

FOOD PRODUCTION UNDER CONDITIONS OF INCREASED  
UNCERTAINTY: THE CHACO EXAMPLE\*

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With an ever increasing world population the food requirement is constantly being increased. This is especially true of the fast growing areas of the world such as South America, Africa and Asia.

The push in these areas has caused agricultural expansion into ever greater hostile and/or agricultural marginal areas. During periods of unfavorable environmental conditions, as experienced recently in the area just south of the Sahara, this seemingly over expansion has claimed much human life and caused untold misery. Yet such lands, may be needed in the next fifty years to produce food to feed the world.

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settlements on the eastern margin. The Chaco Central, just north of the Chaco Austral, now has a railroad line running from its eastern margin to the western margin at the foothills of the Andes. Settlements are starting to dot this railroad although the area is by no means fully inhabited. The real virgin region is

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With an ever increasing world population the food requirement is constantly being increased. This is especially true of the fast growing areas of the world such as South America, Africa and Asia. The push in these areas has caused agricultural expansions into ever greater hostile and/or agricultural marginal areas. During periods of unfavourable environmental conditions, as experienced recently in the area just south of the Sahara, this seemingly over expansion has claimed much human life and caused untold misery. Yet such lands, may be needed in the next fifty years to produce food to feed the world.

Within the interior of South America lies the Gran Chaco, a region with marginal agricultural potential (Figure 1). With increasing pressure for food this environmental marginal plain is being probed more and more for potential settlements. The Chaco Austral, in Argentina, being an extension of the Pampas, already has a number of settlements on the southern, eastern and western margins. The Chaco Central, just north of the Chaco Austral, now has a railroad line running from it's eastern margin to the western margin at the foothills of the Andes. Settlements are starting to dot this railroad although the area is by no means fully inhabited. The real virgin region is the Chaco Boreal of Paraguay and Bolivia. The population density here and to a large extent in the Chaco Central is less than one person per square mile. Except for military outposts, some native Indians

Gift; Rosemary wyse 8-17-93

and a few settlers, the region is empty. In this non-ecumene, a conservative ethnic group of Canadian Mennonites, of German/Dutch origin, settled in the late 1920's (Figure 2). Although their reason for going to the Chaco was to get away from the encroaching "world" in Canada, they nevertheless were the first to attempt to establish an agricultural settlement in the Chaco Boreal. The isolation, which the Chaco provided, was welcomed for religious principles but has forced them to take 50 years to establish themselves economically. The main problem was the fluctuating unpredictable marginal natural environment. Food production for every use and later commercial crops turned out to be a hazardous occupation, especially when compiled with price fluctuation in the relatively primitive market system of Paraguay. Nevertheless, if these marginal areas are to help feed the world in the future, a closer look at the experience of the Mennonites in the Chaco Boreal is needed.

#### Environmental Milieu

The Gran Chaco Region as shown in Figure 1, covers a region of about 400,000 square miles extending for 1100 miles from the headwaters of the Mamore river system in Bolivia in the North to the northern regions of the Argentinian Pampas in the south. It stretches from the foothills of the Andes to the Paraguay/Parana Rivers, some 400 miles to the east. (Shanahan, 1927). The whole region is of relatively low elevation, being some 550 feet above sea level at



Source: WE Bradford, FR Fisher, JW Rando, TS Darrow, *The Paraguayan Chaco*  
(United States Operations Mission to Paraguay) 1952

FIGURE 1

FIGURE 2



FIGURE 2

Source: W.E. Bradford, F.R. Fisher, J.W. Romita, T.S. Darrow, The Paraguayan Chaco (United States Operations Mission to Paraguay, 1955) p. 2

In a recent issue of the local Mennonite (Vol. 48, No. 7, p. 5).

the Mennonite settlements in the Chaco Boreal (Krause, 1952).

It is thought that the Chaco plain has been formed by aluvium deposited by rivers flowing out of the eastern slopes of the Andes. But because of the level terrain, the sandy soils and the high evaporation, a number of these streams have no incised beds and as a result change the beds relatively frequently. The Chaco itself has no springs to feed rivers. The water collects during the rainy season in shallow low lying areas. Because of the aluvium nature of the soil, the water is absorbed into the ground or evaporates.

The soils of the Chaco Boreal region are dominantly of a fine sandy loam and silty clay nature. They are covered with shrub forest or coarse grasses. The bushlands in most instances have been formed by the finer sediments and have a high moisture holding capacity but low permeability, hence the large swamps during the rainy season. The coarse grasses on the other hand grow on the fine sands where permeability is extremely high. Because the soils have been deposited relatively recently from the Andes, and are several hundred feet deep, the soils are relatively rich in mineral and in plant nutrients, at least in comparison to eastern Paraguay where sub-tropical conditions have caused greater leaching. The Chaco soils then have the potential for food production.

As indicated before, the real problem of the environmental mileau in the Chaco is the climatic factor. And within the climatic variation, precipitation is the main culprit. Even the local inhabitants recognize it and incorporate it in their way of thinking.

In a recent issue of the local Mennoblatt (Vol. 48, No. 2, 1977, p. 5), bimonthly paper printed in Filadelfia in the Chaco, for example the story is told in the german vernacular that the moisture variation in the Chaco is sometimes rather large. Last winter for instance the pasture grass was so short (little rain) that even the grasshoppers had to bend down when they wanted to feed and this summer in Neuwiese (a village) the grass is growing so fast (much rain) that the caterpillar was unable to feed since he had to climb continuously in trying to get to the top of the plant! Precipitation variation can be examined on the basis of; (1) yearly variation or variation in total rainfall per growing season; (2) variability within the growing season; (3) spatial variability in rainfall and (4) the effectiveness of the precipitation. In the Chaco all four are of substantial importance. A glance at a map of South America indicates that the Chaco lies in the eastern shadows of the Andes and this to some extent affects it's precipitation. In Table 1 we can see the yearly average precipitation at two stations in the Mennonite colonies in the central section of the Chaco Boreal of Paraguay (Figure 2).

that the crops be planted at the beginning of the rainy season (October/November) to avoid loss of frost. In the Central

Chaco from the planting is delayed the may not receive the require

moisture during the maturation period.

Table 1

## Average Annual Rainfall for Growing Season (mm)

Years

	1955	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Filadelfia	611	596	1109	822	1016	1123	897	621	840	629	1018	792	594	558	858	514	535	482
Halbstadt	-	821	1002	858	1342	1218	831	611	1077	626	963	760	589	688	844	607	939	789

Source: Records provided by the Administration of Fernheim and Neuland colonies.



occurred in February. If we look at the planting month of October and November, the large differences are again seen. The variation at Philadelphia ranges from 1109 mm to 482 mm. In Halbstadt the variation goes from 1342 mm down to 607 mm. In both instances the minimum is less than half the maximum. Such variation seems the norm for savanna type climatic regions but when combined with the soil types found in the Chaco, a flooding results, especially on the fine clayish soils, or drought on the sandy campo soils where the sparse water of the dry season just percolates away. This is helped along by the nature of the precipitation. The rainfall comes usually in heavy showers producing instant floods. Since the area receives only small amounts of frontal precipitation and since the accompanying cloud covered skies and cooler temperatures are also missing, the effectiveness of the rainfall is decreased. After a heavy shower the temperature climbs rapidly back to its normal high value again and the associated high rate of evaporation continues.

