future.

Economic development in Paraguay should focus on the country's assets: its abundance of land and water resources, and its potential for hydroelectric power generation. The ideal use of these resources is crop and livestock farming of carefully selected export-oriented varieties, with more attention to quality and production levels. Use of hydroelectric power in processing primary materials from the agriculture sector effectively doubles its value. With a plentiful labour supply and the lowest wages of all the MERCOSUR countries, Paraguay is also the ideal choice for setting up processing plants. Investment is already flowing in from countries like Brazil and Argentina.

The problem however is in identifying suitable goods and products with which to develop the industry further. Despite efforts at diversification, lucrative products to equal soybeans and cotton, in terms of compensating for the relative difficulty in accessing international

markets, have yet to be found. As capital begins to flow more freely between MERCOSUR countries, and individual members seek to create niches of relative superiority, Paraguay must identify its own areas of greatest natural advantage.

Despite a long history of land redistribution favouring small-scale farmers, illustrating the importance of farming to Paraguayan society, the root causes of the problem have not been adequately resolved. Raising the status and wages of small-scale farming operations, one of the issues identified in the Lineamientos de la Politica Agraria, is a top priority for the Agriculture and Livestock Ministry. True land reform will require far-reaching policy initiatives from the government in the future.

2.7 INTERNATIONAL RELATIONS

2.7.1 Foreign policy & relations

1) Foreign policy

Anti-communist Paraguay has traditionally maintained a pro-American, pro-freedom foreign policy. Relations with neighbouring Latin American countries have been generally friendly, particularly among the Rio Group, and the number of joint programs together with other free countries is also rising. With the upheavals in Eastern Europe in 1990, the collapse of the Soviet Union in 1991 and the birth of the Commonwealth of Independent States (CIS), the government is moving towards the establishment of trade relationships with countries such as Hungary, Czechoslovakia, Bulgaria, and Russia.

Nearer to home, the MERCOSUR common market agreement has improved relations with Brazil, Argentina, and Uruguay. Heads of government are meeting regularly in a bid to boost bilateral trade and establish supply sharing schemes for power and oil.

Relations with America were soured at one stage by its undue pressure on Paraguay to democratize. The situation abruptly improved following the 1989 change of government and has remained favorable ever since. In Asia Paraguay maintains relations with Japan, Taiwan, and South Korea.

2) External relations

(1) Latin American countries

Paraguay has worked to forge close links within the Rio Group of countries at top diplomatic levels, for instance through irrigation and water usage projects on the Parana and Paraguay rivers, the hydroelectric projects at Itaipu and Yacyreta dams, and the MERCOSUR common market agreement with Brazil, Argentina, and Uruguay.

(2) America

Relations improved considerably after the change of power in 1989, culminating in a December 1989 visit by Vice President Dan Quayle. Exchanges between military personnel are increasing.

(3) Europe

The government is continuing with its drive to penetrate the EC market, and working to establish trade relations with the newly democratized free countries of Eastern Europe. In January 1992 Paraguay extended recognition to independent Croatia and Slovakia.

(4) Asia

Paraguay has friendly relations with Japan, Taiwan, and South Korea on both political and military levels.

2.7.2 MERCOSUR

The South American Common Market MERCOSUR (Mercado Comun del Cono Sur), encompassing Paraguay, Argentina, Brazil and Uruguay, is designed to boost economic and social development by creating a common sphere for economic activity. The Agreement was formally signed in Asuncion on 26th March 1991, and expires on 31st December 1994. Specifically it calls for:

1. Deregulation of assets, services and production elements through abolition of duties and other non-duty obstacles
2. Equal rates of duty to outside nations; unified Common Market trade policies; coordination of international trade policy among member nations
3. Coordination of macro-economic and sector-specific economic policies
4. Coordination of relevant laws and regulations between member countries

The most significant aspect of the Agreement is 1. above, which will create zero tariffs and abolish all other trade restrictions by the expiry date. Beginning with a 47% cut on 1st July 1991, tariffs will be brought down 7% every six months.

After a slight delay, the Agreement came into effect on 29th November 1991 with the 47% tariff reduction. The number of exemptions, including some 439 for Paraguay alone, will be progressively reduced by 10% every six months (20% annually).

For Paraguay, MERCOSUR is likely to have a much bigger impact on outside imports than on trade with member nations, which previously attracted a uniform duty of 10%. Importers and retailers of non-registered goods such as whiskey, tobacco and electrical goods will be particularly hard hit, with the loss of an estimated 300,000 jobs.

The Agriculture and Livestock Ministry predicts the following effect on crop selection under MERCOSUR:

1. Viable crops:
   winter fruits and vegetables (e.g. melons), soybeans, wheat (for self-sufficiency), cotton, maize, cassava, "mate" tea, tung-oil, tobacco, castor beans, peanuts
2. Non-viable crops:
   sugar cane, grapes

3. Lucrative crops:
   citrus fruits, milk, bananas, pineapples, mangos, avocados, stevia, asparagus, mushrooms

The basic planks of Ministry policy on MERCOSUR are:

1. Lower taxes on imported agricultural machinery and materials
2. Improved access to agricultural credit
3. Fewer restrictions on the use of foreign capital
4. More technological cooperation with member countries
5. Vertical and horizontal organization of producers
6. Incentives for private sector investment in the agricultural sector
7. Training for technicians in the agricultural sector

It is predicted that the benefits to the Paraguayan agricultural sector, including more investment and technical exchanges and the introduction of more lucrative crops, far outweigh the disadvantages.

2.7.3 Aid from foreign nations and international organizations

As mentioned earlier, cumulative foreign debt in Paraguay during the economic downturn of the 1980s was not as problematic as elsewhere in Latin America. However Paraguay has been unable to meet interest payments by maintaining a trade surplus in the same way as its neighbours, due to its failure to industrialize and resulting over-reliance on imports to sustain growth. Paraguay is now required somehow to maintain a trade surplus while paying off its debts. This cannot be overlooked in any assessment of economic structure and growth.

The government has outlined seven basic social, economic and productivity objectives:

1. to boost production of services and assets
2. to make on-going use of savings, investment and natural resources and create employment
3. to prevent deficit while balancing the domestic macro-economy
4. to balance the external macro-economy without deficit
5. to expand public services
6. to raise living standards and stimulating progress
7. physical, economic, and cultural consolidation via MERCOSUR

Paraguay receives generous aid outlays from a number of friendly nations. The government is aware of the importance of these funds, particularly with respect to job creation, on-going exploitation of natural resources, reform of state institutions, the development of a humane society, and its role in MERCOSUR.

The level of publicly announced foreign assistance reached $123.1 million in 1990, some 25% up from than the previous year, as a direct result of efforts to encourage bilateral and multilateral aid for social, economic and environmental/ecological programs. Funds from Japan, Germany, the World Bank, the Americas Development Bank, and the United Nations were allocated to agriculture (26%), regional development (18.8%), human resources (12.8%), general development (10.3%), economic development (8.4%), and social development (6.9%).

1) Bilateral aid

The principal contributors in 1990 were Japan (27.8%) and Germany (25.5%), followed by America, Holland, France, Belgium, Spain, and South Korea.

Former West Germany provided mainly technical assistance via personnel dispatch in administration, planning, agriculture, the environment, health & hygiene, medical treatment, power, and sales.

In terms of cumulative total funding from Japan up until 1990, Paraguay was the second highest recipient out of the central and southern American countries (yen loans second place, gratis loans fourth and technical assistance second). And since 1976, Japan has been its most generous donor. This is due in part to the long tradition of friendship between the two nations, and the 7000 Japanese nationals currently resident in Paraguay, enabling effective technology transfer in a variety of ODA formats.

2) Multilateral aid

Multilateral aid amounted to $49.3 million in 1990, some 40% of total aid received, of which the World Bank contributed 14.2%, other United Nations organizations 9%, the Americas Development Bank 8%, and the La Plata river basin development fund fonplata 6%.

The three principal international organizations are:

1. Americas Development Bank (IDB)

Although Paraguay had received a cumulative total of $654.3 million from the IDB by

1990, the most of any international agency, the annual funding level fell abruptly to $500,000 in 1989. IDB funding is directed mainly towards energy, transport, and communication.

IDB funding and technical assistance is specifically targeted at agricultural development, including general development schemes, resettlement programs, agricultural equipment purchasing and training for farmers and technical personnel. The Trans-Chaco Highway is one example of IDB funds used in infrastructure development.

2. United Nations Development Planning (UNDP)

The UNDP is the second largest international donor. Funds are used in nearly all fields, particularly general development, agriculture, transport and communication. Recent Country Programs (1987-1991) have stressed training, organization and job creation, and have been geared specifically toward achieving higher export levels.

3. World Food Planning (WFP)

The WFP replaced the IDB in 1989 as Paraguay's leading international source of funds with $1.7 million ODA net, directed at agriculture and forestry development and construction.

3) NGO aid

With $7.8 million gratis loans, NGO aid accounted for 6% of foreign aid.

CHAPTER 3

AN OUTLINE OF THE STUDY AREA

CHAPTER 3 AN OUTLINE OF THE STUDY AREA

3.1 NATURAL ENVIRONMENT

3.1.1 Geography

1) Location

In administrative terms, the study area comprises the whole of the Departamento Presidente Hayes located in the southernmost part of the Paraguay Chaco region, stretching from south latitude 22° 10' to 25° 20' and from west longitude 57° 10' to 60° 45'.

In the north and the northwest, the area borders on the Paraguay Chaco provinces of Alto Paraguay and Boqueron, while the eastern edge of the area is contiguous with the Rio Paraguay and the southwestern edge with the Rio Pilcomayo, giving it a triangular shape. To the east of the area, the provinces of Concepcion, Cordillera, and Central lie on the opposite banks of the Rio Paraguay from the north downwards, while the Rio Pilcomayo, passing to the southwest, itself forms the border with Argentina.

The land area is 72,902 km^2, making this the largest of all the provinces in Paraguay.

2) Topography

The name "Chaco" in general use refers to the physical and geographical entity known as "Gran Chaco", a vast subtropical plain that extends over a million square kilometres straddling Argentina, Bolivia, and Paraguay, as well as part of Brazil. Of this, the parts that fall into the territory of the individual countries are named after those countries. Paraguay Chaco is part of this Gran Chaco.

The most notable feature of Chaco is the extremely vast and flat spread of its land. This plain, stretching from the foothills of the Andes, slopes slightly downwards towards the east, though the average topographical gradient of the Gran Chaco is no more than 1/5000. In the study area, the altitude is highest in the northwest at about 110m, and slopes slightly downwards towards the Rio Paraguay. This is an extremely even topography with an average topographical gradient of less than 0.01%.

3) Topographical zones

Paraguay Chaco is divided into six zones, according to the various water conditions. The study area contains the following three of these zone divisions.

(1) Alluvial delta of the Rio Pilcomayo

This is the zone that skirts the Rio Pilcomayo running from the northwestern extremity to the southern extremity of the area. It is subject to seasonal excesses of water due to

flooding from the river and surface flow from rainwater, combined with conditions of poor drainage. The flooding of the Rio Pilcomayo occurs near the northwestern extremity of the study area, part of which flows into the Rio Montelindo, the Rio Negro, and others to form a vast swampland zone. In addition, the eastern part of this zone also comprises a swampland zone, due to large amounts of rainfall.

(2) The eastern depression

This is a river zone that extends in a strip shape with a breadth of 60-100km along the Rio Paraguay. In places with many drainage channels this becomes inundated by rainwater and flooding from rivers, with partial stagnation.

The Rio Paraguay has numerous tributaries that flow into it from the west. From the north downwards, these include the Rio Mosquito, the Rio Yacare Norte, the Riacho Paraguay, the Riacho San Carlos, the Rio Verde, the Rio Siete Puntas, the Rio Montelindo, the Rio Negro, the Rio Aguaray Guazu, and the Rio Confuso.

(3) South-eastern plain zone

This is a unique zone that has groundwater strata of good-quality freshwater lying in lens-form over water with a high salt content.

Rainwater in this zone is drained by streams that only are only active when it rains. It includes the lakes Ganzo, Buey, and Salada.

3.1.2 Climate

The climate of Chaco can be broadly divided into 4 zones (rather humid; rather humid - rather dry; rather dry; and dry), proceeding westwards from the Rio Paraguay.

The average annual temperature within the study area is between 23.1°C and 24.6°C, with an average annual maximum of between 28.3°C and 31.0°C and an average annual minimum of between 17.5°C and 19.3°C.

Rainfall is around 1,350 mm annually around the Rio Paraguay but around 700 mm in General Garay in the west, thus decreasing towards the west. The number of days with rainfall of 1 mm or more is 60-80 per year, and 60-80% of the rainfall is concentrated in the summer. Sometimes half a month's rainfall can fall in just one day, while the distribution of rainfall is also uneven.

Under the influence of rising air masses from the Andes mountains, east-west winds are

weak at altitudes of less than 5000 m. Although on the whole northerly winds are most common, they often bring rain when they change to a southerly direction.

3.1.3 Resources

1) Forest resources

Apart from evergreen trees, deciduous and low thorny trees are also distributed widely, most of these in the form of natural forests. In low-lying swamplands the palm tree Copernicia alba is predominant.

The trees in this region are suitable for making charcoal, while in some parts tannin is extracted from the quebracho, and palo santo oil from the palo santo. However, in the region as a whole there is a paucity of usable wood, which is hardly exploited at all other than for utility poles and pasture fences.

2) Mineral resources

In geological terms, the Chaco region is similarly lacking in outstanding mineral resources. On the other hand, a rich abundance of clay strata due to river sedimentation is found throughout the Chaco region. The clay in the vicinity of Villa Hayes, Benjamin Aceval, and Cerrito has been confirmed in tests to be eligible for use in bricks. Similarly, that in the Mennonite settlements, Mariscal Estigarribia, and Pozo Colorado has been proved to be suitable for use in bricks, tiles, and other ceramic materials, though it contains salt and has other problems such as its durability and its unsuitability owing to peeling when used for painting walls.

3) Water resources

The study area is sandwiched between the Rio Paraguay and the Rio Pilcomayo, while there are many smaller rivers which flow into the Rio Paraguay, such as the Rio Montelindo, the Rio Negro, and the Rio Verde. However, since the bed of the Rio Paraguay is at low altitude is it difficult to extract water naturally. Furthermore, for reasons such as problems with the salt content in their water, hardly any effective use is being made of other rivers at present.

Moreover, since the groundwater contains salt it is not suitable for drinking or agricultural water, and remains unexploited, with the exception of some groundwater from shallow layer lens-shaped zones.

3.2 SOCIO-ECONOMIC CONDITIONS

3.2.1 Historical background

The northwestern part of Chaco was acquired in the Chaco War with Bolivia (1932-1935). On the other hand, the Departamento Presidente Hayes has been Paraguayan territory since before the Chaco War. The development of the Paraguayan land started from the east, while of necessity the advance of development into the west of Paraguay is comparatively new.

Tannin, which used to stand alongside "mate" tea as the twin standard bearers of export industries in Paraguay, poorly endowed with mineral resources, derives from the felling and extraction of lumber in forest regions along the Rio Paraguay in Lower Chaco. This activity was started around the end of the 19th century. In the heyday of the industry there were seven extraction plants operating inside the region, with private railways connected to the various factories and tannin transportation plants.

From the end of the 1900's to the 1920's, development activity by agricultural and livestock industries thrived in Lower Chaco. This involved free-ranging pasturage of beef cattle on natural grasslands and the cultivation of sugarcane, mainly in Benjamin Aceval and Villa Hayes.

Meanwhile, settlement by the Mennonites into the northwest of Lower Chaco and into Central Chaco started in 1927. The Chaco War started shortly after the area had been settled and areas neighbouring on the settlements became caught up in the fighting. Nevertheless, the settlers remained undaunted by the hardships of the war. Agricultural sector development in Chaco can be said to have started with the settlement of the Mennonites, and the importance of the Chaco region came to be recognized along with the development of agricultural and livestock farming thereafter in the Mennonite settlements.

This recognition led to various projects and studies eventually being carried out. One of these that is worthy of special mention is the Trans-Chaco Highway connecting Central Chaco with Asuncion. This highway was opened in 1961, though it wasn't until 1988 that the whole route was surfaced with asphalt all the way to Filadelfia, the central town in the Mennonite settlements. This Trans-Chaco Highway became a major propelling force in the development of the western region, and is of major significance as such. At the same time, the Mennonite settlements and their inhabitants, who won their desperate battle against adverse conditions of product transportation routes for 34 years until the road was opened and a further 30 years until the road was asphalted, and indeed provided the motivation for the construction of the highway while developing their agricultural and livestock farming, are of great significance in the history of the development of Chaco.

In an agricultural and livestock farming census taken in 1982, the rate of exploitation of the study area was shown to have reached 81.6%, and although this is thought to involve the use of the land as pasturage, it is a high rate compared to the other provinces of Chaco. This in itself signifies that by that time artificial development had already made considerable advances in this region, irrespective of the methods or forms that it took.