But a more crucial variable than overall precipitation in the Chaco is the amount during the crop season. It is important that the crops be planted at the beginning of the rainy season (October/November) to avoid the danger of frost. In the Central Chaco frost occurs in about half the years. But more important if the planting is delayed the crop may not receive the required moisture during the maturation period.

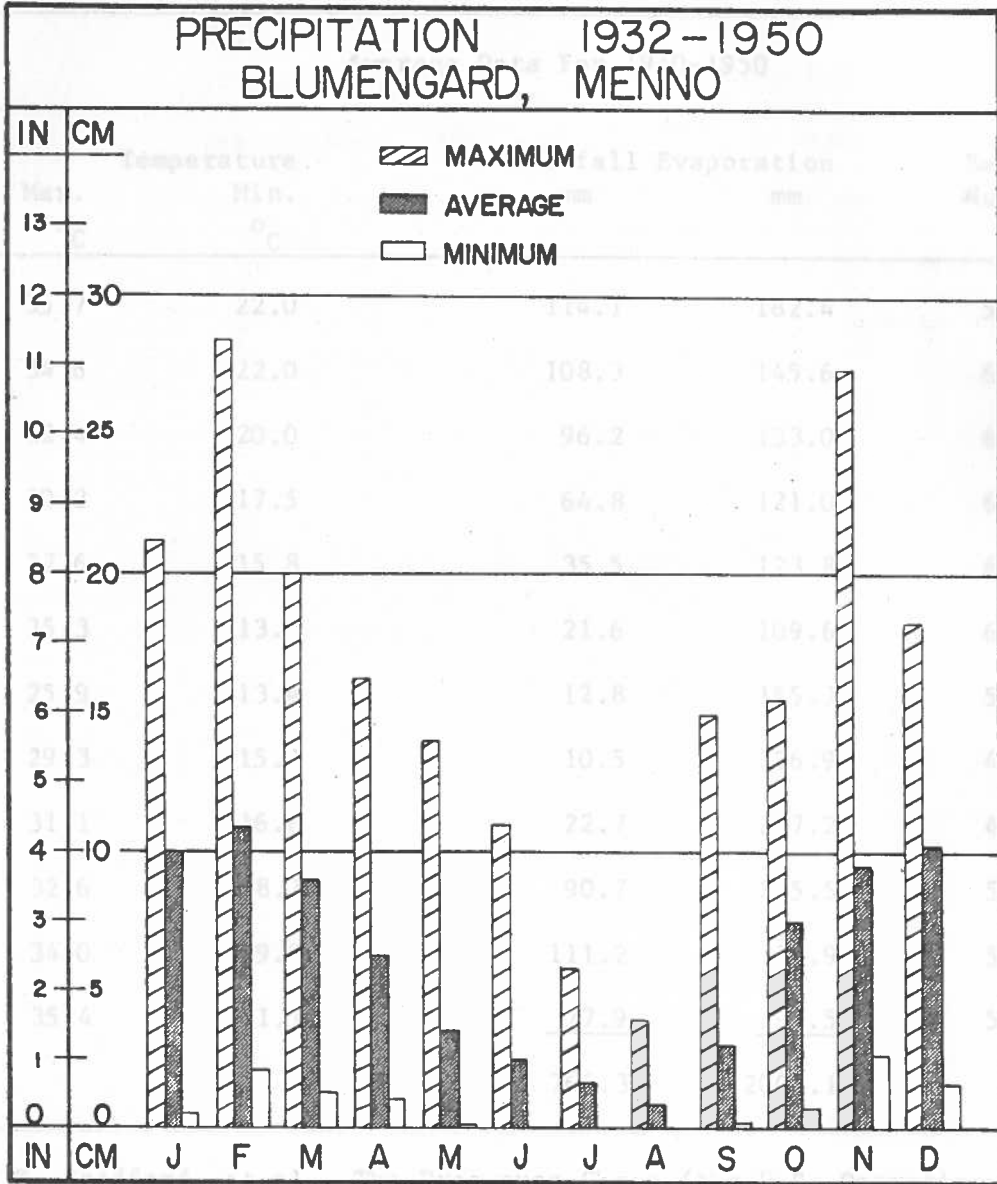
In Figure 4, we can see the tremendous variation in the monthly precipitation over an 18 year time span. The minimum precipitation for January was 1 cm and the maximum 22 cm. A similar size spread

occurred in February. If we look at the planting month of October and November again the large difference is brought out. The minimum for October was 1 cm, for November 4 and December 3 cm. Although not calculated here, the coefficient of variation ( $S/\bar{X}$ ) for the monthly data would be substantially larger than the coefficient of variation for the yearly data. Since the former is far more crucial in the planning of which crop to plant, the fluctuation in the yearly data, does not bring out the precipitation risk in pursuing food production endeavours in the Chaco. The complete dependence on this uncertainty is a great cause for worrying. For others it results in the acceptance of a fatalistic outlook vis-a-vis nature with its associated drawbacks.

The spatial variation in precipitation is presented in Figure 2. The map shows that the average precipitation in the Chaco varies from about 50 inches near the Paraguay River to only 20 inches at the Bolivian border, over a distance of only 400 miles. The precipitation contours in the Chaco run nearly parallel to the Andes. The Mennonite settlements are located in the 30" - 35" isotim region. Similar to the variation in the monthly data, the spatial variation can also be quite large despite the similarity in the averages. Table 1 gave the yearly average for two stations in the Mennonite colonies only 30 miles apart, in a North-South direction.

If we take the lower amount as the reference value, the percent variation between these two stations, comes to; 37, 10, 4, 24, 9, 7, 1, 28, 0, 5, 4, 0, 22, 1, 18, 75 and 63 in the years

TABLE 2  
COMPARATIVE WEATHER DATA  
PARAGUAY - CHACO REGION  
Mariscal Estigarribia



Source: A.E. Krause, Mennonite Settlements in The Paraguayan Chaco,  
(Dept. of Geog Research Paper No. 25, 1952) p. 24

FIGURE 4

TABLE 2

COMPARATIVE WEATHER DATA  
PARAGUAY - CHACO REGION

## Mariscal Estigarribia

## Average Data For 1940-1950

	Max. °C	Temperature Min. °C	Rainfall mm	Evaporation mm	Relative Humidity %
January	35.7	22.0	114.1	182.4	53.8
February	34.6	22.0	108.3	145.6	60.1
March	32.4	20.0	96.2	133.0	64.1
April	30.2	17.5	64.8	121.0	64.9
May	27.6	15.8	35.5	123.8	67.5
June	25.3	13.9	21.6	109.6	66.7
July	25.9	13.4	12.8	155.7	58.6
August	29.3	15.0	10.5	226.9	47.8
September	31.1	16.8	22.7	227.2	47.6
October	32.6	18.7	90.7	205.5	50.4
November	34.0	19.9	111.2	174.9	52.9
December	35.4	21.1	77.9	196.5	52.0
Total			766.3	2002.1	

Source: W.E. Bradford, et al. The Paraguayan Chaco (the U.S. Operations Missions to Paraguay, Asuncion, 1955) p. 11.

1956 to 1972, respectively. A monthly comparison between these two stations for the 1971/1972 growing season for example has the following percentage differences; 8, 58, 37, 47, 34, 173, 20, 107, 25, 175, 300 and 430 from July to June respectively. Although the yearly averages also vary more than usually for this year, the data nevertheless points out the great spatial variation. Thus frequently one village may have a good crop while another only a few miles away may have a bad crop, contributing to the feeling that fate to a large extent determines production.

In nearly every subtropical and tropical region the problem of moisture is one of precipitation vs evaporation and run-off and the Chaco is no exception. Because of the high temperatures and the clear, relative dry air, evaporation is quite high. In Table 2 we have the ten year average of maximum and minimum daily temperature, monthly rainfall, evaporation and relative humidity for Mariscal, Estigarribia, the Chaco administrative and military center, located some 40 miles north of the Mennonite colonies. As can be seen the mean maximum temperature ranges from 25.3°C to 35.7°C (in terms of Fahrenheit from 77° to 96°). Associated with these high temperatures are high rates of evaporation especially in the summer months when the relative humidity is only around 50 percent. Each month evaporation is substantially greater than precipitation and the total evaporation is nearly three times the actual precipitation. With such a negative moisture balance, methods of agricultural practices that conserve moisture

becomes very important.

The above paragraphs have shown that the environmental milieu of the Chaco has relatively fertile soils, favourable topographic features but rather variable moisture conditions. It is this latter element that has made the Chaco seemingly a marginal life support system for the native Indians in the past and more recently for the Paraguayan, Bolivian and Argentinian settlement attempts. In 1926 the first group of Mennonite settlers arrived and set up a settlement deep in the interior of the Paraguayan Chaco Boreal.

#### Chaco Mennonite Settlement

There are today three Mennonite agricultural settlements in the Paraguayan Chaco located approximately 250 miles northwest of the capital city of Asuncion. They are: Menno, founded in 1926 with 6,000 inhabitants; Fernheim, founded in 1930 with 2,700 inhabitants, and Neuland, founded in 1947 with a present population of 1000 (Figure 2). In addition to these 10,000 immigrants there are a few hundred Paraguayans and approximately 9,000 Indians, the latter attracted there over the past fifty years by the prospects of food and employment provided by the three Mennonite colonies.

The sociological background of each of the Chaco settlements is a colonization epic in itself. All three of the groups originated in Russia. The Menno Colony forebearers left Russia in 1874 and settled on the prairies of Canada in the provinces of Manitoba and Saskatchewan. They left Canada after World War I in protest of the

Canadian and provincial government efforts to Canadianize them by means of regulating their schools and compelling them to substitute the English for the German language. The Menno colonists chose the Paraguayan Chaco as a place to settle not because of its ideal agricultural possibilities but because it offered them the political and religious freedom for which they were seeking.

The Fernheim and Neuland colonists came to the Chaco after World Wars I and II as refugees and displaced persons respectively from Russia. They were socially and culturally more progressive than the Menno colonists. The reason for their settling in the Chaco was their limited alternatives. Their first preference would have been to go to Canada but these national doors were closed at the time as were all other countries that would both admit them and honour their pacifist convictions and permit them to settle in compact communities. Paraguay extended to Fernheim and Neuland the same generous privileges in the thirties and forties that it offered Menno in the twenties.

These guaranteed privileges included complete religious freedom, the right to establish and maintain their own school system and conduct them in the German language, exemption from military service and from taking the oath in courts of justice; the right of all Mennonites to immigrate regardless of the state of their physical or mental health and a ten-year exemption from payment of any taxes whatsoever. Without the guarantee of these privileges no Mennonites would have chosen to settle in Paraguay, much less in the isolated and inhospitable Chaco.

Fernheim established in 1930 with 1500 immigrants, was chosen for

A note of explanation of the isolated location of the three Mennonite colonies in the Chaco will help the reader understand why these colonists had extraordinary economic difficulties during the first three decades in getting farm products to market. Because Paraguay is a land-locked country all colonists entering the country were compelled to travel via a 1000-mile winding journey up the Parana River from Buenos Aires to Asuncion, the Paraguay capital city. From there they had to transfer to smaller river boats for another 320 mile boat trip north on the Paraguay River, thence they took a narrow-gauge railroad inland to the west for 90 miles, followed by an additional 55 miles by wagon, ox cart or on foot to the respective settlement locations (Fig. 3).

When the colonists arrived, there were no roads so they had to cut their first trails and fill in swampy places in order that they could move with their wagon cargoes. Added to the difficulties of getting to the settlement sites were the frustrations of having to wait for the surveying of the land so that each family would know where to erect houses and farm buildings. It was the geographical isolation and the lack of transportation that contributed greatly to the difficulties of marketing farm products once the colonists had mastered the art of growing surplus food crops in the Chaco's unpredictable climate and unfamiliar soils.

The Fernheim Colony  
In this paper one of the three Chaco settlements, namely Fernheim established in 1930 with 1500 immigrants, was chosen for



detailed analysis of its food production through time. The reason for this selection is that it was the Fernheimers who brought with them the invisible and non-material aspects of European culture that largely accounts for the survival of all the Mennonites in the Chaco.

The Fernheim colonists were deeply disappointed with their land, their isolation, their impoverished economic circumstances and were extremely discouraged with their future prospects. They often asked themselves whether indeed their situation in the new and strange land was an improvement over that which they had left in Russia during the Soviet Revolution. In Russia they had lost all religious and political freedom, had their homes destroyed and were often forced to flee for their lives. In their new Chaco wilderness homes they had complete religious, political and economic freedom but little where-withall with which to enjoy it, however, they had made their choice so their only option was to make the best of it.

The invisible social and cultural assets which the Fernheimers brought with them need now to be discussed. Among these assets was their religious philosophy of life which included an awareness of, and a sense of dependence upon God as the source of their strength and hope for their future. They were sustained in their difficult early Chaco years by the Biblical stories of the Children of Israel as they wandered in the desert from Egypt to Canaan; their years in Babylon as captives, the difficulties of the early Christians and indeed the centuries of persecution of their own forefathers in Europe prior to their settlements in Russia.

Moreover they brought with them a century of collective experience with the technology of the industrial revolution. The Fernheim colonists came from the most progressive group of Mennonites in Russia where communities had developed industrially as well as agriculturally throughout the latter nineteenth and early twentieth centuries. One-third of the Mennonite capital investment in Russia was devoted to industrial activities. The milling industry and the manufacture of agricultural machinery were two of the major economic activities in which many of the Fernheimers were formerly engaged. In addition there were many who had commercial businesses of their own. Others were well educated and engaged in one or the other of the professions.

The Mennonites in Russia had their own school system which in addition to the elementary schools included high schools, business colleges and teacher training colleges. Likewise, they had their own welfare systems for looking after the indigent, the widows and orphans and their own general and mental hospitals. In addition to all of these they had an extensive system of mutual aid, fire and store insurance societies.

It was this heritage of highly developed social, economic and religious organizations which when adapted to the crude frontier conditions of the Paraguayan Chaco spelled the difference between colonization success and failure. Evidence of this generalization is the contrasting experience of the more conservative Menno Colony

When they were acquainted in Russia they immediately aspired to provide the

basis for similar facilities in Paraguay. A school system was during its first decade without such extensive cooperative immediately set up on the Russian model. At first village elementary organizations. The story of more than twenty-five other immigrant schools and after a few years a centralized secondary school followed settlement efforts in Paraguay also shows the difference efficient and thorough Colony organization made in determining success or failure (Fretz, 1962).

Already on board ship on the way to Paraguay the Fernheim colonists manifested their proclivity toward systematic and detailed organization when they determined how many villages would be laid out and how many and who of the 1481 members would reside in each village. In addition, a "Schulze" or mayor of each village was chosen and an "Oberschulze" or colony governor was chosen, thus providing a working structure for the new colony prior to the actual arrival in Paraguay.