Also, in the same census the study area was shown to contain a population of 45,600, or 55% of the total population of Chaco. At the time, the population distribution in the western provinces was concentrated in the two provinces of Presidente Hayes and Boqueron. This can be seen as reflecting the population density in villages in connection with the Mennonite settlements in the case of Boqueron, and with the industrial zones of Villa Hayes and Benjamin Aceval in the case of Presidente Hayes.

Industrial activity in the survey area started with the establishment of a sugar refinery and an alcohol factory in Benjamin Aceval in the 1800's. Apart from these, as time passed a steelworks was established in this province and soap and oil factories in Villa Hayes.

Chaco is in historical and actual terms an area that has been controlled by the military, thus there are no police or civilian authorities. This can be seen as representing the tradition of Chaco.

3.2.2 Society and culture

The population of Chaco is 57,000, with an extremely sparse density of 0.23 people per square kilometre. On the other hand, its composition is clearly diverse. That is to say, the inhabitants of Chaco are divided into three types, namely (1) creoles (of Spanish descent) and Mestizos (of mixed Spanish and indigenous descent), (2) indigenous peoples, and (3) the Mennonites.

The overall characteristics of the inhabitants of Chaco mentioned above are also the same in the study area within Chaco, thus these will be applied as they are.

The creoles and Mestizos are for the large part concentrated in Villa Hayes and Benjamin Aceval, but apart from the Mennonite settlements and military facilities they live almost everywhere throughout the area. As well as being engaged in livestock pasturage, felling and processing lumber, and cultivating agricultural produce such as sugarcane and vegetables, they also provide labour for the sugar refinery, the steelworks, and other industrial facilities.

The Mennonites are basically concentrated in central Chaco, though some of their settlements take up part of the west of the study area. They have achieved conspicuous economic growth through agricultural and livestock farming as well as, recently, processed farm produce in particular. However, the society and culture of the Mennonites exist in isolation from other social entities within the country.

The indigenous peoples in the west of Paraguay consist of 13 different ethnic groups, of which seven inhabit the study area. In principal they follow a nomadic life of hunting and gathering, but as a side-line they are also known to provide labour for pasturage and farming.

Each of the three groups of inhabitants outlined above has its own independent social and economic systems and different culture, and in general it is unknown for these to intermix or become integrated. Each of the three types will be described below.

1) Creoles and Mestizos

Creoles and Mestizos, as well as being concentrated in the two townships mentioned above, also live in various different configurations scattered throughout the region. Their social and cultural interchanges differ in the degree to which they are in contact with outsiders, but are not qualitatively different from those of the rest of Paraguayan society, including the eastern region.

2) Indigenous peoples

(i) Lifestyle and activity

Unlike the indigenous people in the east, who, as well as hunting, fishing, and gathering, traditionally undertake agriculture in fields as the mainstay of their livelihoods, those in the Chaco region in the west generally live for themselves on the basis of hunting and gathering only. However, in most recent times, some of them have come to undertake economic activities other than these. Since their continued existence is directly related to their fishing and hunting and the gathering of natural produce, they migrate in accordance with the quantitative abundance of things that they need at any time and in any place. In other words, for them natural resources are equated with the foods that nature provides for them, and the supply of these has to be maintainable without running out in the foreseeable future. Therefore, their relationship with nature is extremely limited, and as a result they do not stay for long in one place but soon start their next migration.

Meanwhile, in their economic system, production is guaranteed by what is provided for

them by nature, and they exploit nature as they see fit. In return, this exploitation is always accompanied by moderation and frugality, and their lifestyle is determined by methods that involve a smaller degree of interference or transformation of the environment to which they owe their very existence.

In this we see a fundamental difference with the lifestyle and economy of the indigenous peoples of the east. That is to say, the basis of existence of the latter is production that involves transforming nature, while that of those in the west lies in exploiting resources that already exist in nature. Rather than transforming nature, they in fact adapt to it.

(ii) The concepts of nature and land

These are people who migrate across land in search of existing natural resources necessary for their own subsistence, such as food (making them hunters or gatherers in this sense). For the indigenous inhabitants of Chaco, natural features such as forests, rivers, and swamps are, as they themselves say, their foodstore and their drugstore. Nature is the very basis of their subsistence.

Therefore their philosophy is that they should reduce the transformation of nature by their own hands to the absolute minimum, so as not to destroy or eventually wipe out the things that are their own means of subsistence. For them, the maintenance and protection of the natural environment is connected to their own lives, and is thus of direct significance for them.

For them, land is common property, and anyone has the right to exploit it. In their way of thinking, there is no concept of land as private property.

(iii) Society and the principles that govern it

The most basic unit that goes to form the society of the indigenous hunter/gatherer peoples is the banda. These are small groups of normally no more than 100 people, formed by blood relationships such as parents and children, marital partners, and in-laws.

The number of these "bandas" differs from tribe to tribe, while also growing or shrinking depending on the time of year, in connection with the seasonal growth and decline of the natural resources that are the objects of their hunting and gathering.

In many cases, the "bandas" are divided up into smaller units (normally families) so that the resources available at any time and in any place can be used more skillfully. This is

because, if the population of the banda were to increase, its mobility would inevitably stagnate, the resources inside a specific area might suddenly disappear and the food supply could be ruined. In readiness for cases like this, the scale of the group changes in accordance with the state of the natural world, and migration occurs.

The number, scale, accumulation, migration, etc. of the groups are all interconnected and change around the basis of the natural resources that they need in principle for maintaining life.

In terms of the policy that would normally pertain in an organization, these groups lack a central leader. One of the principles governing these groups is the concept of equality. Some individuals in the group are able to exert an influence over or guide the others. However, it is rare for these individuals to have so much authority that they can create systems or institutions. This means that there is no authority that bears any binding force. In other words, the determined rights that are concentrated in one place have no binding force elsewhere. Therefore, if any individual has a problem with the decisions made by the group, that person simply moves to another group.

As for the system of group regulation in this society, there has been no process of legalization and no organization of rankings for management has been accomplished. Therefore, the actions of the individuals who comprise the group sometimes lapse into self-indulgence as a result.

Another of the norms that governs these hunters and gatherers is that of mutual support. The food and materials acquired through their work in hunting and gathering are shared out within their own banda. Work to obtain food is generally carried out by the whole family, with typically the men doing the hunting and the women the gathering.

When a team returns from hunting or gathering, it is the usual custom for the catch they have made to be shared out amongst the whole of their group. Thus, as long as someone in the group has some food, in principle nobody in the group will go wanting, while conversely if absolutely no-one has any food the principle is that the whole of the group has to move on to find some.

These principles constitute their system of activity based on the norms of the spirit of equality and mutual support. And here we can see the fundamental contrast with the system of activity of the eastern indigenous peoples, based as it is on a market economy. The important point here is that the motivation for acts of hunting and gathering by the

western indigenous people as hunters and gatherers is not directed by the accumulation of economic profit and wealth, but by their credibility and reputation in their society, and by harmony with their surroundings, or more basically by the spirit of mutual support that forms the basis of their society.

(iv) Relations with other societies

Broadly speaking, until the 1960s the hunters and gatherers who comprise the indigenous inhabitants of the Chaco region were spread out to cover the whole region, and seasonal movements of the groups were seen. These people basically lived by hunting and gathering. But recently this original livelihood has started to encompass others, such as work in small-scale farming and elementary pasture management.

In conducting their hunting and gathering they used to take care that no harm can come to nature and that it could always be reproduced quickly. Thus their activity was always accompanied by movement, and the range of this in itself covered a considerably vast area. The day would come when the land that was included within such a sphere of activity would pass into the hands of large farm and pasture owners, and these people, the original inhabitants from ancient times, would be forced out.

In their relationship with nature, they had their own rules which were of great significance in terms of the ecological balance of nature; one of these was their seasonal migrations. However, once they were forced out of this land with its broad range of activity, their traditional economy was no longer possible. From their mobility as hunters and gatherers (the so-called nomadic lifestyle), cases emerged in which they had no option but to become quasi-residential farmers (not 100% farmers but something resembling this) or to take work in livestock farms, factories, and so on. Furthermore, under conditions such as these a scenario evolved in which responsibility and obligations in a stronger sense came to be imposed on them by Mennonite society.

In such cases, the only options left to them were either to adapt to the situation or to cease to exist.

The land on which the indigenous people are active and depend for their subsistence has decreased dramatically, compared to former times when they used to occupy it as their arena of activity. In this diminished land area, those who hitherto lived separately now have to share their lives on a small fragment of land. In some cases the situation arises whereby different ethnic groups, facing the same social problems and complications caused by population increases, have to live together on the same land.

As one option for the sake of their subsistence, one thing that they have imposed on themselves has been to conform to other societies in Chaco (religious missionary groups, landowners, Mennonites, the army, and others). As a result of this option, they appear to have changed their previous form of indigenous inhabitants as hunters and gatherers into that of established farmers, or farm labourers on the land of landowners. However, their traditional acts and activities as hunters and gatherers still continue today in various forms, and they clearly give greater priority to these activities of hunting and gathering than to farming. Nevertheless, in order to conform to other societies they are living as best they can while adjusting their world as indigenous inhabitants, encompassing their previous form and one that has been realized for the sake of their continued subsistence; perhaps we could see this as one of their cultural characteristics.

In terms of the distribution of economic wealth, too, the distribution of possessions in their society is carried out on the basis of their norms of equality and mutual support, and is of important significance in expressing their social system. Therefore, it has been pointed out that an attempt to incorporate them into the development plan along the lines of normal economic concepts could cause them serious psychological disturbance. Also, even though the situation of many different ethnic groups living together in one conglomeration is regarded as inevitable, in actual fact those whose presence will be dominant in terms of both political and social organization, and will moreover have a solid structure, will still be the groups consisting of bandas and family units. Attempts to create a new form of leader such as through regional government or unions are said to have failed for this reason.

(Main reference works)
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3) The Mennonite people and their society

The Mennonites are a Christian sect that was founded by Menno Simons (1496-1561) in Switzerland during the religious reforms of the 16th century.

As an anabaptist sect, their creed includes rejecting the baptism of infants and refusing military service. The Mennonites suffered persecution due to religious activity and were driven out of their Germanic homeland. As a result, a number of permanent settlements of Mennonites emerged in Russia in the 18th century. However, the Mennonites suffered under the impact of the Bolshevik revolution in 1917, and by the 1920's they had no option

but to leave the Soviet Union. They emigrated to Canada, and moved on from there to South America in search of land where they could settle. They found a safe haven in Paraguay, and thus started the first Mennonite settlement here in 1926.

The term "Mennonite settlements" is a general title covering the three settlements of Menno, Fernheim, and Neuland, which were originally established by the Mennonites who arrived here as a result of this historical sequence. Their total land area is about 1.1 million ha, with a total population of 12,000 people.

As of 1926, human activity in the west of Paraguay and the Chaco region mainly involved the felling and transportation of lumber for tannin extraction, as well as management and labour in related factories. There were no roads or such like, and the work of opening up this land (known then as the "green hell") must have been unimaginable. The agricultural development by the Mennonites, which continued undaunted in spite of these adverse conditions, was stimulated by the opening of a national highway linking them with Asuncion in 1952, and progressed for example through the mechanization of agriculture funded by loans and the introduction of agricultural processing facilities. This led in 1971 to the start of a dairy industry whose chief product was long life milk, and dramatic progress was achieved in these settlements on the basis of agriculture and livestock farming.

Each of the three settlements has its own autonomous authorities and agricultural cooperative union, while in each settlement there are also hospitals, schools, and other facilities. Apart from this, there are agricultural and livestock produce processing plants, repair workshops, power stations, and commodity trading centres operated by the agricultural cooperative unions.

The highest authority of the unions is the General Meeting, under which there is a Board of Directors that undertakes the management of the union. There are also judiciary posts answerable to the General Meeting; these make decisions on crime and litigation problems. As for schools, in general there are elementary, intermediary, and high schools in each settlement; there has been a succession of university graduates originating from the settlements. In the Menno settlement, there is an agricultural school, a school for the disabled, and a bible school, while in the Fernheim settlement there is a vocational training school.

Initially, education is mainly carried out in German (with a weight of 60% against 40% for Spanish), thus ensuring the continuation of German culture. The weight of language teaching is reversed later on, with 40% for German and 60% for Spanish, the objective here

being to assimilate both German and Paraguayan cultures by teaching lessons in both languages.

Various sporting and cultural activities thrive in the settlements, mainly for young people, as for example with the Fundacion del Club Deportivo Fernheim in Fernheim.

There is an agricultural and livestock farming test centre in the Menno settlement. This has made a vital contribution not only to farm management in the settlements but also in relation to agricultural development in this area.

Furthermore, apart from various industrial facilities and others connected with economic activity, there are also general social facilities such as those for education and medical care in these settlements, as well as others such as numerous churches, museums that tell the history of the opening up of the settlement land (Menno, Fernheim), an old people's home (Fernheim), a radio station (Fernheim), and others.

The Mennonites and the Mennonite settlements in which they are grouped have achieved the development of Chaco through their long-suffering endurance and their strong solidarity as a religious group, based on traditional German culture and a fanatical faith in their religion. In the process of this they have created a unique society. Their pioneering spirit and development capabilities has received much acclaim as an outstanding example both at home and abroad.

However, although the Mennonites of course have an economic connection with the outside world through their agriculture and livestock farming, on account of their religion they have no social relationships or exchanges with non-Mennonites.

One thing that is particularly noteworthy with regard to the society of the Mennonite settlements is that the Mennonites have their own unique way of relating to the indigenous people who were the original inhabitants of their land.

There are about 15,000 indigenous people living inside the three settlements, and a church serving more than 3,000 believers has been established for 20 of their tribes by the "Luz a los indigenas" set up in the Fernheim settlement.

The Asociacion de Servisio de Cooperacion Indigena Mennonita (ASCIM), formed in 1961, has obtained 155,000 ha of land for the indigenous people with aid from international organizations. 9,000 people from these ethnic groups live in families and are involved in farming on the residential settlements on this land.

Also, some distance from the centre of the settlements ("out of town", as it were), about 6,000 of these people live as permanent, seasonal, or hourly-paid workers.
Support is extended to these indigenous people in the Mennonite settlements in the form of teams made up of agricultural engineers, educators, doctors, nurses, sociologists, union experts, and others.

3.2.3 Population and population composition

The western region (Chaco region) is the least densely populated region in Paraguay. The 72,907 km² of the study area (Departamento Presidente Hayes) takes up about 30% of the surface area of the Chaco region (246,925 km²). As of 1989, the population of Chaco as a whole was estimated at 66,353. The population of the study area is 38,553, the largest within Chaco, taking up 58.1% of the region as a whole. At the time of the census in 1982, the population of Chaco as a whole was taken to be 56,832 and that of the study area 33,021. Thus the population increased 1.17 times or 2.24% per year in the space of seven years. This is well below the average annual increase of 3% for the country as a whole.

However, since the national statistics do not include the indigenous population, to be accurate the Indio population must be estimated and added to the figures. According to INDI data, 26,169 Indios were estimated to be living in Chaco as a whole and 12,630 in the study area in 1982. If we assume the same population increase rate as for Paraguayans, the population of Indios in the whole of Chaco can be estimated at 30,553. Therefore, the total population of Chaco in 1989 is estimated at 96,906, and that of the study area as 53,298. Thus the population density in the study area is 0.73/km², which in terms of Chaco as a whole is on a par with the Departamento Boqueron; however, this is a mere 1/35th of the 25.6/km² in the eastern region.

In the study area, the urban population was 16,276 and the rural population was 22,277 in fiscal 1989, these increasing to 16,542 and 36,756 if the indigenous people are included. Thus the rural population accounts for 69% of the total. Meanwhile, cities referred to in the study area are Villa Hayes, Benjamin Aceval, and Puerto Pinasco. The provincial capital Pozo Colorado is a village situated in the centre of the study area and has a small population. But as it lies on the intersection between National Highway No.9 and the road that links Concepcion (on the Rio Paraguay) to General Diaz (on the Rio Pilcomayo), it has a high likelihood of becoming the focal point of future development.

3.2.4 Regional economy

The main industry within the study area is livestock farming; besides beef cattle production, the largest scale of dairy farming in Paraguay is conducted in the Mennonite settlements situated in the north of the area. Agriculture is the second industry to livestock farming, though arable land is limited to the north of the study area centring mainly on the Mennonite settlements, and the suburbs of the capital in the south. The main agricultural products include peanuts, castor oil plants, sorghum, and cotton in the north, and sugarcane and cotton in the south.

In the industrial sector, Paraguay's only steelworks (Acepar) manufactures steel reinforcement materials in Villa Hayes. Apart from this, there are, among others, a cane sugar refinery and a small-scale alcohol factory operating in Benjamin Aceval. Acepar uses Paraguayan charcoal for its energy and makes steel from imported iron ore. It was the subject of massive investments by the Paraguayan government, but it is not being managed satisfactorily and moves are afoot to have it privatized.