In addition the colony immediately formed a cooperative to which every family head was required to belong. It was through this cooperative that all buying and selling was done. Individuals had accounts at the colony cooperative which were credited and debited whenever goods were sold to or bought from the cooperative. Very little cash ever changed hands during the early decades. The colony cooperative not only served as a bank, it also served as an effective regulator of consumer spending. Since individual colonists could only buy and sell at the colony-owned stores and since the cooperative stocked only necessary items, it in effect prevented people from spending for non-essentials.

Because of the high standards of living with which Fernheimers were acquainted in Russia they immediately aspired to provide the colony operated as a collective if had real bargaining power when it came to negotiate for the marketing and purchasing of economic goods

basis for similar facilities in Paraguay. A school system was immediately set up on the Russian model, at first village elementary schools and after a few years a centralized secondary school followed by a teacher training school. In the Fernheim colony a hospital was established, at first with doctors imported for short periods of time from the United States and/or Germany. Provisions were made for the care of indigent aged and orphans. Likewise roads were built from colony to colony and village to village. All of these public or community services were paid out of earnings from the colony cooperative. This was of course a method of funding colony services in place of levying taxes and much less painful.

It was this effective colony organization to meet economic, social and religious needs on the part of Fernheim which served as a model for the more conservative and older colony of Menno which at first had no cooperative organization. It had brought with it from Canada a strong commitment to individual ownership and enterprise which had worked well in Canada but was ineffective to the point of ruination under the severe economic conditions of the Paraguayan Chaco.

By means of cooperation the Fernheim Colony could move its agricultural produce in bulk to the rail head, thence on a three-day riverboat trip to Asuncion. The colony employed representative who resided permanently in Asuncion to serve as buyer, seller and negotiator on all matters economic and political with public and private agencies. It was utterly impossible for each of the colony farmers to market his own products or purchase his own needs in any other way. Because the colony operated as a collective it had real bargaining power when it came to negotiate for the marketing and purchasing of economic goods

and for securing commercial air service from Asuncion to the Chaco. Likewise the successful economic growth of the three Chaco colonies was the primary basis for the construction of the trans-Chaco road from Asuncion through the colonies to the Bolivian border which was eventually to become a part of the Pan American Highway. This road completed in the sixties has opened up the Chaco for food production and distribution in a more efficient and profitable way.

#### Food Production

As indicated before the first group of Mennonites that settled in the Chaco came from Canada. They had been commercial grain farmers in Manitoba and Saskatchewan. Grain farming was very much in their mind when they settled in South America. It is said that their decision to locate in Paraguay was based upon a hurried attempt at growing wheat in Paraguay. A Mr. Engel (Klassen, 1976) who surveyed the Chaco region of Paraguay for them in the early 1920's did sow wheat near the Port of Casado before he entered the interior. When he returned some weeks later he found that the wheat had sprouted and grown into a substantial plant and his remarks to the group back in Canada was that he had attempted to grow wheat and when he got back a few weeks later, healthy, young wheat plants had awaited his return. It is questionable how much this information influenced the decision. Certainly when they arrived in the Chaco reality presented a different picture to them.

As stated earlier, because of isolation, for the first 40 years or so the emphasis in the Mennonite colonies was for self sufficiency in food production. Only since the early 1960's has a change in emphasis taken place from pure food production for home consumption to the raising of crops and livestock for a commercial market (Hecht, 1975). As late as 1950 Krause in describing the settlement attempt of the Mennonites in the Chaco says "the typical farm operation in the Mennonite colonies include crop raising with some animal husbandry. Of these crops cotton was the only commercial oriented crop, while the food oriented crops were sorgum, peanuts, beans (in North America usually called cow peas) mandioca, sweet potatoes and watermelon." (Krause, p. 47)

During the early years local food consumption came primarily from the food crops mentioned above. "The twin starch foods of sweet potatoes and mandioca took the place of the white potato." (Krause, p. 54) Although both crops provide a fair amount of starch, they do not have a high calorie content. Because they are grown exclusively for the local household consumption, the total acreage per farm was very small. Most farmers would devote a maximum of a hectare to these two crops. Similar to sweet potatoes and mandioca, cow peas were grown mainly for home consumption and provided a variation in the near daily diet of sweet potatoes and mandioca. All three of these food crops could be stored and therefore provided a basic diet during the dry season. The root crops were left in the field while cow peas were stored in relatively cool spaces to prevent insects and

worms getting at them. The watermelon was one of the major vegetable diets although its availability was for a short time only. Other melons are also grown, but not with the same beneficial results as with watermelon. Some farmers also attempted to grow such vegetables as cabbage, tomatoes and carrots. However, because of the high temperature during the rainy season, and the absence of rainfall and high evaporation during the dry season results have been very disappointing.

Food crops with higher acreages devoted to them because they presented also a potential commercial source of income, were peanuts, sorgum and for a time in the '60's wheat. From Table 3 we can see that the peanuts acreage varied from 697 hectares in 1955 to 2,442 hectares in 1975. The high point in terms of acreage occurred in 1972, when 3075 hectares of the Fernheim colony cultivated land was devoted to peanuts. Much of the variation in peanuts acreage can, I believe, be contributed to the commercial component of its value. When prices increased the acreage increased. When prices decreased, or when there was no export feasibility, home consumption only was satisfied and the acreage decreased. Peanuts have turned out to be one of the more viable food crops. It provides oil that was desperately needed especially in the early period, and secondly it provided feed for horses, chicken, pigs, cows and horses as well as straw for livestock bedding. In a sense it is an ideal subsistence crop. It has been used as a basic food by the Mennonites and native Indians. The latter were frequently paid in part in peanuts for their labour by Mennonites.

The amount of sorgum that the colonies planted from 1955 to 1975, varied from 839 hectares to 2321 hectares. (Table 3) During the early years, sorgum was one of the basic cereals used by the Mennonites. During many years the amount of flour that could be brought in to the colonies was restricted by the capital available and/or by the ability of Paraguay to import flour from Argentina. During such times sorgum ground up would be mixed with white flour and provide a flour that was used for baking purposes. The resulting bread usually was of a dark, sticky, wettish variety, but nevertheless provided a bread that so many of the Mennonites were used from their experience in North America and in Russia. During this time sorgum was also used as a cereal, similar to some of the grains in North America. Roasted it formed the basis of a drink called "priips" which looked like coffee when it was ground but certainly did not taste like it.

But more importantly again, it provided a base for the livestock industry. The straw of sorgum was a good feed for horses and cattle and could be stored in case it was needed during the dry season. In most instances after harvest, the straw, was left standing in the fields for horses and cattle to graze in.

An interesting experiment in growing wheat occurred in the Chaco between 1958 and 1969. As can be seen from Table 3, the number of hectares devoted to wheat increased from 12 to 1500 in 1964 and then collapsed so that by 1970 no wheat was grown in the Chaco. Why this occurred can be seen from research on growing wheat at the experimental farm in Fernheim.



Table 3  
Agricultural Land Uses (ha)

	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>4</sub>	A <sub>5</sub>	A <sub>6</sub>	A <sub>7</sub>	A <sub>8</sub>
	Cotton Hectares	Peanuts Hectares	Beans Hectares	Sorgum Hectares	Wheat Hectares	Rizimus Hectares	Other -Area	Buffel- Grass
1955	1041.	696.	100.	839.	-	-	(300)	-
1956	1173.	676.	105.	960.	-	-	(300)	-
1957	931.	1379.	79.	767.	-	-	(300)	-
1958	820.	1335.	56.	782.	12.	-	(300)	-
1959	936.	940.	52.	827.	45.	-	(300)	-
1960	790.	1012.	62.	882.	103.	-	(300)	-
1961	574.	1416.	75.	910.	428.	433.	(300)	-
1962	500.	1100.	83.	873.	1296.	844.	(300)	-
1963	864.	1376.	82.	1272.	1458.	499.	316.	1917.
1964	412.	1287.	139.	1421.	1528.	376.	308.	2438.
1965	782.	1494.	115.	1342.	1066.	593.	113.	2985.
1966	216.	2023.	55.	1705.	377.	147.	360.	3495.
1967	337.	2033.	121.	1799.	317.	20.	441.	3917.
1968	394.	1886.	73.	1600.	10.	146.	341.	4616.
1969	300.	2034.	75.	2011.	20.	543.	140.	5813.
1970	405.	2543.	154.	1938.	-	500.	146.	7200.
1971	395.	2695.	104.	2321.	-	220.	278.	8158.
1972	741.	3075.	160.	1458.	-	161.	203.	8432.
1973	850.	2314.	98.	1390.	-	944.	245.	13947.
1974	441.	1583.	76.	1303.	-	2323.	190.	15303.
1975	547.	2442.	165.	978.	-	788.	240.	22835.

Source: Data provided by Fernheim Colony Administration

To improve the production of the various crops in the Chaco, the Fernheim colony has for a long time supported an agricultural experiment station. Mr. Robert G. Unruh, an American trained agronomist, has run the experimental farm for some 20 years, and did experiment with wheat production in the years '69 to '73. After testing various kinds of varieties in the Chaco for four years, Unruh comes up with the following conclusions "wheat can successfully be raised in the Chaco provided one observes the following practices. a) use only dark heavy campo soil or sandy bush soil, b) practice summer fallow and cultivate as well after every rain in order to conserve moisture, c) plant the 20th to the 30th of May in order to eliminate the danger of frost after heading as much as possible" (Unruh, 1969-1973). From the above one can see that much labour and capital has to be put into the growing of wheat in the Chaco region. Unruh goes on and states that "as long as the price of cattle, cotton and peanuts remains high and flour or wheat can be obtained from Argentina in abundant quantities it is quite unlikely that much if any wheat will be raised in the Chaco. In spite of this it would be well to continue testing varieties and planting methods for one cannot foresee what the future holds." (Unruh, 1969-1973).

One of the interesting changes in the food production of the Chaco region has been the recent large emphasis on beef production. Until the beginning of the 1960's nearly all of the beef was being raised on the sustenance from natural bush and coarse campo grass. Under these conditions however, no cattle could mature in less than

5 years, and then the meat produced was of the tough lean variety. In the middle '50's it was found that buffel grass imported from the U.S. could withstand the drought conditions of the Chaco fairly well. Furthermore it provided a good cattle feed hence the emphasis on the establishment of improved pasture of buffel grass in the last decade. By the early 1960's the Mennonites were also able to procure from the World Food and Agriculture Organization a 'clean bill of health' for their cattle if they inoculated against hoof and mouth disease. This meant that the beef was now of the table variety in comparison with the dog and cat variety prior to this period. At the same time an increase in the price of beef also occurred. Between 1962 and 1973 the price of beef more than doubled. To take advantage of this the Mennonites every year increased the total acreage devoted to pasture. By 1975, for instance, the buffel grass acreage in Fernheim was five times the acreage devoted to the cultivation of other crops.

#### Production variation and climatic and technological conditions

As mentioned at the beginning of the paper one of the real problems that the Mennonites encountered was the great variation in the environmental milieu that determined to a large extent the production of their agricultural products. In Table 4 part of this

production variation is provided. Cotton, for instance, varied from 327 kg per hectare to 866 per hectare between 1955 and 1975. The other cash crop, castor beans, varied even more, going from 327 kg per hectare to 1161 kg. But the real extreme variation occurred in the food crops of peanuts, beans, sorghum and wheat. The production of peanuts per hectare ranged from 109 kg to 1186 kg with production seemingly not related to acreage (Fig. 6). That of beans varied from 139 kg to 997 kg, sorghum from 451 to 2068 kg, and wheat for the time period that it was planted from 150 kg to 549 kg per hectare. No wonder the Mennonites seemed to be able to see the 'handwriting on the wall' for wheat production.

To see to what extent the variation in production is related to the climatic factors and to what extent it is related to technological factors a simple correlation analysis was run between the production per year figures and the climatic and technological data on hand. As can be seen from Table 5 the correlation between cotton and yearly rainfall is nearly zero, between cotton and the amount of rainfall during the seeding season of October and November is negative  $-.12$ , but the relationship between the production of cotton and the amount of rainfall during the growing season of January and February is significant with a value of  $.46$ . Peanuts had a similar relationship.

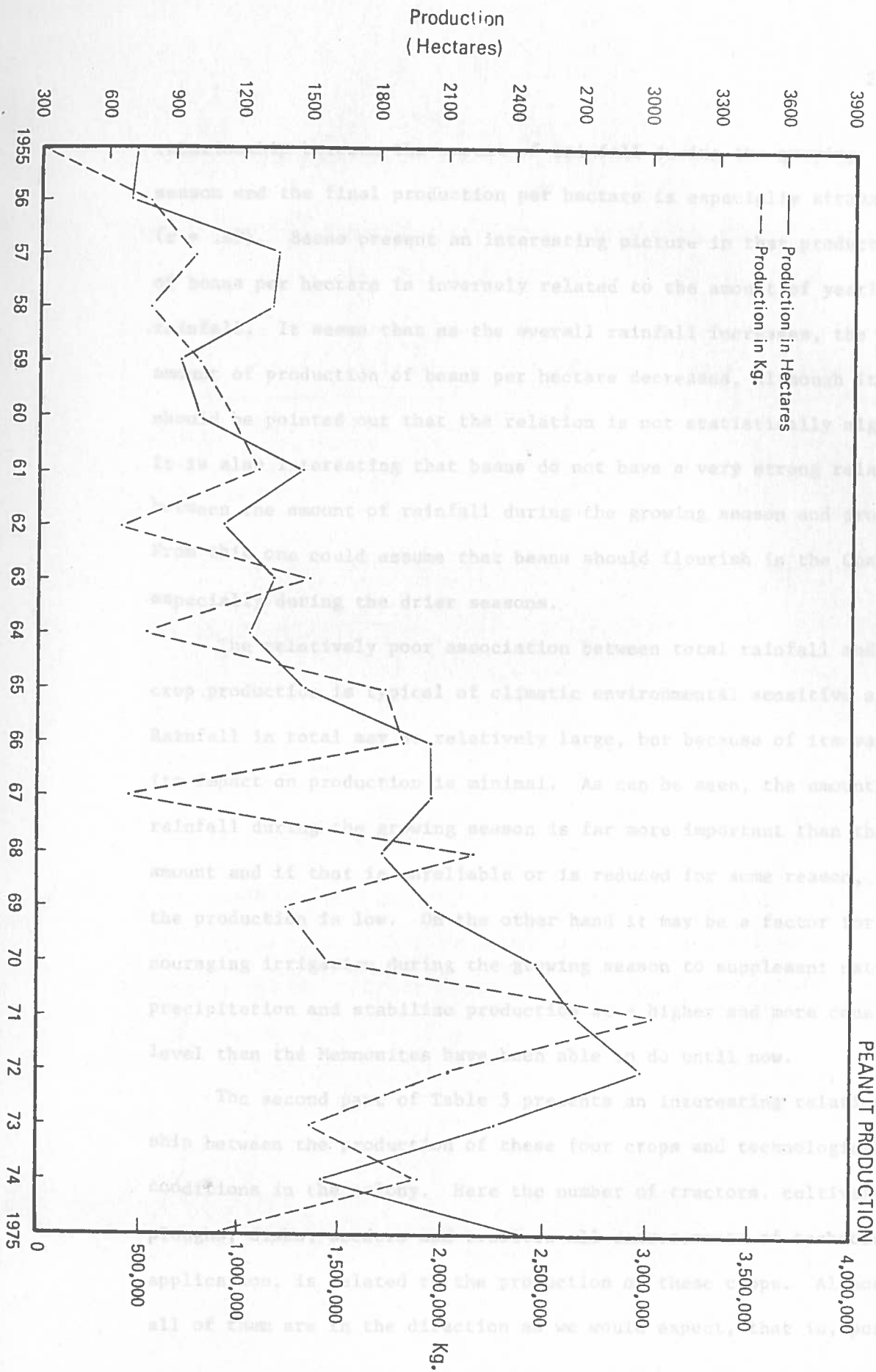
The importance of rainfall in the growing season of January and February is far greater than the amount in total or the amount during the seeding season. Similar results occur for sorghum, where the