Factories for dairy processing, cotton spinning, oil, animal fodder, palo santo oil extraction and others are concentrated in the three Mennonite settlements, forming a complex for processing the agricultural produce of Chaco. Meanwhile, since the volume and value of production in the Mennonite settlements are statistically counted as being within the Departamento Boqueron, it is difficult to assess the value of agricultural and livestock production in the study area accurately.

3.3 INFRASTRUCTURE

3.3.1 Roads

Within the study area there are three national highways: National Highway Nos. 9 (Asuncion - Eugenio A. Garay) and 12 (Chaco - General Bruguez), and the road connecting General Diaz to Pozo Colorado and Concepcion. The most important of these is National Highway No. 9, which as part of the Pan American Highway is relied upon as a major artery linking the Pacific to the Atlantic oceans, by virtue of linking up with the road network in Bolivia. So far, its surface has been asphalted from Asuncion to Mariscal Estigarribia (534 km) or for about 69% of its total of 777.8 km. Other important roads in the study area are those between Pozo Colorado and Concepcion (140 km) and Pozo Colorado and General Diaz (179 km). On the road between Pozo Colorado and Concepcion, the second bridge linking Chaco with the eastern region has already been completed over the Rio Paraguay, and work has started on surfacing from the Pozo Colorado and Concepcion ends. In future this is expected to be important as a transportation route for agricultural produce from central and northern Chaco. The road between Pozo Colorado and General Diaz is important in terms of promoting the development of agriculture and livestock farming in the north of the study area, and at present it is being managed comparatively well by MOPC. However, surfacing work has not yet started.

Roads that have been improved by the private sector include earth roads linking the large pastures (estancias) with the trunk roads or the ports along the Rio Paraguay, and roads inside the Mennonite settlements. The roads inside the Mennonite settlements are being well managed by the agricultural cooperative unions, but the estancia roads have little traffic and are not adequately managed.

3.3.2 Airfields

With a low density of roads and access impassable for long periods during rainfall, private airfields have become a vital means of conveyance for many estancias. The private airfields all have earth runways. There are thought to be 441 airfields in Chaco, and 327 or 74% of these are located in the study area. This is linked to the fact that estancias are concentrated in the study area and that livestock farming is well developed here. Though it is outside the study area, there is a 3,500m long and 60m wide military airfield with concrete surfacing in Mariscal Estigarribia; this is equipped with functions that could make it a base for the development of Chaco in future. Also, in the Mennonite settlements, there are good airfields (albeit with earth runways) in Filadelfia, Loma Plata, and Neuland.

3.3.3 Electricity etc.

As of 1991, in the Chaco region only 4,418 households in Villa Hayes, Benjamin Aceval, Nanawa, and Cerrito in the south of the study area had access to an electricity supply from the national electricity corporation (ANDE). In the Mennonite settlements, power is independently generated using wood gas and diesel, and this is supplied to most of the union members over an independent transmission network.

In other regions, the main form of power is self-generated using oil or wood, while a partial back-up supply is provided by solar energy. Wind-power generation is also used mainly for low water pumping. Indigenous people and small farmers without capital mainly use firewood.

3.3.4 Communications

Turning to telephone communications in the Chaco region, cable telephones are limited to the suburbs of the capital in the south of the study area, though micro-wave communication facilities are now being developed by the state telephone company Antelco and communications in central Chaco are becoming easier. In addition, a UHF communication network aimed at the port towns along the Rio Paraguay is being developed with a base in Concepcion. As of 1989, the number of households using Antelco inside the study area was 403, followed by 185 in Departamento Boqueron.

3.4 THE IMPORTANCE OF CHACO DEVELOPMENT IN VARIOUS POLICIES RELATING TO NATIONAL PLANNING AND AGRICULTURAL DEVELOPMENT

The main tasks for the agricultural production sector in Paraguay's national socio-economic plan for 1985-89 (formulated in 1984) are diversifying agricultural produce, expanding employment opportunities, protecting the environment, making effective use of natural resources, and improving the income levels of rural inhabitants by raising productivity. The plan that followed on from this (1989-90), with the basic aim of improving the national welfare, had objectives such as self-sufficiency in food, promoting employment, protecting the natural environment, distributing land evenly, setting fair prices for agricultural produce, organizing producers, and reinforcing testing and research. It was aimed at the agricultural and livestock farming sectors which are the mainstay of the country's economy.

On the basis of these national plans, the government aims to improve environmental conservation and land productivity rather than proceeding with future development with respect to the eastern region in which development is already advanced. On the other hand it aims for a balanced development of the national land by promoting the development of the western Chaco region, where the level of development is lagging behind. Thus it has determined and promoted the expansion of export products and employment opportunities that will accompany this, as well as measures for small farmers and various agricultural policies which will contribute to this.

The request by the government of Paraguay for cooperation from the Japanese government in formulating the Integrated Agriculture and Livestock Development Project at Lower Chaco was made under the above circumstances in May 1990, and the development of Chaco is given importance via objectives such as a balanced development of the national land, the expansion of export agricultural produce, an expansion of employment opportunities, and so on.

Thereafter, although the next socio-economic plan that was scheduled for 1990 has not yet been formulated, the Economic Planning Agency formulated "Socio-Economic Guidelines" with regard to the socio-economy and the Ministry of Agriculture and Livestock "Agricultural Guidelines" with respect to agriculture and livestock farming, in February 1991 in either case. These are seen as replacing national plans.

In the "Agricultural Guidelines", the main issues in the agricultural sector are securing food for the nation, diversifying export commodities, and providing the small farmer population with capabilities for production efficiency. Thus it does not differ fundamentally from the course of agriculture and livestock farming in the previous national plans. In addition, with regard to the

development of Chaco, a "Strategy for the Sustained Development of Chaco" was drawn up by presidential ordinance as a basic framework for requesting aid from the EC. This, while making even clearer the importance of Chaco development as positioned by the "balanced development of the national land" in the Socio-Economic Development Plan (1985-89), in terms of the form that this development should take it clarifies it as "sustained development" with prime emphasis on environmental protection.

3.5 EXISTING DEVELOPMENT PLANS

After the Chaco War with Bolivia at the beginning of the 1930's, the Chaco region was a sensitive area in military terms, and military bases were established over the whole region. Subsequently, though, the tension with Bolivia has gradually relaxed, and the importance of comprehensively developing the Chaco region, disregarded until then, has been recognized. Thus in 1977 the Committee for the National Development of Chaco (CNDCH) was set up in the Defense Ministry. The CNDCH, in conjunction with OEA, promotes surveys on soil and vegetation, as well as the formulation of integrated development plans aimed at the whole of the Chaco region. Some of its programs are already moving towards implementation.

For Paraguay, the most important aspect of the development of Chaco is to contribute to national economic and production activity via the rational use of its abundant natural resources. Specifically, the objectives of Chaco development are as follows.

(i) Balanced development between the Chaco region and the eastern region
(ii) The development of the latent productivity of Chaco, using methods that are in harmony with the natural environment
(iii) Improving the living conditions of the local inhabitants

Integrated development plans in connection with the Chaco region were proposed in the "La Cuenca del Plata" survey by OEA in 1971. In this survey, conclusions were reached regarding the possibility for example of developing livestock farming in the semi-arid Chaco region, developing agriculture, creating employment, and developing alternative forms of energy. The first phase program, the "Project for the Multi-Purpose Use of the Rio Pilcomayo Basin" (Proyecto de Aprovechamiento Multiple de la Cuenca del Rio Pilcomayo), was started jointly by the Argentine, Bolivian, and Paraguayan governments, OEA, UNDP, and the World Bank in 1974. In this first phase, outline surveys and diagnoses of the area in question were carried out, and as a result of this a large number of investment projects were launched, covering an area of about 100,000 km^2 in Paraguay Chaco. In the second phase of this survey, a new project for 70,600 km^2 in the three countries was proposed by OEA in 1980. Meanwhile, the CNDCH had already been set up in Paraguay in 1977, and a system for the fully fledged development of the Chaco region was already in place. Also, in 1978, the "Plan Regional para el Aprovechamiento de la Zona de Influencia de la Ruta Transchaco" survey was implemented in view of the development along National Highway No.9.

In 1981, the "Desarrollo del Area Paraguaya del Proyecto Pilcomayo" survey was implemented by the OEA. In this survey, a package of concentrated investment projects to the tune of US$48

million were proposed in connection with production, social, and support sectors for about 19,000 km2 along the road between Pozo Colorado and General Diaz.

On the basis of the various projects mentioned above, the Paraguayan government, with the cooperation of the OEA, started the "Proyecto Regional Integrado del Chaco Paraguayo" survey for the Chaco region in 1982. In this survey, the OEA launched 49 new projects in addition to the 99 existing CNDCH projects. Furthermore, the central southern region of 56,120 km2 around Pozo Colorado is given as the area within the whole of the Chaco region that has the highest order of priority for development. This area includes the northern half of this study area, the Departamento Boqueron, and part of the south of the Departamento Alto Paraguay, and takes the road between General Diaz, Pozo Colorado, and Concepcion as its central pivot. The reasons why this has a high order of priority are that there is a broad expanse of land that is suited to agriculture and livestock farming, and that the abundant water resources of the Rio Paraguay can be utilized. Meanwhile, the area subject to the previously mentioned Proyecto Pilcomayo is also included in this subregion.

Table 3.5.1 shows the state of implementation of projects (including surveys) connected to the Chaco region that are currently registered at the Economic Planning Agency of the President's Office. According to this Table, the state of progress is that 3 projects have been completed, 6 are underway, 4 are under negotiation, 1 has not been adopted, and 4 have potential but their implementation has been postponed. Of these, 5 (including this study) are projects for which the Ministry of Agriculture and Livestock (MAG) is the host organization. These projects have the aim of contributing to the development of the region and the national economy by rationally activating available resources while protecting and managing the abundant nature and environment of the Chaco region.

3.6 THE CURRENT STATE OF AGRICULTURE AND LIVESTOCK FARMING

3.6.1 Agriculture

Grasslands, forests, and mountains account for 97.9% of land utilization in the study area, while arable land takes up a mere 1.2% (1981). The main areas for cultivation are the Mennonite settlements and the Asuncion suburbs, while hardly any crop farming is conducted in other areas.

The main agricultural products of the study area include cotton, sugarcane, peanuts, sorghum, and castor beans. In the Mennonite settlements, cotton, peanuts, castor beans and others are cultivated, and until now favorable results have been achieved, considering the harshness of the cultivation environment. However, production is unstable and production costs are becoming inflated, as a result of which the focus of production has been shifting from agriculture to livestock farming in recent years.

In the suburbs of Asuncion sugarcane is cultivated in abundance, and is transported to the sugar refining factory there. Meanwhile, the advantages of the city suburb location are put to good use in producing various fruits and vegetables. Apart from these, sorghum for animal fodder as well as cassava, poroto, and others are produced for self-sufficiency consumption.

Viewing the production of the various crops in terms of the Chaco region as a whole, cotton is cultivated in the Mennonite settlements and in the south of the study area, with a total of 15,000 ha and about 18,000 tons cultivated overall in fiscal 1990 (2.0% of the total national crop yield area, 2.8% of the national production output). Sugarcane is cultivated in the south of the study area (the only such location in the Chaco region) with a crop yield area of 15,000 ha and a production output of 64,000 tons (2.1% and 2.8% of the national totals). Peanuts are the largest commercial crop in the Chaco region, and are mainly cultivated in the Mennonite settlements, with a crop yield area of 20,000 ha and a production output of about 24,000 tons (62.8% and 58.4% of the national totals). Sorghum is mainly cultivated in the Mennonite settlements as animal fodder, with a crop yield area of 15,000 ha and a production output of about 16,000 tons (65.2% and 57.7% of the national totals). Castor beans are cultivated in the Mennonite settlements, in Departamento Alto Paraguay, and elsewhere, with a crop yield area of 7,000 ha and a production output of about 6,500 tons (21.2% and 17.6% of the national totals).

3.6.2 Livestock farming

The study area (Departamento Presidente Hayes) is the largest livestock producing province in Paraguay, and, according to the agricultural and livestock farming census of 1991, 1.79 million head of cattle (or 23% of the national total) were being raised here. There are also 64,400 sheep, 30,800 goats, and 34,000 horses, representing 18.0%, 30.1%, and 10.8% of the respective national totals. The figures for sheep and goats are the largest in the country. But those for pigs and chicken are relatively low, being 13,200 and 76,400, or 1.3% and 0.7% of the respective national totals.

In the Mennonite settlements dairy farming is predominant, and the three farm cooperatives between them produce 35,000 tons of milk each year. This represents 35% of the domestic production volume, a figure that is increasing annually. Paraguay's self-sufficiency in dairy produce is said to be 30%, and milk production in the Mennonite settlements is one of the most promising industries in the Chaco region.

The production of beef cattle in the study area is carried out by year-round free-range pasturage in natural grasslands created by felling low scrubland forests. The manner of husbandry is uncontrolled, and individual pasture areas extend to several hundred hectares, most of them with nothing but perimeter fencing. Since the grassland area used per head is large (2.5-3 ha or more) there is the advantage that fattened cattle can be brought to market more quickly than in the eastern region. A characteristic of this area is that large-scale management pastures take up the majority of the land and cattle in the area, and there are no few cases in which the pasture owners live in Asuncion and contract the pasture management to farm engineers. The destinations for fattened cattle are livestock markets and slaughterhouses in Asuncion.

Apart from the Mennonite settlements, the principle form of land use in the Chaco region is livestock farming on natural grasslands. Natural grasslands are divided into lowland and highland types, the productivity of grass in the former being about 2,700-7,000 kg/ha while that in the latter is about 800-3,000 kg/ha (both dry weight). There are differences in the suitability of grasses in improved grasslands depending on land and climate conditions, so these are not necessarily the same from region to region. In the study area these are mainly pangora, while other grasses such as bracchiaria and salinas are also commonly used.

There is no fertilizer cultivation management of improved grasslands using chemical fertilizers. The production of fodder crops in the area is negligible, with the exception of the Mennonite settlements. Sorghum is silage-adjusted and produced as a supplementary fodder for dairy farming at times when fodder is in short supply.

The reason why so many sheep and goats are raised is in order to remove weeds and scrub, as well as for self-sufficiency by small farmers and indigenous people.

There are many melliferous plants such as water hyacinths, palm, algarrobo, and aromita in the study area, providing the most suitable natural conditions in Paraguay for apiculture. Apiculture products can be stored for long periods in the form of primary materials, their unit price is high compared to other agricultural produce, and transportation costs take up a low proportion of the price. Therefore, they can be produced to advantage even in this area which is remote from markets and where the road conditions are poor. Many of the national support systems for agriculture and farming are concentrated in the eastern region, and there is only one research institution in the study area, viz. the Chaco Test Site of the Livestock Farming Trial Research National Program in Pozo Colorado. There are two agricultural diffusion sites.

3.6.3 Forestry

Forestry in the Chaco region mainly involves the supply of raw materials for tannin and palo santo essence extraction, small-scale timber production in the Mennonite settlements, and the consumption of firewood, charcoal, pasture fences and others within the area. The amount of timber used in Chaco is said to about 2% of the national total, and is estimated to have accounted for 110,000 tons of the national total of 5.6 million tons in fiscal 1989. Because development is lagging in the Chaco region and there are meagre usable timber resources, forestry is not thriving. The wood that is considered useful in Chaco includes quebracho colorado, used for tannin extraction, and coronillo, used for construction materials or pasture fences. There are factories for extracting palo santo essence in Filadelfia and Loma Plata, and this is exported as a raw material for perfumes. All the tannin and palo santo essence in Paraguay is produced in the Chaco region, and this is said to account for almost half of forestry production in the Chaco region. Recently charcoal production has been increasing, stimulated among others by the start of operation of the steelworks (Acepar).

3.6.4 The importance of agriculture and livestock farming in the regional economy

With the exception of the Acepar steelworks, the production sector in the study area entirely involves agriculture and agricultural processing industries. The study area is near the capital region, and its agricultural and livestock farming development shows the fastest progress in the Chaco region as a whole, alongside that of Central Chaco. But land productivity is low because the population is sparse and farm management is uncontrolled, and so the high potential in agriculture and livestock farming is not being used to good advantage. As the future direction for development in the study area, one method would be

to introduce city suburb type industries, as can be seen in the example of Acepar, but suitable land for this is limited to part of the south of the study area. From the point of view of the useful exploitation of resources, agriculture and livestock farming that use ample land and water resources are most suitable, and economic development ought to proceed from investment into these industries. Moreover, because the population is sparse, permanent human settlement is vital, and we need to implement improvements to social infrastructure facilities such as electricity, communications, drinking water, school, and hospitals in parallel with their maintenance and management, in order to improve the living environment.

CHAPTER 4

OUTLINE OF THE STUDY

CHAPTER 4 OUTLINE OF THE STUDY

4.1 HYDROLOGY, CLIMATE AND WATER RESOURCES

4.1.1 Climate

1) Contents of the study

(1) Meteorological data were collected through the Department of Meteorology and Hydrology (DMH) of the Private Aviation Agency (DINAC). For the records of observation stations not under the jurisdiction of the Department, existing reports were reviewed.

(2) In order to supplement existing materials and undertake continuous collection of meteorological data, meteorological observation equipment was installed with the cooperation of DINAC-DMH.

2) Results of the study

(1) The annual average temperature is 23-24°C. It is 23-30°C during the summer time (October through April) and 17-23°C during the winter time (May through October), increasing from the southeastern region to the northwestern region. The high-temperature season is between November and February while the low-temperature season is between June and July.

(2) The annual average relative humidity is 65-75%. Due to the influence of the decrease in temperature, humidity is higher in the winter season when precipitation is low than in the summer season when precipitation is great.

(3) Annual precipitation is 1,300 mm in Asuncion, 800 mm near Mariscal Estigarribia in the northwestern region, and 1,100 mm in Pozo Colorado. It decreases from the southeastern region to the northwestern region at the rate of 1 mm per 1 km. 60-80% of precipitation is concentrated in the summer time. 50% of it is concentrated in the quarter from November through January. The modes of precipitation are extremely varied.

(4) The amount of evaporation is 1,012 mm in Asuncion, 1,973 mm in Mariscal Estigarribia, and 1,400 mm near Pozo Colorado. It increases towards the northwestern region.

(5) Annual daylight hours are 2,670 hours in Asuncion and approximately 2,400-2,460 hours in other areas.

(6) The most frequent directions of wind are from the south and north. Approximately 25% of the study area has no wind. 75% has wind blowing from different directions. The annual wind velocity is 2.3 m/s in Pozo Colorado and 8.9 m/s in Loma Plata. Strong winds blow from May through November, with a peak in October (10.9 m/s).

(7) The number of days of frost is 0.3 days/year in La Victoria and 2.8 days/year in Pozo Colorado. Frost is concentrated in June and July. There is no frost in other months.

4.1.2 Hydrology

1) Contents of the study

(1) With the cooperation of DINAC-DMH, automatic water level observatories were installed along the Rio Aguaray Guazu, the Rio Monte Lindo, and the Rio Verde which flow along the lands suitable for field husbandry.

(2) Hydrological factors were analyzed. The hydrological potential of the whole area was assessed. Also, the flow of major rivers was analyzed.

2) Results of the study

(1) Overview of topography and rivers in the area

The topography is generally flat, inclining from west to east with an extremely mild incline of 1/5,000.

The study area is sandwiched between the Rio Paraguay in the east and the Rio Pilcomayo in the southwest, running along the border with Argentina. Near the border with Argentina in the southwestern region lie wetlands called patiños. There are also many dry rivers which have water only during the rainy season.

All the rivers in the area flow into the Rio Paraguay, which is divided into eight branch streams. An overview of major rivers in the area is as follows:

a) Rio Paraguay

This river originates in Sierra de Parecis in Brazil and its catchment area is 1,095,000 km^2. During the flooding period, it floods over a wide range of lowlands on the shore. The annual average flow is 3,580 m^3/s at the Concepcion point and 4,050 m^3/s at the Asuncion point. The quality of water is good soft water and it is suitable for drinking. However, no concrete water utilization plan has been formulated due to geographical and economical factors, including the fact that natural water intake is difficult as the river flows in the lowland area along the Chaco region.

b) Rio Pilcomayo

This river originates from the Andes in faraway Bolivia, collects water from the Tlacapa Plateau, flows down to the south, and joins the Rio Paraguay at Asuncion. The average flow at Villa Monte (Bolivia) is 200 m^3/s. The quantity of sand sedimentation is 100 million tons per year. This is a flood river with repeated erosion by floods and sedimentation, and it has an unstable flow. It causes floods during the rainy season and resultant damage, but is useful in terms of the filtration of water underground and the supply of water to neighbouring rivers and marshes.

c) Other rivers in the study area

Major rivers in the area include the Rio Aguaray Guazu, the Rio Negro, the Rio Monte Lindo, and the Rio Verde. Since the inclination of the rivers is very mild, they meander greatly. The flow situation, flow volume, and water quality are unstable, and change greatly according to the year and season. Many of them become dry in the dry season. Rivers which flow even during the dry season include all of the above rivers except the Rio Verde.

The rivers located in the south of the Rio Monte Lindo are extremely unstable, changing in accordance with the water level of the Rio Pilcomayo which has an unstable flow situation. During the dry season, the salt content increases and electric conductivity reaches more than 20,000 micromho/cm. Even goats, which have strong resistance to salt content, do not drink this water.

(3) Hydrological analysis

a) Water level of rivers in the area

The water levels of rivers in the area fluctuate greatly. The fluctuating pattern differs greatly according to the month and year.

The annual average water level of the Rio Negro is 2.28 m. It is highest in June and lowest in October. The most common water level is 1 m (130 days in a year). The ordinary water level is 1.4 m.

The annual average water level of the Rio Monte Lindo is 2.36 m. It is highest in May and lowest in September. The most common water level is 1.75 m (60 days in a year). The ordinary water level is 1.8 m.

The annual average water level of the Rio Pilcomayo (at General Bruguez point) is 1.6 m. It is highest in May and lowest in September. The most common water level is 1.6 m (103 days in a year). The ordinary water level is 1.3 m.

b) Quantity of flow of rivers in the area

The water level and flow curves (H-Q Curves) were calculated from the water level and flow speed on the basis of data measured by the Harbour Management Agency (ANNP) and the flow speed measured in this study. The monthly and annual flows of the Rio Negro, the Rio Monte Lindo, and the Rio Paraguay (at Concepcion and Asuncion), for which water level data were available, were calculated. For the results of analysis, refer to (3) Water resource reserves, 2) Results of study, 4.1.3. Water resources.

4.1.3 Water resources

1) Contents of the study

(1) Electric conductivity and pH were measured as basic material to facilitate the utilization of rivers in the area for agriculture. In order to review the possibility of utilization as water for irrigation and drinking, the Water and Environmental Research Centre was commissioned to analyze the quality of water of the four rivers in the area for chemicals and micro-organisms. The water for analysis was taken from the points shown in fig. 4.1.1.

(2) The water resource reserves in rivers and basins in the area were calculated and the water resources available for utilization were reviewed.

2) Results of the study

(1) Accumulation of salty water and saline substances

The current situation of accumulation of salty water and saline substances in the Chaco region is as follows:

(i) Groundwater collected in the Andes in Bolivia very slowly flows down while dissolving saline substances contained in strata of the 3rd and 4th Cenozoic Periods, which have a thickness of 1,000 m (reaching 3,000 m in the western Chaco region) under the ground of the flat Chaco region.

(ii) This groundwater comes to contain high concentrations of salt near the central Chaco region where the incline from the Western Chaco becomes mild, the particle size of sediments becomes fine, and the water transparency coefficient becomes small. Groundwater flows 6-10 m below the ground surface, or comes up to the ground surface. Since this spring water becomes the source, the water comes to contain high concentrations of salt when the water level becomes low.

(iii) According to the Chaco Agriculture and Livestock Farming Service (SAP) in the Mennonite settlements, the rise of the groundwater level due to long-term inundation changes the water of lakes and irrigation ponds, which up to this point has been fresh water, into water that contains high concentrations of salt; saline substances are retained in the soil even after the water level goes down. They then gradually come up to near the surface layer and accumulate there due to repeated precipitation and evaporation, causing extremely significant damage. In the Mennonite settlements, water retained in dams which had been fresh water became salty water due to long-lasting rain in 1983.

(2) Current status of utilization of river water

As a result of analysis of topographical maps of 1/50,000 and aerial photography, water mainly in the upper reaches of the Rio Verde and its branch streams has been dammed up to be used mainly as drinking water for livestock.

However, this form of reservoir has been shown to cause a rise of groundwater. In actuality, at the crossing point with National Highway No. 9, the water has a very high concentration of salt throughout the year.

(3) Water resource reserves

a) Flow volume in major rivers

In order to assess the absolute quantity of water resources in the rivers in the area, the flows of the Rio Paraguay (at Asuncion and Concepcion points), the Rio Negro, and the Rio Monte Lindo, for which water level data were available, were analyzed. The results of analysis are as follows:

(a) Rio Paraguay

The annual average flow and annual total flow at the Concepcion point are 3,580 m3/s and 13 billion m^3/year, respectively. In a year, the flow takes a mountain-type distribution in which it is least in December, gradually increases thereafter, reaching a peak in June, and then gradually decreases. The monthly average minimum flow was 1,655 m^3/s at the Concepcion point in December 1988, the lowest value during the period of statistics. In terms of daily flow, December 19-20 showed the absolute lowest flow of 1,539 m^3/s during the period of statistics. From the above-mentioned results of analysis, taking water for irrigation from the

Rio Paraguay (50 m^3/s for example) is considered not to affect the flow of the river or the navigation of ships.

(b) Rio Negro

The annual average flow of the Rio Negro at the crossing point with the National Highway No. 9 is 16.6 m^3/s while the annual total flow is approximately 500 million m^3. However, the monthly and annual fluctuations are large, making it an extremely unstable river.

(c) Rio Monte Lindo

The annual average flow of the Rio Monte Lindo at the crossing point with National Highway No. 9 is 18.7 m^3/s while the annual total flow is approximately 600 million m^3. However, monthly and annual fluctuations are large as with the Rio Negro, making it an extremely unstable river.

b) Water resource potential in basins

From the distribution of precipitation in the eight basins within the study area, the annual average precipitation per area and the precipitation supply were calculated. The catchment area of all eight basins (including regions outside the study area) is 109,247 km^2. The supply is 970 mm/km^2 per year. The annual flow of the Rio Aguaray Guazu is 900 million m^3/year.

(4) Quality of water in rivers and tamajar reservoirs

a) Potential as irrigation water

In the case of rivers, when the water level is low, both electric conductivity and pH show extremely high values. But when the flow due to precipitation dilutes the river water, the values go down rapidly.

The quality of water of tamajar reservoirs, which retain precipitation and surface water, is good and salt is not mixed.

As a result of analysis of the quality of river water during the flooding period when water quality is good, the risk of Na contamination of rivers in the north of the Rio Negro is medium to high, while the risk of salt concentration contamination is medium to extremely high. Also, the toxicity of salt is great and utilization for irrigation water is extremely limited. On the other hand, the water quality of the Rio Aguaray Guazu is generally good during the flooding period. During the dry season, there is a fear that the concentration of salt may become high.

b) Potential as drinking water

Judging from the results of previous and current water quality analyses, water from

rivers except the Rio Aguaray Guazu has abundant Na^+ and $SO4^{2-}$ even when the flow increases and makes the water quality good, and may cause diarrhoea if it is drunk. There is also water contamination by faeces and urine of livestock which makes it unsuitable as drinking water.

While colon bacilli are detected from the Rio Aguaray Guazu (during the flooding period), its water is available for drinking if filtered and boiled.

(5) Review of available water sources

a) Rio Paraguay

The water quality is soft and suitable for all kinds of utilization. There is no problem in terms of reserves. This water source is available for irrigation.

b) Rio Pilcomayo

This river transports a huge amount of river sediments which amount to 100 million tons per year. The location of the river varies greatly, making it a flood river with an extremely unstable flow situation and flow volume. Since the river flows into low damp ground in the upper reaches of the study area, there is very little flow in the study area with high salt concentration. This is also an international river flowing through three countries, as well as forming the border with Argentina. From these facts, when the utilization of the Rio Pilcomayo is considered, there is a need to execute a program to prevent erosion as well as soil and sand effluence in the upper reaches in Bolivia, and to stabilize its flow situation. Also, co-ordination is required on the basis of international agreement between the three countries. Therefore, as it is extremely difficult to incorporate the utilization of this river into the present Plan, after consultation with the related agencies it was decided to omit the utilization of this river from the present Plan.

c) Rivers in the study area

In rivers to the north of the Rio Negro in the study area, the salt concentration is high when the water level is low. The fluctuations of water level are great and extremely unstable. Furthermore, the quality of water is not suitable for irrigation and its utilization is extremely difficult. On the other hand, the water quality of the Rio Aguaray Guazu can be used for irrigation during the flooding period. Its water level is not measured and its flow situation is unstable in the same manner as other rivers in the study area. Therefore, its use would be limited.

d) Precipitation reserve dams

This type of dam exists in the Mennonite settlements. The study shows that the problem of salting of reserved water in the dam arises. Also, by building dams, the quality of water in the whole river is deteriorating. Furthermore, as the topography is flat, there is almost no suitable land for dam sites. Therefore, there is little possibility to develop this kind of dam in the Chaco region.

e) Tamajar reservoirs

The tamajar, which retains precipitation and surface water, is actually widely utilized in the Chaco region, and is a promising water source for livestock farming.

f) Utilization of constantly inundated areas

The water of constantly inundated areas scattered around in the south of the study area is available for irrigation in terms of quality. However, they are so-called plate ponds with a shallow water depth. Due to the supply of water by precipitation and slight topographical change, the range of wetlands changes greatly. Therefore, it is difficult to assess the available volume or to plan, construct, and maintain the water facility. If this is incorporated into the Plan, the ecological system of the flora and fauna that inhabit the wetlands will be completely destroyed, giving a great impact on the environment. Therefore, its use would be limited to a very small size.

g) Direct reserves of precipitation

As drinking water for humans, one promising method is to guide precipitation on roofs with water pipes and to retain it in underground concrete tanks, as is generally practiced in the study area.

4.2 GEOLOGY AND GROUNDWATER

1) Contents of the study

Through material collection, assignment of work, field study, and analysis of aerial photography, a study to assess the outline of hydrology and geology in the Chaco region, the hydrology and geology in the study area, and groundwater reserves was executed. Hydrological and geological studies as well as welling and pumping tests were commissioned to the Chaco Water Supply Department (CNDRICH-MDN). Boring studies of 28 wells have been conducted so far. On the basis of the results, 14 wells were bored to conduct simple water pumping tests (see fig. 4.2.1).

2) Results of the study

(1) Geology of the Chaco region

The geology of Paraguay is generally divided into two independent geological units of the eastern and western regions with the Rio Paraguay as the border. Among them, the western region including the study area is occupied by the Chaco sediment basin extending to the north of Argentina.

The Chaco stratum is composed of unsolidified sediments from the 3rd and 4th Cenozoic Periods. Its thickness amounts to a maximum of 3,000 m. It frequently includes rock salt and evaporated salt such as gypsum, regardless of whether they are formed on land or in the ocean. These evaporated salts were caused by the evaporation of running water in the dry period of the geological period. The evaporated salts existing in large quantities are considered to have been caused by the drying of inland lakes or shallow seas.

(2) Hydrological geology

a) Topography

Most of the Chaco region is topographically classified as strata of the 4th Cenozoic Period.

Looking at the topography in detail, old river beds are recognized in addition to the present ones. Old river paths in the forming period do not have continuity compared to newly formed ones. Vegetation is seen to vary according to the level of groundwater and water permeability. Such old river paths are found more commonly in the northern region of the study area through the surroundings of Filadelfia. In the central and southern regions, they are mostly accompanied by palm trees and wetlands. Many old river paths have aquifers that contain fresh water groundwater and form an important topography.

b) Aquifers

Aquifers in the Chaco region can be classified into the Chaco stratum of the 3rd and 4th Cenozoic Periods and the patiño stratum in the Cretaceous Period. The distribution of aquifers in the study area is mostly occupied by the former (see fig. 4.2.1). The Chaco stratum is classified into four aquifers in terms of stratum phase and water quality.

(i) The Chaco aquifer

Groundwater in the Chaco stratum basically flows in harmony with the topographical inclination. Since the groundwater dissolves a huge amount of evaporated salts contained in the stratum, the longer the flowing time, the higher the concentration of salt becomes. According to the results of boring surveys, below the second aquifer from approximately 10 m to 150 m deep, the concentration of salt is 500-56,900 micromho/cm, which is higher than that of ocean water. The result of analysis of the groundwater shows a NaCl type and a water quality of alkaline non-carbonated salt.

In Alto Chaco, the Lower Chaco stratum is widely distributed. The groundwater in this stratum (the first aquifer) shows a salt concentration of 2,600-19,400 micromho/cm. Groundwater with a relatively low salt concentration is often found in the sediments of old river paths.

(ii) Patiño aquifer

On the other hand, in the southern area from Benjamin Aceval, a patiño aquifer composed of Cretaceous sand rock is distributed. The groundwater in this aquifer is retained in cracks. This aquifer has good quality groundwater with a salt concentration of 50-1,000 micromho/cm.