TABLE 4

Production (Kg) per Hectare

	Cotton	Peanuts	Beans	Sorgum	Wheat	Rizimus (Castor Beans)
1955	472.67	109.54	250.65	1,095.88	-	-
1956	565.28	890.84	672.83	1,353.65	-	-
1957	521.20	559.74	412.21	1,267.67	-	-
1958	570.52	450.12	286.87	1,080.18	500.00	-
1959	778.31	836.43	324.51	1,256.47	476.66	-
1960	611.02	941.50	333.38	1,459.18	549.90	-
1961	606.03	806.49	511.33	1,279.12	374.30	727.32
1962	327.44	398.70	334.45	540.78	422.53	368.48
1963	827.03	965.62	524.39	1,414.54	266.12	853.87
1964	475.13	411.23	503.59	1,374.03	187.33	643.54
1965	704.85	1,156.59	594.34	1,531.33	150.09	645.64
1966	601.57	929.31	477.56	1,678.59	383.87	1,131.63
1967	866.67	235.12	419.00	1,565.87	173.75	625.00
1968	600.52	1,122.70	997.94	1,454.13	375.00	1,161.23
1969	445.31	612.09	343.84	867.03	460.00	343.43
1970	686.49	555.48	335.12	901.14	-	400.40
1971	787.66	1,125.92	433.17	2,068.50	-	773.14
1972	645.41	669.65	324.37	880.73	-	634.72
1973	344.28	585.89	139.79	451.47	-	370.50
1974	(459.86)	1,186.35	485.52	1,767.46	-	717.61
1975	454.06	358.80	273.09	852.56	-	327.51

Source: Fernheim colony Administration provided acreage and total production.



Years  
FIGURE 6

relationship between the amount of rainfall during the growing season and the final production per hectare is especially strong, ( $r = .69$ ). Beans present an interesting picture in that production of beans per hectare is inversely related to the amount of yearly rainfall. It seems that as the overall rainfall increases, the amount of production of beans per hectare decreases, although it should be pointed out that the relation is not statistically significant. It is also interesting that beans do not have a very strong relationship between the amount of rainfall during the growing season and production. From this one could assume that beans should flourish in the Chaco especially during the drier seasons.

The relatively poor association between total rainfall and crop production is typical of climatic environmental sensitive areas. Rainfall in total may be relatively large, but because of its variation its impact on production is minimal. As can be seen, the amount of rainfall during the growing season is far more important than the total amount and if that is unreliable or is reduced for some reason, then the production is low. On the other hand it may be a factor for encouraging irrigation during the growing season to supplement natural precipitation and stabilize production at a higher and more consistent level than the Mennonites have been able to do until now.

The second part of Table 5 presents an interesting relationship between the production of these four crops and technological conditions in the colony. Here the number of tractors, cultivators, ploughs, disks, seeders and trailers all measurements of technological application, is related to the production of these crops. Although all of them are in the direction as we would expect, that is, positive,

TABLE 5

Production (kg) per hectares vs climatic and technological condition

Simple Correlation

	Cotton	Peanuts	Beans	Sorghum
<u>Climatic</u>				
Yearly rainfall	.07	.25	-.22	.02
seeding season " 1	-.12	.05	.15	.14
growing season " 2	.46*	.49*	.23	.69*
<u>Technological conditions</u>				
Tractors	.28	.30	.28	.26
Cultivators	.27	.21	.23	.23
Plows	.29	.29	.25	.28
Disc	.26	.25	.22	.24
Seeders	.22	.18	.13	.16
Trailers	.28	.28	.24	.29

Source: Data provided by Fernheim colony administration.

1 Defined as rainfall for the months of October and November.

2 Defined as rainfall for the months of January and February.

\* Significant at  $\alpha = .05$



the more technology, the more production per acre, the relationships (r) are all in the same order of magnitude, approximately .25.

One could conclude from this that technology is able to explain from 5 to 10 percent of the variation in the production per area.

#### Food Production in the Chaco and the Changes in the Economic Environment

The change of food production in the Chaco has been one of change of emphasis from self sufficiency to one of specialization. The amount of food grown for purely local consumption has gone down, the amount grown for export purposes has increased, and the purchase of the food commodities from outside has also increased.

The data in Table 6 also shows a different change, which merits a closer look. In 1955 about 34 percent of the income derived from the production of various commodities in the Chaco came from non food items, namely, cotton. By 1972, this percentage had gone down to approximately 10% consisting of cotton and castor beans. The rest had now been taken by such food items as peanuts, beef, chickens, cheese, butter and eggs. The main switch as a source of funds from the outside world has been between cotton and beef. The percentage of beef compared to total income had increased from 23 to 44 percent, an increase of 21 percent. The decrease in cotton was from 33 to 9 percent or a decrease of 24 percent. If we do not take 1955, but rather 1956, as the reference year, the variation is even larger.