(3) Current state of utilization of groundwater

a) Utilization of groundwater

In the whole Chaco region, more than 1,000 wells have been bored. Most of them are concentrated in the Departamento Boqueron. The distribution of these wells that tap water from the Chaco aquifer is summarized as follows according to the objective of utilization and area. (i) Groundwater has a water quality of EC = 225-2,000 micromho/cm for drinking water and 2,040-8,00 micromho/cm for livestock farming. When 8,000 micromho/cm is exceeded, water is not utilized. (ii) Water for drinking and water for livestock farming occupy 30% each of the utilization rate according to purpose. (iii) While the depth of the aquifer used becomes shallower from the

northwest to southeast, the geographical feature of the salt concentration is not particularly clear. (iv) In the Departamento Presidente Hayes, the depth of aquifer is shallowest and the average salt concentration is as high as 8,200 micromho/cm. The patiño stratum is one of the strata assessed as being a useful aquifer in Paraguay. Since this aquifer contains fresh water, it is used as water for drinking, factories, and miscellaneous purposes in Benjamin Aceval and Asuncion.

b) Utilization of tamajar reservoirs

A characteristic utilization of groundwater is conducted in the vicinity of Filadelfia in the north. This is the system of filtering the water collected in tamajares (dug ponds) through their bottom to the underground aquifer, and using the reinforced groundwater for drinking. This tamajar takes the form of a permeation-type tamajar, as compared to the reservoir-type tamajar commonly seen in the Chaco region.

This method artificially cultivating groundwater utilizes non-pressurized aquifer with a thickness of approximately 10 m in locations where old river paths have developed. The usefulness of this system is that there is no impact of evaporation due to underground reserves and improvement of turbidity.

(4) The volume of groundwater reserves

a) The volume of groundwater reserves in the Chaco stratum

Groundwater reserves were calculated by the distribution of old river paths surveyed by aerial photography, welling and boring surveys in old river paths and analysis. The groundwater sought after was limited to EC < 4,000 micromho/cm, which is the general limit for livestock farming. Underground water reserves = area x old river path distribution ratio x fresh water ratio x effective gap ratio of the aquifer

As a result, the old river path ratio was recognized in the area ratio of 8.8%. Among them, aquifers with groundwater of EC < 4,000 micromho/cm were calculated to have a width of 200-300 m and a thickness of 3-4.5 m, with an aquifer ratio of 6.7%. Therefore, in the model area with effective gaps a ratio of 8% is calculated to have reserves of approximately 1.4 million m^3 (1,400 m^3/km^2).

The calculated reserve should be understood to be the saturated groundwater volume of the aquifers, i.e. the reserves. Therefore, from the facts that groundwater that can be pumped by wells is smaller than this value, that the development of the fresh water stratum in old river paths in this area is irregular and is difficult to specify, that the thickness of the aquifer is thin and the water depth for utilization cannot be taken, etc., it is concluded that planned water taken from the Chaco stratum is difficult.

b) Underground water reserves in the patiño stratum

The groundwater capacity of this stratum is 1 $m^3/h/m$ on average in terms of output and is not large. But the thickness of the aquifer is estimated to be as thick as 100 m, or more. Water quality is as good as EC = 200-300 micromho/cm. Therefore, it is possible to increase the pumping volume by lowering the water level. In other words, if the water level is lowered to 20 m, a pumping volume of 20 m^3/h would be expected.

The cultivation volume of this stratum is estimated to be 14-28 x 10^3 m^3/km^2. This can be considered to be almost equivalent to the maximum groundwater reserve that can be pumped continuously. However, the actual possible pumping volume in the wells is smaller than this value. The spread of this stratum in the study area is at least approximately 50 km^2 according to geological maps, with a huge cultivation area. Since the Chaco stratum is distributed in the periphery of the distribution area of this stratum, it should be noted that the lowering of water level due to excessive pumping may pump up salty water in the Chaco stratum.

4.3 SOIL AND LAND USE

4.3.1 Soils

1) Contents of the study

Related materials were collected and the field survey was conducted with a focus on assessing the soils in the study area. The major survey items were as follows.

(i) Supplementary collection, collation, and analysis of materials concerning the soil survey, (ii) assessment of the classification of features and physichemical nature of soils in the study area, and (iii) consignment of soil analysis and survey work and review of survey results.

Especially in (iii) consigning soil analysis and survey work, the points of soil survey were selected before the survey was conducted in order to clarify the basic properties of the soil by physichemistry. The consigned party for both first and second soil analyses and survey works was the Soil Research Class in the Department of Agriculture, University of Asuncion. The major contents of consignment were as follows:

[Contents of consignment in the first survey]: Experimental boring survey: at 40 points, and (2) Sampling of soils and physichemical analysis: 106 samples. [Contents of consignment in the second survey]: Experimental boring survey: at 35 points, and (2) Sampling of soils and physichemical analysis: 140 samples.

The locations of this soil survey are shown in fig. 4.3.1.

2) Results of the study

(1) Status of soils in the study area

Solonetz, which is equivalent to lime clay soil, occupies approximately 75% of the study area. Xerosol, planosol, fulvisol, and regosol, which are equivalent to sandy clay/lime clay soil, occupy 4-6%. Xerosol, fulvisol, and regosol are widely distributed in the northwestern part, planosol in the northeastern part, and solonetz in the central to southern parts. A soil map of the study area is shown in fig. 4.3.2.

As a result of the soil survey on the pH of soil in the study area, solonetz and planosol show strong alkalinity. Other soils show minor alkalinity or neutrality to weak acidity. While substitute lime (CaO) is contained in regosol to a smaller extent, it is appropriately contained in other soils. Substitute potassium (K_2O) is relatively abundantly contained in soils other than regosol. Substitute magnesia (MgO) is also abundantly contained. As

for trace elements, thermo-soluble boron (B) and soluble copper (Cu) are appropriately contained. But easily reducible manganese (Mn) and soluble zinc (Zn) show very small values. The results of physichemical analysis of soils are shown in Table 4.3.1.

(2) Application of respective soils to agricultural and livestock farming development

From the results of the soil survey, the following are considered for the aptitude of soils in the study area to agriculture and livestock farming.

a) Soils suitable for agriculture

Among the soils in the study area, soils which are most suitable for agriculture are regosol, xerosol, fulvisol, and nitosol. Nitosol is distributed in the area near the suburbs of Asuncion and in the northwestern part of the study area.

b) Soils suitable for livestock farming

Solonetz and planosol other than the above-mentioned soils are suitable for livestock farming and are widely distributed from the northeastern and central parts to the southern part of the study area.

4.3.2 Land utilization

1) Contents of the study

Related materials were collected and a field survey was conducted with an emphasis on assessing the current situation of the study area and the current status of land utilization. The major contents of the study are as follows.

(i) Supplementary collection, collation and analysis of materials concerning land utilization, (ii) land utilization potential classification map conducted by remote sensing survey and verification of land utilization potential estimated on the basis of the first survey and the field survey, (iii) discussion with officials of related government agencies of Paraguay concerning land holding divisions, and (iv) surveys on the road situation.

2) Results of the study

(1) Status of land utilization

In the last few years, land utilization in the Mennonite settlements in the study area has been in progress. The use of land for farming is increasing. Land utilization is lagging behind in other areas. The status of land utilization is as follows. The distribution of forests, open forests, and scrub forests is shown in fig. 4.3.3.

(i) Forests occupy approximately half of the study area, and are distributed in the whole area except the southeastern part. Their area covers approximately 3.3 million ha.

(ii) Farmland (zoned farmland including pastures) occupies approximately 200,000 ha. It is distributed in the Mennonite settlements (cultivating cotton, peanuts, and others) and the suburbs of Asuncion (cultivating sugarcane, vegetables, fruits, and others).

(iii) Dry grasslands (dry grasslands seen on slightly high land which is not inundated) occupy approximately 800,000 ha and are distributed in the whole study area.

(iv) Dry grasslands which turn into wetlands during the rainy season occupy approximately 900,000 ha. They are distributed mainly in the southern half of the study area.

(v) Wetlands and locations which turn into marshes during the rainy season occupy approximately 1.55 million ha, and many of them are distributed in the central part of the study area.

(vi) Wetlands occupy approximately 550,000 ha. Many of them are distributed along the upper reaches of the Rios Pilcomayo and Paraguay.

(2) Status of inundation

Areas where wetlands inundated by precipitation and flooding water of rivers continue during the dry season (June through August) are the flooding areas of the Rio Pilcomayo (the range between the Rio Monte Lindo and the uppermost reaches of the Rio Confuso) and lowlands along the Rio Paraguay and between the Rio Monte Lindo and the Rio Negro. The total area is approximately 1.1 million ha, representing 15% of the subject area (see fig. 4.3.4).

During the period, floodwater from the Rio Pilcomayo spread to upstream areas of the Rio Confuso, the Rio Monte Lindo, and the Rio Verde as well as to the lower reaches of the Rio Verde. The total area is approximately 1.3 million ha, representing 18% of the study area.

Also during the rainy season (November to April), floodwater is seen in the upper and lower reaches of the Rio Confuso, in the upper reaches of the Rio Monte Lindo, in the middle reaches of the Rio Verde, and along the Rio Paraguay. The total area is approximately 1.8 million ha, representing 25% of the study area.

(3) Land classification

Prior to this study, remote sensing surveys were conducted and the following thematic charts were already prepared: (i) false color images (S = 1/250,000) for dry and rainy

seasons, (ii) vegetation and land utilization charts (S = 1/250,000) for dry and rainy seasons), (iii) soil classification charts (S = 1/250,000), (iv) marsh distribution charts (S = 1/250,000) for dry and rainy seasons, (v) march variation charts (S = 1/250,000), and (vi) land classification charts (S = 1/250,000).

In addition, from these thematic charts, (i) development potential classification chart, (ii) soil productivity classification chart (fertile soil, excessive contamination by Na), and (iii) land utilization potential classification chart (fields, grasslands, and total) were prepared.

This study utilized these thematic charts and classification charts and verified a variety of land classification charts in consideration of (i) topography (altitude, incline), (ii) current land utilization and vegetation, (iii) soils, (iv) inundating situation, (v) environment, etc. As a result, there was no large difference.

(4) Land use classifications

In land use classifications, (i) land suitable for development (land suitable for agricultural development, land suitable for livestock farming development), (ii) land with low development potential (constantly inundated lands, rivers, lakes, and ponds) were selected on the basis of the land utilization potential classification chart prepared by remote sensing on the basis of the status of soil and marshes and the status of vegetation and land use.

In accordance with the laws, policies, and regulations of Paraguay, (i) areas designated as national parks, (ii) environmental preservation areas, (iii) area designated as cultural asset preservation areas including historical monuments, (iv) Mennonite settlements, and (v) some indigenous reservations in the periphery of the Mennonite settlements were excluded from the land suitable for development and land with low development potential, and were specified as areas excluded from the development target.

This plan must fully consider and preserve the fragile natural environmental conditions in the area, and utilize land by taking advantage of the ecological features of the area. Furthermore, to get maximum project effects with minimum project expenditure required for consolidation of production infrastructure, the agricultural development plan, irrigation and drainage plan, and farming and cultivation plans were comprehensively reviewed in consideration of natural conditions. As a result, this plan adopted the following land utilization classification (land use classification areas are shown in Table 7.1.11).

The areas excluded from the development target are 4,307,000 ha (59% of the study area) while those subject to the development plan are 2,993,000 ha (41% of the study area).

a) Areas excluded from the development target

(a) Areas designated as national parks (280,000 ha)

In Paraguay, 16 locations are designated by law as environmental preservation areas. The Tinfunque National Park is applicable to the preservation area in the study area.

(b) Environmental preservation areas (1,736,000 ha)

The Environmental Bureau and the Natural Resources Bureau of the Ministry of Agriculture and Livestock and the Fundacion Chaco Paraguayo have been conducting surveys concerning "preferential areas to be preserved in the western part of Paraguay" from last year for two years. 16 locations are applicable to this survey in the study area. At present, the designation of these environmental preservation areas is not stipulated by law. However, in view of the importance of environmental preservation, these areas were treated as environmental preservation areas.

(c) Areas designated as cultural asset preservation areas including historical monuments (the land area to be preserved is not specified)

According to the Ministerio de Defensa Nacional, Parques Nacionales y Monumentos Historicos, Paraguay has many cultural assets such as historical monuments from the Chaco War during the 1930's. The preservation, collection, and repair of these cultural assets are stipulated by Law No. 946.

The Chaco region has 12 cultural assets to be preserved. In the study area, the following nine war-time forts are designated: (i) Fortin Sorpresa (Adolfo Rojas Silva), (ii) Isla Poi o Villa Militar, (iii) Fortin Boqueron, (iv) Fortin Nanawa, (v) Fortin Gondra, (vi) Fortin Muñoz, (vii) Fortin Arce, (viii) Fortin Falcon, and (ix) Pozo Favorito. However, the land areas to be preserved of these designated areas are not specified. The locations of these cultural assets including natural monuments to be preserved are shown in fig. 4.3.5.

(d) Areas with low development potential

Constantly inundated land covering 1,801,000 ha was designated as areas with

low development potential from the viewpoint that the operation of agriculture and livestock farming is difficult in areas which are inundated throughout the year, as well as for preservation of the natural environment. Rivers, lakes, and ponds covering 29,000 ha were also treated in the same manner.

(e) The Mennonite settlements (405,700 ha)

These settlements were excluded due to the fact that (i) most of the settlements have been already developed. Development is also planned for the remaining lands, and that (ii) the settlement has a unique society and system.

(f) Some indigenous reservations in the periphery of the Mennonite settlements

These are areas that receive technological and economical cooperation from the Mennonite settlements, Asociacion de Servicio de Cooperacion Indigena Mennonita (ASCIM), etc., and where indigenous people closely related with them are living.

b) Areas subject to the development plan

For areas subject to the development plan, refer to 6.2.2 "Selection of the areas subject to the development plan".

(5) Current status of areas subject to the development plan

a) Areas subject to the agricultural development plan

(i) Suburbs of Asuncion

This area includes Benjamin Aceval and Villa Hayes in the suburbs of Asuncion. Its altitude is approximately 60-100m. The land area is 9,000 ha. The soils are nitosol and planosol. Sugarcanes are cultivated in this area. The rest is natural grasslands.

(ii) Northern part of Pozo Colorado

This is the northern part of Pozo Colorado, located approximately 320 km from Asuncion. Its altitude is approximately 95-100 m. The land area is 76,000 ha. The soil is fulvisol. The majority of the area is forest zone with some natural grasslands and some marshes seen at certain periods in the year. The Rio Verde flows from east to west in the area. While a road exists along the river, its condition is not so good.

(iii) The southern part of the Mennonite settlements

This area comprises the southern part of the Mennonite settlements through the

surroundings of Avalos Sanchez. Its altitude is approximately 115-135 km. The land area is 68,000 ha, and the soils are xerosol, regosol, and fulvisol. At present, the majority of the area is forest land, with some natural grasslands. The state of roads in the area is relatively good,with connections to the Mennonite settlements and Pozo Colorado.

(iv) The eastern part of the Mennonite settlements

This area comprises three blocks around the eastern part of the Mennonite settlements. Its altitude is approximately 105-130 km, and the land area is 185,000 ha. The soils are xerosol, regosol, and fulvisol. The majority of the area is forest zone with some natural grasslands, open forests, and scrub forests. There is no inundated area. While this area skirts the boundary of the Mennonite settlements, roads are not well developed.

b) Areas for livestock farming development

While planosol is distributed in the northern part of the area, the majority of the soils is solonetz. The majority of the area is occupied by natural grassland and forest zone while there are some marshes seen in certain periods of the year and some open forests and scrub forests. Some areas are used as stock farms. Its land area is 2,655,000 ha.

(6) Status of land ownership

According to discussions with the Institute de Bienestar Rural (IBR) which administers land ownership, the assessment of land ownership in the Chaco region is lagging behind compared to that in the eastern region of Paraguay. Especially, in the Departamento Presidente Hayes in the study area, the status of land ownership has not been accurately assessed. IBR started a two-year survey on land ownership in 1992. No adequate data concerning land ownership could be collected during the period of this study.

A subsequent survey by IBR has not made smooth progress due to lack of budget. According to IBR, as the general survey method, land ownership division maps of 1/100,000, 1/50,000, and 1/20,000 are prepared according to the size of land ownership in the study area. Furthermore, the detailed registry of title deeds is prepared by the field survey. However, road conditions in the study area are poor, and car transportation is difficult. In addition, the installation of boundary fences is not easy.

(7) Status of agricultural development

Arable land in the study area (zoned farmland including grasslands) is approximately

200,000 ha, distributed in the Mennonite settlements where cotton and peanuts are cultivated and the suburbs of Asuncion where sugarcanes, vegetables, and fruit are cultivated. Farmland has been developed in these areas for many years now. Especially in Filadelfia and Loma Plata, the Mennonite settlements were established during the 1920's-1940's. As road development has been in progress on both sides of Pozo Colorado and Concepcion, farmland development has gradually progressed around this road.

(8) Road situation

As shown in fig. 4.3.6, major roads in the study area include (i) National Highway No. 9 from the capital city of Asuncion through Pozo Colorado and Filadelfia, (ii) the unpaved road from Pozo Colorado to General Diaz, (iii) the unpaved road from Pozo Colorado to Concepcion, and (iv) National Highway No. 12 from Asuncion to Rojas Silva. Of these roads, paved National Highway No. 9 is passable throughout the year. During and after rainfall, the road is closed and becomes impassable to secure safe passage and maintenance of the road. At present, the unpaved road between Pozo Colorado and General Diaz in (ii) is under construction for asphalt pavement, and is planned to be turned into a trunk road in the study area.

4.4 PRESERVATION OF THE ENVIRONMENT AND FARMLAND

1) Contents of the study

(1) Environment

a) Laws, policies, and regulations concerning the environment

b) Status and trend of natural and environmental preservation

c) Ecological features in the area

d) Flora and fauna in the area and flora and fauna to be preserved

e) Environmental assessment

f) Status and issues of forest industry in the area

(2) Preservation of farmland

a) The state of farmland preservation

2) Results of the study

(1) Environment

a) Laws, policies, and regulations concerning the environment

Preservation of wild life: the Wild Life Law was resolved by Congress and was enacted on December 24, 1992.

Forest Law (Law No. 422): this draft has been deliberated in Congress to fully revise it into the Forest Resources Law. The current Forest Law was enacted in 1973. As its major points, it stipulates (i) the rational use and management of forests and woods for the public interest, and (ii) preservation, maintenance, management, improvement, and fostering of forest resources as a public duty (Forest Law Article 1), emphasizing the public nature of forests. As the basic purpose of the Forest Law (Forest Law Article 2), it promotes the increase of forest productivity and emphasizes the role of forests to preserve national lands by controlling soil erosion and preserving river basins by forests. Furthermore, in the "Regulations for Use", actions concerning forests are stipulated. Especially in relation with agricultural development, the following provisions are stipulated:

(i) to prohibit utilization which would cause devastation of forests and woods (Article 23);

(ii) to prohibit the use of fire in forests (Article 30);

(iii) to prohibit the felling of trees, causing damage to or destroying forests in the peripheries of water sources and streams (Article 31); and

(iv) those who own land of more than 20 ha in forest areas must maintain 25% of the

forest area as areas not subject to use. If this is not secured, the owner must plant trees in the area equivalent to 5% of the forest area.

In Phase II of the study, the Paraguayan counterpart requested that, even though the Forest Resources Law had not yet been enacted, this development plan should be formulated on the basis of the Forest Resources Law (draft). The Japanese counterpart accepted this request in drafting the Development Plan. The outline of the Forest Resources Law (draft) is described in (1) and (2) of 2) of 7.2.9 Environmental conservation measures.

b) Status and trends of natural and environmental conservation

(a) Organizations related with agricultural and environmental administration and their outline

(i) Agencies in charge of agricultural development: Ministry of Agriculture and Livestock, Ministry of Public Works and Communications

Major duties:

Ministry of Agriculture and Livestock:

Crops, soils, agricultural development, livestock farming, diffusion, forestry, environmental preservation, national parks, preservation of wild flora and fauna, settlement, cooperatives, irrigation and drainage projects, etc.

Ministry of Public Works and Communications:

Agricultural roads, etc.

(ii) Organizations related with environment

Various ministries and agencies are in charge of environmental issues. In the Ministry of Agriculture and Livestock, the Environmental Development Bureau of the Office of Under-Secretary for Natural Resources and Environment is in charge of environmental issues. Other agencies which implement environmental programs include the Ministry of Public Works and Communications, the Ministry of Commerce and Industry, and the Ministry of Health. The Planning Agency has environmental data.

Organizational structure (for the Ministry of Agriculture and Livestock only): as per fig. 4.4.1.

Major duties (only of the Office of the Under-Secretary for Natural Resources and Environment in the Ministry of Agriculture and Livestock)

Forestry Bureau:

preservation, management regulation of forests, management of water sources, fostering of forestry, education, surveys, and diffusion of forestry.

Environmental Development Bureau:

preservation of farmland such as preservation of water basins and soils, regulations on the use of farmland, environmental adjustment, environmental education, environmental management.

National Parks and Wild Life Bureau:

regulation at all levels of national park management and preservation of wild life.

(b) Status of natural and environmental preservation

As natural and environmental preservation areas, there are 16 national parks in the country and one national park at Tinfunque (area: 280,000 ha) in the study area. The environmental preservation areas have also been surveyed and important areas immediately designated. Paraguay has joined the Washington Treaty and the Ramsar Convention (filing for area designation), and is actively promoting preservation.

The Forest Law is not strictly observed. In the eastern region where trees are cut randomly, soil erosion is taking place. In the western Chaco region, the risk of wind erosion is increasing in bare farmland. Therefore, the government is planning to enact the Forest Resources Law to reinforce regulations and management and to encourage afforestation.

(c) Trends of natural and environmental preservation

Trans-Chaco environmental impact monitoring: as National Highway No. 9 has been improved as an all-weather road almost up to the central part of Chaco, this road will all the more contribute to development. In order to survey how this road will affect the environment, an ecological monitoring project covering a range of 80 km each to the north and south of the road has been conducted since 1992 with German cooperation.

Trend for cooperation and assistance by the EC: while Paraguay filed 40 applications for financing of development projects and environmental survey projects, only 20 applications were approved. Development projects which do

not give due consideration to environmental aspects are strictly rejected from the subject of assistance.

c) Ecological features of the area

(a) Wetlands

Many of the flooding areas along the Rio Paraguay and the Rio Pilcomayo are always inundated and form marshes. There are many environmental preservation areas. Also, indigenous people live here. Marshes are also the habitats of wild animals. Many water birds and migratory birds live here (their migratory routes have not yet been clarified). Natural forests exist in the form of islands or corridors and are slightly higher in altitude than the peripheral lowlands. Many trees have a height of approximately 15 m and a diameter of below 30 cm at chest height. As for the vegetation of trees, the Copernicia alba, the palm tree unique to this area, is dominant. The majority of these are distributed in the lowlands to the east of Pozo Colorado.

(b) Semi-arid area

Part of the area belongs to the semi-arid area.

(c) Damage from salt

If farmland is not properly used or managed, salt damage may be caused.

(d) Damage from wind

Since strong winds blow during the winter, bare farmland may be susceptible to wind damage.

(e) National parks, environmental preservation areas, historical monuments and cultural asset preservation areas

(i) National parks

The Tinfunque National Park is applicable in the study area.

(ii) Environmental preservation areas

These are areas designated by the Environmental Development Bureau and the National Parks and Wild Life Bureau of the Ministry of Agriculture and Livestock and the Fundacion Chaco Paraguayo. These areas are currently not designated by law, but are given attention in terms of environmental preservation.

(iii) Historical monuments and cultural assets preservation areas

There are nine forts remaining from the Chaco War, to be preserved as cultural assets in the study area. The law stipulates the preservation, repair, and restoration of these cultural assets.

(f) Indigenous people

There are seven ethnic groups of indigenous people, a total of 20,000 people, inhabiting 93 locations in the study area. These indigenous people are hunters who originally have a sphere of behavior covering a wide area. As agricultural and livestock farming development projects have been in progress, their sphere of behavior has been restricted and narrowed. Their lifestyles have also been changing.

(g) Mennonite settlements

In the northwestern part of the area are the Mennonite settlements. They were established in 1926 and are currently divided into three sub-settlements. The settlers are followers of the Menno sect of Christianity, maintain a unique culture and social system, and operate high-standard economic activities based on agriculture and livestock farming.

As the five items mentioned above explain, the ecological features of the study area manifest that the area has very fragile environmental features. Consideration for environmental aspects is an important factor that enable continuous development.

d) Animals and plants in the area and flora and fauna to be protected

One of the features of the study area is that it is on low land, and has many marsh zones and wild areas. However, the flora and fauna to be protected in this area have not yet been fully specified. They must be surveyed in future.

(a) Fauna

According to information collected so far, the species of animals are as shown in Table 4.4.1.

Table 4.4.1 Animals in the area

	Paraguayan name	Academic name
(i) Mammals	Osito melero	Tamandua tamandua
	Zorro gris	Dusicion sp.
	Gato montes	Felis geoffroyi
	Jaguarundi	Felis yaguaroundi
	Aguara guazu	Chrysocyon branchyurus
	Tapir	Tapirus terrestris
(ii) Reptiles	Yacare	Caiman latirrostris
(iii) Birds	Mandu	Rhea americana
	Pato picazo	Cairina moschata
	Chuna pata roja	Chunga busnisteri
	Charrua	Gonorimopsa chopi
	Tucan	Rhanphasto tosco
	Moitu	Crax fasciolata

Source: Un Sistema de Areas Protegidas para el Gran Chaco, FAP/PNUMA 81985)

(b) Plants

Forests in the western region consist of mesophytes (species which grow with appropriate humidity) and xerophytes. A change in vegetation is observed from the eastern part of Chaco which starts from the Rio Paraguay and has annual average precipitation of 1,300 mm, to the most western part which faces the border with Bolivia and has precipitation of 500 mm.

Tortorelli classifies forests in the Chaco region as follows:

1. Bosque chaqueño
2. Parque chaqueño
3. Sabana arbolada chaqueña
4. Monte occidental

Of these, forests in the Departamento Presidente Hayes are applicable to all of 3. and some of 1. and 2.

The major trees seen here are:

Phyllostylom rhamnoides (palo lanza)

Tabebuia sp (lapacho)

Tabebuia nodosa (payagua labon)

Diplokelebon floribunda (yvrya ita)

Pizonia zapallo (yukeri ruzu)

In general, there are many shrubs and trees of small diameter which are of low economic value in forestry.

e) Environmental assessment

(a) Geographical and environmental conditions of the study area

(i) Designation as special areas

Marshes applicable to the Ramsar Convention (one location in the area has been filed for registration and designation), national parks, nature and environmental preservation areas exist in the study area and affected outlying areas. There are also habitats of animals applicable to the Washington Treaty, but the areas are not designated.

(ii) Social conditions

Indigenous people and minority ethnic groups inhabit the study area and affected outlying areas.

Surveys show that there are historical monuments and cultural assets inside and outside the study area.

(iii) Natural conditions

There are marshes, wild areas, and semi-arid areas inside and outside the study area.

Paraguay has recently joined the Ramsar Convention. There are some marshes which should be registered and designated. But the ecology of flora and fauna are yet to be surveyed.

Forests are being logged at random. Regulation by the Forest Resource Law and planned afforestation are required.

(b) Environmental assessment

In order to judge the impact of this Development Plan on environment, a survey was conducted according to a check list made according to JICA guidelines.

The findings of the survey according to a "Check list for local scoping" are shown in Table 4.4.2.

(f) Status and issues of forestry in the study area

As representative forestry products from forests in the Chaco region, the production of tannin extracted from the quebracho colorado has been continued, and the quebracho colorado and coronillo enjoy a high reputation as construction and fencing materials for livestock farming. However, many trees in the forests in the study area are shrubs and trees of small diameter that are of low economic value. The salt contained in the soil and groundwater is considered to be the cause (source: Vegetacion del Paraguay; MAG).

However, in recent years, the demand for fuel (charcoal) has been increasing at the steelworks (Acepar) located in the suburbs of Asuncion. Its requirement is estimated to be 150,000 tons per year. It is equivalent to the afforestation of 7,000 ha by planting trees. For this purpose, there is a plan to execute an "Afforestation Project using Eucalyptus" which grows fast within the study area, and to increase firewood of 210,000 m^3 on average per year, or approximately 90,000 tons of charcoal. The Acepar steelworks plans to launch an "Afforestation Project" in the area applicable to the above figure in the Estancia Navidad farmland (45 km west of the 192 km point on the Trans-Chaco National Highway) from 1993. In reality, the opening of a road is required, and the annual plan after the afforestation of 100 ha in the first year is not clear. Charcoal production facilities in the study area are small-scale, and new facilities are required.

All due care needs to be taken such that the national afforestation project is promoted in a planned manner, and that a balance between production and demand for timber is fully secured. This is especially so from the standpoint of environmental preservation in the ecologically fragile Chaco region, to ensure that the rapidly increasing demand for charcoal does not damage the preservation of forest resources in Paraguay including the Chaco region.

If the afforestation project by the Acepar steelworks is to be implemented on a full scale in the lower Chaco region, it must be concretely adjusted with this Integrated Development Plan.

(2) Preservation of farmland

a) Status of farmland preservation (in the eastern and western regions)

In the eastern region of Paraguay, forests have been logged at random and have been developed without order due to the increased production of beans and wheat during the last decade. Therefore, appropriate forest preservation and soil erosion prevention

programs are required from the standpoint of farmland preservation.

The majority of the study area in the western region comprises natural grasslands. Crop farming is limited to the Mennonite settlements and sugarcane production areas in the suburbs of Asuncion. Hardly any soil erosion has been taking place, except on some inclined land. Since the majority of the land is flat in general, people have a low awareness of farmland preservation.

Since strong northern winds blow during the winter dry season and cold winds occasionally blow from the south, erosion of farmland by wind is observed. The Mennonite settlements in the northern part of the study area have windbreak forests. However, they are still insufficient. The Paraguayan Government has been implementing the "Model Windbreak Forest Project" to diffuse windbreak forests. The establishment of windbreak forests is essential in farmland development under this Plan.

Accumulation of salt is observed in some parts of the northwestern part of the study area, manifesting the occurrence of salt damage. Therefore, agricultural cooperatives in the Mennonite settlements are experimenting and researching how to prevent salt damage. In locations where the risk of salt accumulation is high, it is important to have proper sewage, to keep the level of groundwater to a depth which is tolerable to crops cultivated and the nature of soil, and not to keep irrigation water for a long time.

4.5 IRRIGATION AND DRAINAGE

1) Contents of the study

Through analysis of existing materials, field surveys, and aerial observation, the status of poor drainage was assessed, and the status of irrigation and drainage was surveyed through interviews with farmers and officials of related research organizations.

2) Result of the study

In the study area, irrigation and drainage facilities have never been systematically established. Therefore, they have no experience of having constructed irrigation and drainage facilities, nor do they have any concept of irrigation. However, in some parts of the study area, they have experience of having constructed drainage ditches by exploring the possibility of using agricultural machines. They have taken water by closing rivers without any plan in order to secure drinking water for livestock, thereby causing deterioration of the quality of water in the lower reaches of those rivers and the deterioration of farmland adjacent to water reservoirs through salt damage. Thus, those concerned with agriculture have an increased awareness concerning water management in farm land.

The cause of poor drainage in the area is that the whole area is flat, with little inclination; the lowlands are always inundated, and serve as retarding basins, retaining water that has flown in from upstream and making the inclination of the water face flatter. In addition to the fact that the land is flat, there are divisions of rainy season and dry season in the year. Clays carried down during the rainy season are moved and accumulated to form a layer of even particles of clay.

During the dry season, the layer thus formed turns into adobe by receiving strong sunlight and makes it difficult for water to permeate underground. Also, as the soil lacks organic substances and cannot create corrosion, the soil structure becomes very poor. In addition, as the soil is made of even particles, it is easily compacted and this further hinders the permeation of water.

The meandering of rivers in the study area due to the fact that there is almost no inclination of land is one factor causing poor drainage. As rainy seasons and dry seasons come in alternation, meandering rivers are obstructed by accumulated soils and sands, resulting in the formation of crescent lakes and continually changing river paths. In such a process, the land is further flattened. The artificially poor drainage is created by the insufficient drainage facility of crossing roads. The upstream side of roads in the alluvial fans located at the Rio Pilcomayo and the Rio Monte Lindo are areas with poor drainage.

4.6 CULTIVATION AND FARM MANAGEMENT

4.6.1 Cultivation

1) If we look at the soil distribution in the study area, xerosol, regosol, and fulvisol are distributed in the northwestern part of the study area, i.e. the Mennonite settlements and their surroundings. Nitosol is distributed in the suburbs of Asuncion. These areas are selected as lands suitable for agriculture in this study. The detailed properties of these soils are described in 4.3.1 Soils. They are commonly suitable for growing agricultural crops. In the area on the right shore of the Rio Paraguay, fulvisol with poor drainage is distributed. This soil can be used if drainage is improved.

According to the result of soil analysis, the property of soil in the land suitable for agriculture is clay loam-sandy clay loam and is suitable for cultivating majority of crops. The pH is approximately 5.7-8.5, depending on the depth of the soil layer and land area. The soil is generally suitable for cultivating field crops which are to be introduced. As the phosphoric acid absorption coefficient is as small as approximately 20-30 (usually 1,500-2,000), and, above all, the K content is as relatively large as 0.3-1.8 me/100 g (usually 0.3-0.5), advantageous conditions for crop cultivation are existing.

As mentioned above, as far as the area subject to the agricultural development plan is concerned, the soils are almost suitable for crop cultivation and have no significant obstructions.

2) Crops

(1) Major crops and their cultivation system

a) Field crops

The major field crops in Paraguay are cotton, soybean, wheat, sugarcane, corn, cassava, etc. Except wheat, these are all summer crops. Cotton and soybean are the major export crops of Paraguay. Both of them combined occupy 60-70% of the export amount.

The major field crops in the study area are cotton, peanuts, sugarcane, sorghum, castor beans, etc. (for the area, production, and crop, see Table 4.6.1).