The basic change of farmers from growing cotton to the raising of cattle must be viewed in light of the changing uncertain conditions for producing beef and cotton. As long as cattle had to rely upon

TABLE 6

## FERNHEIM

Percent of total external agricultural income derived from different commodities

YEAR	COTTON	PEANUTS	RIZINUS	CHICKEN	CATTLE	CHEESE	BUTTER	EGGS
1955	33.89	5.89	0	0	23.07	6.31	12.50	18.33
1956	30.29	28.54	0	0	15.06	4.68	8.98	12.44
1957	25.51	33.75	0	0	15.29	3.27	10.46	11.71
1958	25.20	25.89	0	0	13.42	5.99	15.16	14.33
1959	36.44	25.94	0	0	12.03	4.82	10.07	10.69
1960	23.04	25.32	0	0	19.60	6.21	14.25	11.58
1961	16.86	30.52	7.25	0	11.72	8.60	10.58	14.47
1962	11.86	15.55	8.32	0	23.19	10.68	9.26	21.14
1963	21.55	25.80	7.63	3.44	18.55	6.36	5.74	10.92
1964	9.54	16.51	4.97	8.10	14.79	10.33	10.53	25.22
1965	14.82	30.32	4.68	6.32	8.34	8.02	7.02	20.47
1966	3.01	31.30	2.19	5.21	20.74	8.30	6.00	23.25
1967	12.12	14.50	.30	7.55	28.12	7.25	5.25	24.90
1968	8.13	38.05	3.08	3.63	23.49	5.86	3.73	14.03
1969	3.47	24.45	3.29	3.21	42.30	5.89	3.97	13.42
1970	5.45	24.73	2.22	2.05	49.23	5.88	2.13	8.30
1971	6.46	38.40	1.53	1.25	36.65	5.70	1.77	8.24
1972	9.45	25.48	1.40	1.16	44.69	7.33	1.85	8.64

Source: Data provided by Fernheim colony administration

natural pastures, and these in turn relied heavily on the natural precipitation and associated variations, the emphasis on beef production was relatively low. The ability to stabilize beef and dairy production through the creation of improved pastures with drought resisting grasses was the turning point in the food production economy of the colonies in the Chaco.

But the environmental milieu was not the only factor affecting the crop production in the Chaco. Price variation in products also had an impact. During the beginning of the 1960's the colony supplied a large proportion of the Asuncion market with eggs and chickens. Prices were relatively high, sorgum was the main feed for chickens and it is a crop that yields steady harvests despite varying climatic conditions. In the late sixties and seventies, however, the egg price structure changed. Competition from Japanese colonists near the capital of Asuncion dropped the price to a level where the Chaco producers could no longer compete. It forced the farmers to turn back and reexamine their food and income producing crops, and when this occurred they turned to the planting of improved pastures with even greater vigour.

#### Production decisions and the environmental and economic decision making milieu

Because of the unpredictable Chaco climatic conditions, the decision a farmer has to make at the beginning of each new crop year as to which crop to plant and how much, is an agonizing one. To some extent he has to rotate crops, but to a large extent he can also

make selection on the basis of his information as to which crop will give him the best return.

In Table 7 the number of hectares that the farmers in Fernheim devoted to a particular crop is related to the price in previous years. For sorgum, peanuts, buffel grass and cotton the correlation is statistically significant. For castor beans and wheat the picture is less certain. Castor beans even have a negative correlation, which would mean as the price for castor beans increased, the amount of acreage devoted to it decreases. The same holds true for cotton. It is an oddity which might be explained on the overall decrease, at least until 1972, of castor beans and cotton in the total economy of the Chaco settlement.

The relationship between acreage planted and the production conditions in the previous years are far less certain than those between acreage and price (Table 7). To some extent one would expect this. There is no way that farmers can anticipate the climatic conditions which determine to a large extent the production. Hence one would not expect a decision process to take this into consideration, except for minimizing the overall climatic effect as seen in the selection of improved pasture where the impact of the climatic factor is not so great.

#### Primary Products Processing Industries

A major evidence of the successful battle with an adverse climatic condition and isolated geographical location is the way in

<sup>1</sup> Price and production values are taken from the previous year.

N.D. - No Data

\* Significant at  $\alpha = .05$  level

TABLE 7

## Simple Correlation Analysis

Crop Selection and Price Variation <sup>1</sup>							
	Cotton	Peanuts	Beans	Sorgum	Wheat	Castor Beans	r/Cattle
Cotton	-.72*						
Peanuts		.91*					
Beans			N.D.				
Sorgum				.79*			
Wheat					.41		
Castor Beans						-.45	
Buffel grass							.89*

Crop Selection and Production Variation <sup>1</sup>							
	Cotton	Peanuts	Beans	Sorgum	Wheat	Castor Beans	
Cotton	-.46						
Peanuts		.37					
Beans			-.09				
Sorgum				.03			
Wheat					.28		
Castor Beans						.41	

<sup>1</sup> Price and production values are taken from the previous year.

N.D. - No Data

\* Significant at  $\alpha = .05$  level

which Fernheim, and the other Chaco colonies have developed industrially as well as agriculturally. The above tables have shown the amount and kinds of foodstuffs produced. What these tables do not show is the degree to which industrial processing has developed within the Chaco.

Very early in Fernheim's history an oil extracting plant was erected to produce oils from peanuts, cotton seed and castor beans. These oils provide an important substance for domestic use as well as a cash export commodity. Processing in the colony naturally reduces the size of bulk goods which in turn economizes shipping costs. Filadelfia, in 1951 also had three palo santo extracting plants. Palo santo is a native Chaco wood which, when chipped and boiled under pressure, yields a resin which is sold for use in perfumes and for various chemical and pharmaceutical purposes.

A large cheese and butter factory, equipped with modern machinery provides a market for farmer's milk. These processed products are marketed in Asuncion to which they are conveyed since 1962 by large semi-trailer trucks.

As an indication of the degree to which this colony, in spite of its geographical isolation, has developed technologically, a summary of industrial activities is given. Perhaps most important is the colony's electricity generating plant. This facility has contributed in a major way to making life in the colony reasonably comfortable and comparatively modern. In addition to industrial power it provides the facility for domestic appliances such as electric refrigerators

which 85% of the colony families now enjoy. This alone has allowed a mammoth advance in the area of food preservation and diets which because of the long hot seasons each year were a problem.

The colony has a tannery, a shoe factory, a metal foundry, two tile and brick yards, a telephone service, furniture factory, machine repair shops, blacksmiths, tinsmiths, and the three Chaco colonies jointly maintain a large agricultural experiment station which has been a boon to all Chaco farmers and thus to the colony economy.

#### Evidence of Economic Stability

The accompanying tables of statistical data pertaining to demographic, educational and economic matters over a forty-year period by five-year intervals (Table 8) speak objectively to the question of the feasibility of successful human habitation in a hazardous climate and inhospitable geographic environment. By means of a combination of human determination, technological experimentation, cultural adaptation seasoned with a religious faith and a socio-ethnic identify, the Mennonites in the Chaco have demonstrated that permanent settlements and a relatively high standard of living is possible.

The chart showing the population trends of the three Chaco Mennonite populations and the Indian population in the central Chaco (Fig. 7) area reveals that only the Neuland Colony has had a steady decline in the course of its 25-year existence. Menno, the oldest and most conservative colony, has experienced the most steady and most

TABLE 8

Fernheim Demographic Data: 1933-1973

	1933	1938	1943	1948	1953	1958	1963	1968	1973
Population	2,078	1,330	1,717	2,222	2,486	2,500	2,591	2,702	2,810
Illages	18	19	19	21	21	20	23	23	23
Arms	369	221	217	261	264	258	293	292	286
Utilities	412	280	328	402	449	463	523	546	607
Marriages	26	13	14	25	16	31	29	17	20
Births	90	91	70	84	99	78	90	78	60
Deaths	31	10	5	18	6	19	7	10	13
Arrived	—	92	61	73	79	48	13	48	47
Left	76	50	8	73	150	131	51	40	123
Elem. Schools	13	13	15	19	19	17	14	14	14
High Schools	337	169	328	586	504	374	402	357	404
High School Students	45	29	31	81	134 (est.)	104	136	169	—

Fernheim Domestic Animal Census: 1933-1973

	1933	1938	1943	1948	1953	1958	1963	1968	1973
Horses	90	541	874	1,434	1,691	1,575	1,779	1,642	1,415
Cattle	1,871	2,770	5,177	11,362	9,218	10,690	12,079	17,352	18,414
Pigs	467	323	677	475	575	392	294	206	370
Chickens	8,246	6,262	8,514	10,402	13,903	20,163	32,781	46,898	—

Fernheim Appliances and Implements 1933-1973

	1933	1938	1943	1948	1953	1958	1963	1968	1973
Farm Wagons	102	226	215	245	326	305	323	276	269
Buggies	—	22	97	197	259	325	329	302	323
Plows	337	230	282	296	459	514	571	441	382
Harrow	302	181	168	170	238	296	336	299	276
Cultivators	325	213	256	322	509	589	648	557	516
Planters	—	41	96	128	189	290	321	302	240
Tractors	0	0	0	0	5	9	31	47	71
Trucks	0	1	1	13	16	24	33	53	15
Radios	0	6	12	15	20	63	135	244	420
Refrigerators	0	0	0	0	2	17	115	240	517

Source: Data provided by Fernheim colony administration.