(a) Cotton

Cotton is cultivated in the Mennonite settlements as export crop. The fields are ploughed and prepared in August-September. The seeds are planted in October-November (20-25 kg/ha). weeding is usually conducted six times (four times by

machine and twice manually). Pesticides are sprayed approximately six times. Then, the crop is harvested in February-March. (output is 1,200-1,300 kg/ha in a normal year.) The variety is mostly Reba P288 (or alias Linea 100).

(b) Peanuts

Peanuts are also cultivated as export crop, similarly to cotton, in the Mennonite settlements and other areas. The fields are ploughed and prepared in August-September. seeds are planted in September-November (50-60 kg/ha). After weeding is conducted and pesticides are sprayed approximately six times, similarly to cotton, the crop is harvested in February-March. (output is 1,000-1,200 kg/ha in a normal year.) The major variety is Star.

(c) Sugar cane

Sugar cane is cultivated as material for sugar in Benjamin Aceval, etc. in the suburbs of Asuncion. Seedlings are usually planted in February-April (or in August-November). Intertillage and weeding are conducted twice by using chemical fertilizers (15-15-15, etc.). The crop is harvested from June to November, i.e. continuously during the summer since the following year of planting (June-August for the early maturing variety, August-September for the medium-term maturing variety, and September-November for the late maturing variety (output is 50 t/ha in normal year). Sugar cane is usually cultivated for five years by dividing stocks after planting seeds once. While there are many varieties, the early maturing varieties of SP 48103, Tukumana 6724, Tukumana 5619, etc. are the main ones.

(d) Sorghum

Seeds of sorghum are cultivated in summer as material for assorted fodder. It is also green cut as fodder for livestock in winter. In the case of sorghum to harvest seeds, the fields are ploughed and prepared in August-September. seeds are planted in October-November (5 kg/ha). After weeding approximately twice (by machine), the crop is harvested in May-June. (output is 1,800 kg/ha in a normal year.) In the case of green cut sorghum, seeds are planted in around March as a successor to summer crops such as cotton and peanuts. After a green cut has been conducted two or three times, the fields are ploughed in July. The winter crop of sorghum is used as silage fodder for livestock (output is 20 t/ha in a normal year) and is ploughed in as green manure. It also has great significance as a windbreak in winter. Hybrid varieties are used. The major varieties are Fredy (for silage and feeding grass), Sileca 1844 (for silage) and Alex-Chaco (for seeds).

(e) Cassava

Cassava is not a commercial crop, but is cultivated for self-consumption by farmers. Usually, chemicals are not used. Seedlings are planted in August-September. Simple intertillage and weeding are conducted two or three times by manual labour. The output largely depends on a variety with harvesting extending throughout the year from March in the following year. (output is approximately 16 t/ha.)

(f) Castor beans

Castor beans are originally a perennial crop. However, due to the reason that manual harvesting becomes difficult if the height of plant is high, the low-lying variety is cultivated as a yearly crop in the study area. seeds are planted between October and February depending on the precipitation status. If there is no precipitation, seeds are not planted. Weeding is conducted twice (once by machine and once by manual labour). Pesticides and germicides are not used.

Harvesting is conducted 140-160 days after planting. If seeds are planted in October, the crop is harvested in March by manual labour (output: 800 kg/ha). The major variety is Lynn.

(g) Others

In addition to the above-mentioned crops, farmers in the Mennonite settlements started to cultivate crops for oil such as sesame, sunflower, and safflower in recent years. Sesame and sunflower are summer crops. The fields are ploughed and prepared in around September. seeds are planted in around October. crops are harvested in around February-March. On the other hand, safflower is a winter crop. The fields are ploughed and prepared in around March. seeds are planted in around April-May (15 kg/ha). weeding is conducted twice by machine. The crop is harvested by machine in October-November (output: 600 kg/ha in a normal year).

b) Perennial crops

The major perennial crops in Paraguay include oil paulownia or tung (Aleurites fordii), sour oranges or naranjo agrio (Citrus aurantium, the leaves of which is used as a raw material for petty grain oil), yerba mate tea (Ilex paraguayensis), sweet oranges or naranjo dulce (Citrus sinensis), and grapefruit or pomero (Citrus paradisi).

The major perennial crops in the study area include sweet orange and grapefruit.

Several 100 t of them are produced in the Mennonite settlements. In addition, small quantity of papaya, mango, banana, pineapple, etc. are produced by farmers for their own consumption.

In the eastern region of Paraguay, cultivation of macadamia nuts is recently catching attention (10 kinds including Macadamia integrifolia; there are three kinds for cultivation). Macadamia nuts were introduced to Paraguay once before, but not for commercial cultivation. However, their production has not met the demand on the world market in recent years. It is noted as a promising crop for which consumption should grow further grow in future. In 1991, a research council was organized to promote expanded cultivation of macadamia nut in planned manner.

c) Vegetables

Many kinds of vegetable are cultivated in Paraguay. The production output of especially, tomato, green pepper, onion, sweet potato, etc. is large. In the suburbs of Asuncion in the study area, a variety of vegetables are cultivated including tomato, water melon, melon, and pumpkin, as summer vegetables, and onion, lettuce, carrot, and garlic as winter crops by taking advantage of the convenience of the mild climate and the location which is near to the consuming sites.

(2) Main planting systems in the study area

For cotton, peanuts, and sorghum, their major field crops (see Table 4.6.2), the Mennonite settlements have adopted a planting system of cotton-peanuts, cotton-sorghum (for seeds), and peanuts-sorghum (for seeds) in almost all its fields. SAP has been also encouraging to cultivate sorghum (for green cut) or crop for green manure (avena negra, Melilothus, etc.) during winter. Its diffusion rate (land area of field to be cultivated during winter / total land areas of fields) is approximately 30%. In the Mennonite settlements, however, it is said that the fields occupy 50,000 ha and that grasslands occupy 550,000 ha. Thus, bare fields in winter is very few as a whole.

It is understandable that farmers are not willing to cultivate winter crops as most of them do not become commercial products and do not lead to cash income. However, to keep the fields bare in winter has many problems. From the viewpoints to prevent wind damage, cultivate nutrients in the soils, and improve the property of soils, it is desirable to promote cultivation of these winter crops on a large scale.

On the other hand, in sugarcane cultivating fields in the suburbs of Asuncion, planting of sugarcane (six years)-non-cultivation (one year)-beans (one year) is conducted. In

general, sugarcane is a crop to deprive a large amount of soil fertility. Therefore, the sugar refinery is giving a detailed cultivation guidance and is attaining effects in maintaining and recovering soil fertility.

(3) The field/pasture rotational system in the study area

In recent years, the Mennonite settlements started the following field rotational system between field husbandry and livestock farming.

Field (three years)-pasture (three years)- field (three years)-pasture (three years).

This is a repetition of a pattern of using the field as planting field for three years (for example, first year: peanuts, second year: sorghum for seeds, and third year: cotton), followed by pasture for the subsequent three years. There are very little fields which are actually introducing this method. It has been conventionally known that such a method has an effect. Because precipitation is unstable, crops of farming products are unstable, and sales prices of products are unstable depending on their kinds, farmers actually did not have the capacity to introduce the field rotational system. However, as the emphasis of farming has been shifted from agriculture to livestock farming, and cultivation of crops the prices of which are unstable (for example, castor beans) were reduced, farming management has been stabilized. On the other hand, soil fertility has been gradually deteriorated due to non-fertilizer cultivation conducted for many years. Thus, the environment has been ready to implement such a method.

(4) Constraints in cultivation

a) Wind damage

In the study area, crops are often not cultivated in winter as there is no suitable commercial product. Therefore, there is no wind damage to the crop due to strong wind in winter, but the erosion of the fertile surface soil by wind damage is posing a problem. Therefore, the Mennonite settlements cultivate crops even in winter as mentioned above, and ensure the protection fields and increase soil fertility by cultivating green manure crops. EECC (Chaco Central Agricultural Experiment Station) also recognizes wind damage as a large problem in this area, and is experimenting and researching method to prevent it. From these facts, cultivation with windbreak forests is required.

b) Salt damage

In the study area, there is a risk of causing salt damage if water is taken from small rivers in the area and if drainage is not properly conducted. Proper management is required in cultivation.

c) Damage by diseases and insects

Cotton, peanuts, corn, sorghum, etc., major field crops in the study area, have their own pests and fungous diseases. These are forming constraints to farming in the study area in the form of expenses for chemicals and their spraying.

The pest known as the picudo (Anthonomus grandis), which has been a major problem in cultivating cotton in other countries, invaded the eastern region of Paraguay in 1989. It was the advantage of cotton cultivation in Paraguay that this insect did not exist in Paraguay in the past. While it is not yet confirmed in the Chaco region, it is likely to invade there as time passes by. While cultivation of cotton in the study area including the Mennonite settlements has been decreasing year by year, yet it remains as one of the major crops. When the insect invades, insecticide is likely to become a burden in farming.

In recent years, the problem of stone beans (granos duros: disease whereby the beans harden) has been taking place in peanuts cultivation in the Chaco region. As its cause, involvement of drought, soil (insufficient nutrients, decaying), heredity, disease, etc. are considered, but the clear cause is not yet known. At present, the cause is researched into and measures are reviewed. As this is likely to become a large problem in future, measure must be quickly established.

d) Frost damage

As shown in the results of survey in the meteorological area, the surroundings of Pozo Colorado are considered to have the highest possibility of frosting (annual average number of frosting days: 2.8 days/year). In other areas, it frosts 1-2 days in a year. The time is limited to June-July. Therefore, there is no need to consider the possibility of frost damage in other months. However, caution is needed as there was a case of exceptional frosting in September.

e) Drought disaster

Annual precipitation in the study area is 800-1,300 mm. The total volume is not little at all, but the mode of precipitation is varied. crops are generally cultivated on the basis of annual precipitation and precipitation pattern. These fluctuate largely, and if there is no precipitation when water is needed in the growing stage of crops, seeds must be planted again, or planting must be abandoned. Furthermore, the crop may be largely reduced due to drought during the maturing stage.

f) Damage by weeds

The study area is relatively drier than the eastern region, but weeds on farmland are also problem. For example, with cotton which is a representative crop, after weed killer is used first, weeding is conducted six times by both machine and manual works. The same applies to peanuts. These labour and expenses become a burden.

g) Damage by birds and animals

In the study area, damage of sorghum and corn eaten by birds is heard. Since this area originally has many wild animals, damage by birds and animals may become much bigger as development proceeds further and crops are cultivated on a larger scale in future.

4.6.2 Farm management

1) State of farm management

(1) Mennonite settlements

An average farming household in the Mennonite settlements has 25-50 dairy cows, 50-100 ha of fields, 100-150 ha of improved grasslands. On the whole, it has anarea of approximately 200 ha. Majority of farming type is full-time livestock (meat cows and dairy) farming or combination of livestock farming and field farming. full-time field farming is very few. A family is usually composed of parents, husband and wife and three children. In addition to two-four family labour, a few workers are employed throughout the year and some 10 workers are employed during the harvest time of cotton. As for machines, a household owns one or two tractors, one small truck, one or two combined harvester/threshers (for harvesting cotton and peanuts). Seeds and materials such as agricultural chemicals are all purchased from the agricultural cooperatives. All the crops are also sold to agricultural cooperatives. The annual income is estimated to be 20 million-40 million Gs., judging from interviews, the number of dairy cows, area of fields, etc. This settlement does not have extremely small-scale farmers as seen in the eastern region. A relatively uniform technological and management level is its feature.

SAP is existing for technological guidance and diffusion. Although the farmers must bear expenses, it dispatches technicians upon request. It also conducts guidance through radio and publications. farmers can also get loans from the agricultural cooperative.

As problem, the gradual deterioration of soil fertility due to long-term cultivation without using fertilizers is raised. Therefore, introduction of green manure is encouraged as mentioned above. While cotton and peanuts occupy the majority of crops due to the

response to natural conditions and market, stable income cannot be secured as their prices are fluctuating.

With such a problem, the emphasis of farming in the settlement is being shifted from agriculture to livestock farming. The ratio of field husbandry and livestock farming was roughly 50-50 until seven or eight years ago. At present, sales of field husbandry have fallen down to 25-30%. The reasons are: (i) The cost of materials such as fuels and agricultural chemicals and manpower are sharply increasing; (ii) Production is unstable, depending on precipitation and output is gradually decreasing; (iii) labour work is too heavy; (iv) Sales prices of the 1990 crop and 1991 crop of cotton dropped, etc. (See Table 4.6.3). It is important to overcome these problems by adopting the aforementioned planting system in promoting agriculture.

(2) Suburbs of Asuncion

The sugar refinery of Censi y Pirotta is located in this area. The sugarcane to be delivered to this sugar refinery is the major crop of this area. Sugar cane has the most production output among agricultural crops in the study area as a whole (area of cultivation: 1,500 ha, output: 40-80 t/ha). The number of farming households is 300 in Benjamin Aceval (of these, 160-170 households sell sugarcane to the sugar refinery); this number is less than 10 in Villa Hayes. The average size of cultivation is 5-20 ha. The annual output of sugarcane by a large-scale farmer is approximately 1,000 tons. A family is usually composed of a couple and three to four children. Workers are employed for harvesting sugarcane. Agricultural machines such as tractors are usually not owned. In the technological aspect, the sugar refinery prepares technical guidelines concerning fertilization, weeding, cultivation management, etc., and offers guidance as well as finance to the farmers.

While sugarcane cultivation is the main activity in this area, farmers are growing a variety of vegetables by taking advantage of being located in the suburbs of a city, and selling them in Asuncion. Many farmers who produce fruits and milk for their won consumption sell surplus products.

There is the SEAG's promotion centre in this area, giving technological guidance mainly to sugarcane farmers. There is one agricultural promotion worker there. This number is absolutely insufficient in view of the number of farmers. Since vegetables other than sugarcane are cultivated, the worker cannot respond to the farmers' needs properly.

Since it is located in the suburbs of a city, the available lands are already used for housing lands and factories in addition to farmland. There is no sufficient land for development for those farmers who want to expand the size of their farming, which hinders farming development.

(3) The Campo Aceval settlement

The majority of approximately 300 settlers in the Campo Aceval Settlement are those who settled from other parts of Paraguay. While the sizes of their farming are varied, approximately 100 ha seem to be the average. The major cash crop is cotton. Cotton is cultivated by 17 farmers on 82 ha (largest size: 35 ha, smallest size: 2 ha as of 1992). sorghum for fodder is cultivated by four farmers on 312 ha (largest size: 250 ha, smallest size: 12 ha as of 1991) in the whole area.

The majority of the settlers cultivate crops for self consumption such as poroto, cassava, peanuts, pumpkins, melons, and mangoes. A family is usually composed of a couple and three to four children. Apart from indigenous people who are employed for weeding and harvesting cotton, cultivation is managed by family members.

Many cotton cultivating farmers are consigning all works from ploughing and preparing the land through harvesting to the agricultural cooperative in the Mennonite settlements by paying fees. There are, however, three to four farmers who operate on a large scale, have capital accumulation, owns some machines such as tractors, and are farming by themselves.

There is a branch office of the Ministry of Agriculture and Livestock in this area, and some staff from SEAG and SENACSA are stationed. Since this area is near the Mennonite settlements and can also receive guidance from SAP, there is not much problem in terms of technological guidance. Therefore, the farmers' level of cultivation technology is not low at all. The whole crop of cotton is purchased by the agricultural cooperative of the Mennonite settlements and is treated in the same manner as crop produced by farmers in the Mennonite settlements.

If the farmers desire, they can receive loans from agricultural cooperatives in the Mennonite settlements, but the majority of farmers consign cultivation to others as mentioned above as they do not have sufficient capital accumulation and cannot own machines by themselves.

The farmers' income is estimated to be approximately 5-10 million Gs., judging from

the land area of field and interviews. There are some farmers who have little money left after their consignment fee is deducted from sales due to unstable weather and stagnant price. production output is unstable. Except farmers who are cultivating by themselves, farmers are likely to be losing the desire for cultivation year by year. The deficit by field husbandry is supplemented by dairy farming, work away from home, and others (running a shop, part-time work for wage).

In similar manner to the Mennonite settlements, field husbandry is also declining here year by year. The reasons are: (i) Since precipitation is unstable, there is a large fluctuation in crop year by year; (ii) Since prices are fluctuating, field husbandry alone results in deficit. There were farmers who used to cultivate cotton on more than 100 ha in the past. Now, the cultivating area is decreasing. The dairy farming was introduced to stabilize farming management, but it is not sufficient. Many farmers go to other stock farms and farms to do labour works for wage.

2) Agricultural technology

(1) Mennonite settlements

This area has its own agricultural experimental station, and farmers are conducting sophisticated farming with advanced technology.

Seeds which were produced within the area are used, and are renewed every year to secure quality. The varieties for commercial crops are unified. The experimental station is always trying to introduce new crops and new varieties in addition to cultivation experiments of crops already cultivated and stabilized in the area. Therefore, crops and varieties suitable to the natural conditions of the cultivating area are cultivated. In addition to such experiments and research, crops are cultivated in accordance with the cultivation system and planting system which suit the environment on the basis of experiences accumulated since the first settlement.

Fertilizers are not used since the settlement was started some 60 years ago. The testing station is conducting fertilization experiment. As a result, it was found out that it is better not to use chemical fertilizers because (i) more costs are incurred although the crop is increased; (ii) Since this is very dry area, seedlings may be damaged even initial growth is good; and (iii) as soil fertility is deteriorated in sandy soil, it is better to introduce plants in the bean family as green manure and cultivate organic substances. However, it seems that soil fertility has been gradually deteriorated as result of long-term non-fertilizer cultivation and that the crop is becoming unstable.

The Campo Aceval Settlement depends its agricultural technology on the Mennonite settlements, and has the same technological level. As for diary farming, however, farmers are using cows which produce more milk among existing hybrid cows. It is estimated to have significantly lower level than the Mennonite settlements.

(2) Suburb of Asuncion

In sugarcane cultivation, four to five different varieties are cultivated for the early maturing variety (harvested in June-August), the medium-term maturing variety (harvested in August-September), and the late maturing variety (harvested in September-November), respectively. More early maturing varieties are cultivated, and the factory is also encouraging to grow them. The basic cultivation system is as mentioned above. The cultivation standard prepared by the factory has rough description on preparation of the field, furrowing, selection of seedlings, fertilization, intertillage, weeding and concrete instructions per respective working time. cultivation technology is standardized by the factory's instruction. The factory has a research laboratory which researches into improvement of sugar production rate, improvement of quality of products as well as analysis of soils, and gives fertilization guidance on the basis of these.

As for vegetables, by taking advantage of the favorable environment that the area is close to the capital city which is the consumption site, that it has a relatively mild climate, and that it is favored with groundwater, a variety of vegetables are cultivated. products and varieties are selected in consideration of marketability rather than whether the features of products meet environmental conditions. In that sense, the area may have good environmental conditions.

However, majority of farmers are cultivating vegetable on a small scale including own consumption. Specialization of cultivation is not seen. The guidance of SEAG worker is centred on sugarcane, and little guidance is given on vegetables. farmers are likely to be gradually improving existing technology on the basis of their experiences and are conducting cultivation suitable to the area, and has the technology to cultivate products acceptable in the domestic market

3) Agricultural materials

(1) Seeds

In Paraguay, seeds are produced, imported, and sold by SENASE (National Seeds Service), an agency of the Ministry of Agriculture and Livestock.

In the Mennonite settlements, SAP has a structure for producing and purchasing seeds

for cotton, peanuts, sorghum (for seeds as well as green cut) and fodder grasses by giving guidance and supervising seed producing farmers in the settlement. SAP has the facility for quality testing (germination rate, water content, etc.) and seed warehouse. The supply is usually sufficient for seed production in the area. As for sales volume of seeds (1991), approximately 150 t of sorghum is sold, and it is increasing approximately 20% every year. Sales volume of seeds of cotton (approximately 120 t) and peanuts (approximately 400 t) is decreasing year by year. This also manifests the trend in the Mennonite settlements that livestock farming is growing and field husbandry is declining. prices are 800-900 Gs./kg for cotton and peanuts and 1,000 Gs./kg for sorghum. Since Campo Aceval is near the Mennonite settlements, its situation is the same as above.

Concerning sugarcane cultivation in the suburbs of Asuncion, sugar refinery is supplying seedlings, and the quantity is secured. However, farmers are trying to refrain from renewing seedlings to save costs. The prices of vegetable seeds are some 10,000 Gs./kg. Many farmers purchase seeds imported and sold by SENASE every year.

(2) Fertilizers

Paraguay depends on imports for all its chemical fertilizers. Imports are approximately 56,000 tons. The average price is 200 Gs./kg (CIF basis). Imports from Brazil and Argentina, major exporters, occupy 95% of total imports (1991 figures). The kinds include regular chemical fertilizers, urea, and phosphoric acid fertilizers.

In sugarcane cultivation in the suburbs of Asuncion, the sugar refinery is giving fertilization guidance on the basis of soil analysis. The factory supplies chemical fertilizers and deducts the price from sales of sugarcane by the farmer. There is no problem in securing the volume of fertilizers. The Mennonite settlements do not use fertilizers.

(3) Agricultural chemicals

Paraguay also depends the supply of all agricultural chemicals on import. The import of pesticides and weed killers are approximately 1,100 t, respectively with an average price of 8,000-9,000 Gs./kg (CIF base). The percentage of imports of Brazilian and Argentine products among total imports is 25% for pesticides and 75% for weed killers. The pesticides are imported from many exporting countries. There is much import from Europe. On the other hand, the import of bactericides is as small as approximately 80 t with a high average price of 25,000 Gs./kg (CIF basis). The percentage of imports of Brazilian and Argentine products among total imports is 25%. In the same manner with pesticides, much quantity is imported from Europe.

In the Mennonite settlements, agricultural cooperatives are importing them from the U.S., Europe, etc. through distributors, and are selling to member farmers. Many farmers are using pesticides (Dipterex, Dimili, etc.) and weed killers (Treflan, etc.) for cotton and peanuts. Due to high prices, bactericides are used only when bacteria prevail depending on location and timing.

In sugarcane cultivation in the suburbs of Asuncion, agricultural chemicals are used upon technical guidance by the sugar refinery. In general, only weed killers are used and bactericides are not used. In the same manner with fertilizers, the factory supplies them with prices to be offset later. There is no problem in securing quantity.

(4) Machines

The agricultural machines are also imported from the U.S. Europe, neighbouring Brazil, Argentina, etc. in the same manner as other materials. The prices are US$20,000 for 75HP tractor, US$30,000 for 110HP tractor, 40 million Gs. for 2 t truck, and 46 million Gs. for 4 t truck. Therefore, they are substantially expensive from the viewpoint of the income of general farmers. The combined harvester/thresher for cotton is as expensive as US$180,000. From such price levels, it will be an excessive burden for farmers to own agricultural machines. If they are to own them, farming which can generate matching income is required. The prices of accessories are roughly 2 million-3 million Gs., depending on the type and function. Although each of them is not so expensive, the whole set would amount to a substantial price.

In the Mennonite settlements, the size of farming and crops are generally the same among many farmers. The ownership of machines are also generally similar. Many farmers own one or two tractors, one or two small trucks, and a few combined harvesters/ threshers (for cotton, peanuts, etc.).

On the other hand, in the suburbs of Asuncion, many farmers are small-scaled, and do not own agricultural machines such as tractors except some farmers who are cultivating sugarcane or fodder grasses on a large scale.

4) Production costs of major crops

(1) Field crops (See Table 4.6.4.)

Cotton has the largest gross income (440,000 Gs.) and the largest production costs (380,000 Gs.) among major field crops in the study area with profitability lower than those of other crops (60,000 Gs.) Cotton has a working system to spray pesticide many times unlike other crops. This is manifested in the high cost of seeds and chemicals (900,000 Gs.). The high machine cost (200,000 Gs,) is another factor. The profitability is approximately 15%, not so high.

In peanut cultivation, percentage of the seed planting cost (20%) is relatively high among production costs by type of work. Although the price of seed is similar to that of cotton, the quantity of seeds planted is three times as much as that of cotton. As a result, the cost of seeds become expensive. The profitability is 20%, slightly higher than cotton, but not so high in general.

The green cut sorghum has high machine costs (220,000 Gs./ha, 74% of production costs by type of work), reflecting the working structure of ploughing after cutting several times. This is also reflected in the fact that the harvesting costs are outstandingly high (210,000 Gs./ha, 68% of the production costs by type of work).

The sorghum for seeds also has high percentage of machine costs (75%). The total production costs are approximately half of that of the green cut. The difference is because the harvesting cost differs substantially. The profitability is some 20%, slightly higher than peanuts. This is because the production costs are less. The amount of profit itself is similar.

Castor beans have higher manpower costs and lower machine costs than other crops. Percentage of the harvesting costs are the largest by type of work. This would be because of harvesting by manual labour. The production costs are larger than the gross income, resulting in deficit. This is because the price of this year became half of that in the previous year. It is necessary to pay attention to price trends in cultivating this kind of crop.

Sesame also resulted in deficit in the same manner as for castor beans. Sesame has a short history of cultivation in the study area. Unlike that crops of cotton and peanuts are exceeding the average international level, the crop of sesame is originally low and changeable weather brought forth much less crop. Sesame is an important crop in diversifying crops, but to improve output, it is desirable to establish a cultivation system suitable to the area.

Safflower is cultivated in a relatively rough condition. As the production costs are low, profitability is higher than other crops. The management costs are less in the production costs by type of work. Percentage of works by machine such as ploughing and harvesting is higher.

As mentioned above, the working system of respective crops are reflected in their respective production costs. On the whole, it is a common point that all crops have high

percentage of machine costs. By item of work, ploughing, field preparation and harvesting works require much costs.

(2) Vegetables (see Table 4.6.5.)

Vegetables are cultivated mainly by using domestic animals. Machines may be used in some of the ploughing and field preparing works. The prices largely fluctuate at peak and out-of-peak seasons. The profitability obtained by annual average price may be just a reference, but as a general tendency, the prices of vegetables are higher than those of other field crops.

The production costs largely vary according to the crop. In this case, the working system is also reflected in the production costs. For example, with tomatoes which uses posts and steel wires and have accompanying work has more material and management work costs than other vegetables. With strawberries, unlike other vegetables, purchased seedlings are planted, and the harvesting period is longer. Thus, it has more seedling and harvesting costs. Tomatoes and strawberries have outstandingly more production costs as the above-mentioned works incur costs. On the other hand, watermelons and potatoes have smaller production costs, reflecting the relatively rough cultivation method.

4.7 GRASSLANDS AND FODDER CROPS

1) Contents of study

The field surveys were conducted in the surroundings of the Mennonite settlements, the Rio Verde area, the Campo Aceval area, etc. to assess the status of grasslands and fodder crops in candidate areas for development, and status of utilization of grasslands.

2) Result of study

(1) Grazing capacity

The annual dry fodder output in natural grasslands near marshes which are inundated for a long period of time in the lower Chaco region is approximately 7,000 kg/ha, Its grazing capacity is 0.25 UA/ha. The beef cow requires 3.5-4 years until shipment. On the other hand, the annual dry fodder output in natural grasslands in wetlands known as bañados and has less depth of inundation and short period of inundation is approximately 4,400 kg/ha. Its grazing capacity is 0.5 UA/ha. On the slightly higher land within the marsh where palms are growing, plants in the rice and bean families and shrubs are growing. The annual output of dry fodder is approximately 4,400-7,000 kg/ha. Its grazing capacity is as comparatively high as 0.56 UA/ha. In areas at high altitude in the northern region of the study area, shrubs in the bean family are dominant, and there are few grass plants. The locations where the shrubs in the Prosopis genus are densely growing have less utilization value as grasslands. The dry grass output is as small as 800-3,000 kg/ha, and the grazing capacity is 0.07-0.3 UA. The average grazing capacity of natural grasslands in the lower Chaco region as a whole is approximately 0.5 UA/ha.

(2) Development and management of grasslands

As a method to utilize grasslands in the study area, it is general to utilize natural grasslands as they are with existing vegetation. There are some cases where wild shrubs are cut down by bulldozers and manual labour, and the resulting grasslands are used as natural grasslands. Since the area is so huge, the most popular method to prepare improved grasslands is to open natural forests with bulldozers, dispose wild shrubs, prepare the lands, and plant seeds of fodder grass. The grassland improvement rate in the study area is generally low. Except the Mennonite settlements and other advanced stock farms, the grassland improvement rate in the majority of stock farms is considered to be 5-10 %. The greatest problem in grassland management is the management of wild grasses and shrubs. The major methods of weeding applied are: (i) to pull up the roots by manual labour, (ii) to push wild shrubs with the blade of the bulldozer and remove the roots, (iii) to use a rotary mower, (iv) to use weed killer, (v) to inundate the grassland, and (vi) to fire the grasslands.

(3) Fodder grasses and fodder crops

The varieties of grass diffused in the improved grasslands in the study area include pasto bufalo, estrella, colonial, gatton panic, and pangora. The varieties to be introduced under this plan include pasto bufalo, estrella, colonial, gatton panic, pangora, and brachiaria. Since the natural grasslands in the study area have less plants in the bean family and the source of protein is insufficient, the introduction of grasses in the bean family is desired. Judging from natural conditions, the introduction of Leucaena leucocephala and Cajanus cajan is considered. Sorghum is most widely diffused as a fodder crop. In the Mennonite settlements, it is cultivated mainly as fodder for dairy cows. In beef cattle stock farms, sorghum is cultivated mainly for weaning cows and for silage. Cameroon grass (Pennisetum purpureum Schum), corn, and sugarcane are also cultivated for silage in some areas.

(4) Seeds

While the agricultural cooperatives in the Mennonite settlements and some farmers in the eastern area produce and supply grass seeds, their number is very small. The majority of seeds are imported from Brazil and Argentina. The seeds currently distributed in Paraguay have problems in quality as they have low germination rates and have impurities mixed in. The varieties are not constant, either. As for fodder crops, sorghum seeds are produced in the Mennonite settlements in the study area.

(5) Experiment and research

The La Patria Livestock Experiment Station is a testing and research organization for grassland and fodder crops. This testing station is located in Departamento Nueva Asuncion, and is the only such institute in the northwestern Chaco region. It belongs to the Livestock Farming Fund and is extending technological support to livestock farmers in the northwestern Chaco region. Its major functions are to survey the development potential owned by the area, to experiment and research in livestock farming, and to serve as a pilot testing centre in the settlement. It is implementing a joint research with the Department of Agriculture of the University of Asuncion and the Livestock Farming Bureau of the Ministry of Agriculture and Livestock.

4.8 LIVESTOCK FARMING

1) Contents of study

The twelve stock farms in the eastern region and in the study area were surveyed in order to assess theirstatus, problems and constraining factors in livestock farming during rainy and dry seasons. When stock farms were surveyed, stock farm owners were interviewed concerning the Chaco Development Plan. The aerial survey was conducted by airplane to assess the status of land utilization, topography and vegetation in the study area. In the field survey, land utilization in the candidate area for development, vegetation, status of livestock farming, varieties of grasses growing in natural and improved grasslands were surveyed.

Through the survey of more than 10 testing and research organizations, the problems of development and the role of respective testing and research organizations in development of livestock farming in Paraguay were assessed.

2) Results of study

(1) Livestock farming in Paraguay

The livestock farming occupies approximately 8% of the gross national product of Paraguay as of 1990. The percentage of livestock farming among the total production of agriculture and livestock farming in the same year is 28%. 7% of foreign exchange revenue is obtained by the export of livestock products centred on beef. Thus, livestock farming occupies a major part in the national economy.

Looking from the aspect of land utilization, 20,021,000 ha or 49.2% of the national land is used for livestock farming. Majority of it is used for production of beef cattle. From the aspect of land utilization, production of beef cattle plays an important role.

a) Beef cattle production structure

In Paraguay, beef cattle are produced in accordance with "labour-saving livestock farming management" in which productivity per unit area is low, but productivity per labour unit is high by roughly utilizing vast natural grasslands.

Looking at the number of stock farms by size of livestock farming and distribution of the number of cows, majority of the lager land owners are said to be stock farm owners. The production structure shows that stock farm owners who breed more than 1,000 head of cattle own the largest number of cows (Table 4.8.4).

In eastern and western Paraguay, cow breeding structures, for example, breeding density, farming size, and production base, differ largely.

Table 4.8.5 shows the number of cows bred by each Departamento. 69% of the total of 7,627 head of cattle are bred in the eastern region and 31% in the western region.

In the eastern region, the development of artificial grasslands and livestock management facilities are generally advanced with high livestock breeding density. The area of grassland per head (value of the total area for livestock farming grasslands divided by the number of cattle bred) is 12 ha. The farming area and the size of breeding are small.

On the other hand, in the western region, individual farming areas are generally huge except in the Mennonite settlements, and breeding density is thin. The area per head is 3 ha/head in the southern Chaco region, 6 ha/head in the central Chaco region, and 10-11 ha/head in the northern Chaco region. Percentage of large-scale stock farms is high.

b) History of cow breeding and varieties

The history of cow breeding in Paraguay is old. The first cow was introduced in 1553. In 1568, several thousands of the Andaluza variety were introduced via Peru. By the 1840's, it is said that 2 million cows had been already bred. Such European varieties were bred through natural selection in the natural environment in Paraguay, and became the original cow which is called "Ganado Criollo" (means local cow).

During this century, the European Hereford variety, Shorthorn variety, and Aberdeen variety, etc. were introduced and were used to improve conventional cows. In the 1940's, the zebu-strain Nelore variety and the Brahman variety were introduced from Brazil and the U.S.A. to improve the cows into ones with quality anti-disease and anti-heat features, and crossbreeding is promoted.

The varieties of cow which are currently bred are as shown in Table 4.8.6.)

c) Improvement of cows

(a) Production of breeding stocks

According to the 1991 Agricultural and Livestock Farming Census, 7,627 cattle are bred in Paraguay. Among them, the number of multiparous cows used for