CHACO INDIAN AND MENNONITE POPULATION GROWTH  
1927 to 1972

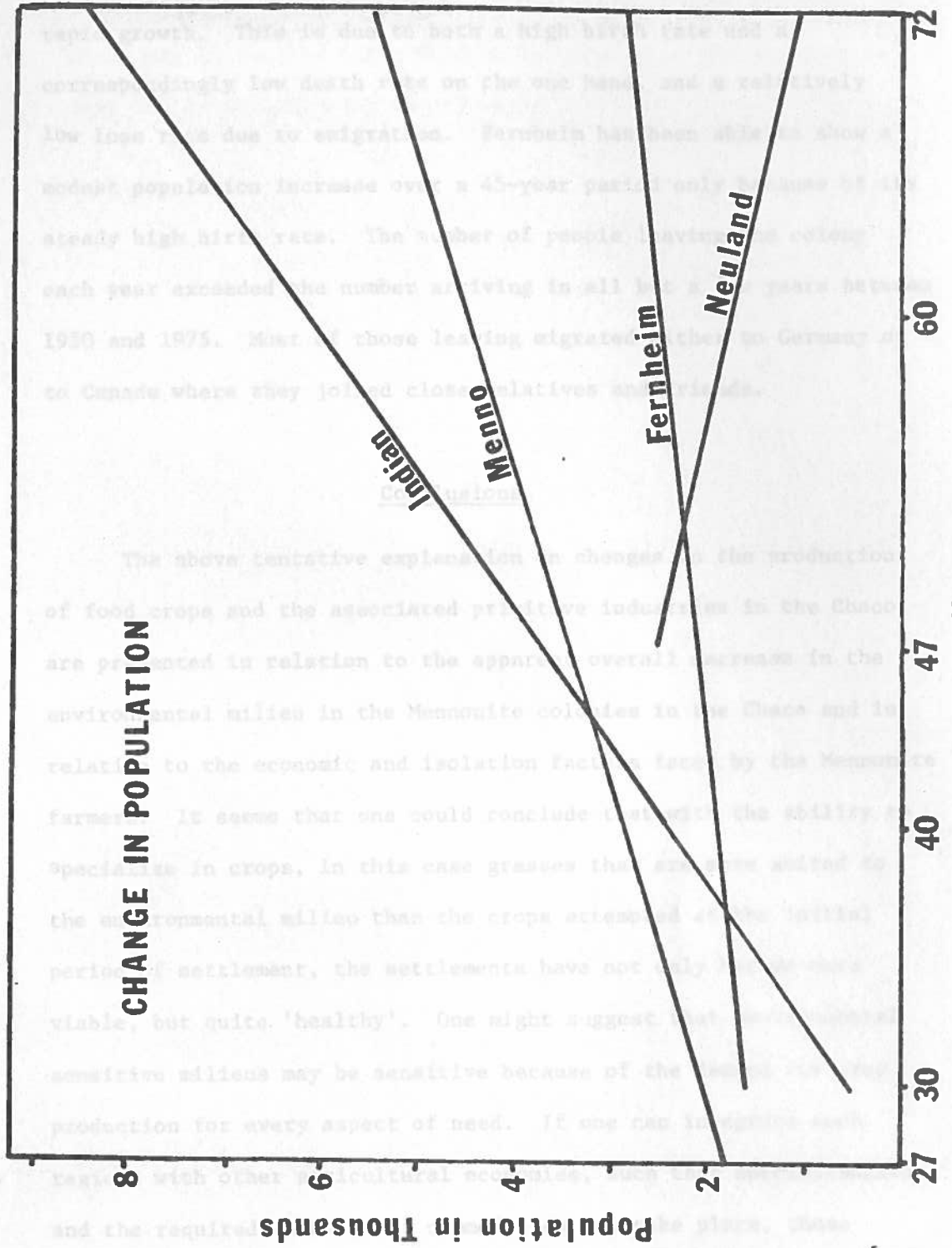


Figure 7

rapid growth. This is due to both a high birth rate and a correspondingly low death rate on the one hand, and a relatively low loss rate due to emigration. Fernheim has been able to show a modest population increase over a 45-year period only because of its steady high birth rate. The number of people leaving the colony each year exceeded the number arriving in all but a few years between 1950 and 1975. Most of those leaving migrated either to Germany or to Canada where they joined close relatives and friends.

#### Conclusions

The above tentative explanation on changes in the production of food crops and the associated primitive industries in the Chaco, are presented in relation to the apparent overall decrease in the environmental milieu in the Mennonite colonies in the Chaco and in relation to the economic and isolation factors faced by the Mennonite farmers. It seems that one could conclude that with the ability to specialize in crops, in this case grasses that are more suited to the environmental milieu than the crops attempted at the initial period of settlement, the settlements have not only become more viable, but quite 'healthy'. One might suggest that environmental sensitive milieus may be sensitive because of the demand for crop production for every aspect of need. If one can integrate such regions with other agricultural economies, such that specialisation and the required exchange of commodities can take place, these

environmental sensitive regions of the world such as the Gran Chaco may in fact be quite helpful in helping to produce food to feed the ever increasing hungry world.

De Loew, Cather and Company of Canada, "Feasibility Report on the Santa-Trinidad-Chaco," Consultant report presented to Excmo. Señor Ministro, Genl. de Dto. Marcel Sumariño, Ministerio de Obras Públicas y Comunicaciones, Asunción, Paraguay on 21 March 1967 (Ottawa: De Loew, Cather and Company of Canada, 1967).

J.W. Probst, Immigrant Group Settlements in Paraguay (North Newton, Kansas: Bethel College, 1962).

\_\_\_\_\_, Pilgrims in Paraguay, (Scottsdale, Pa.: Herald, 1970).

A. Nacht, "The Agricultural Economy of the Mennonite Settlements in Paraguay," Growth and Change, Vol. 8, No. 4, (1977), pp. 747-771.

A.M. Krauss, Mennonite Settlement in the Paraguayan Chaco (Chicago: Department of Geography, Research Paper, No. 15, 1952).

Manochara, 16 January, 1977, p. 4.

J. Pincus, The Science of Paraguay, (New York: Praeger, 1966).

E.W. Sherman, South America, (New York: Methuen, 1937).

E.H. Ehrlich, "Experimental Farm Reports", (Philadelphia, Fairbairn Delong, Chaco, Paraguay, January, 1973).

SELECTED BIBLIOGRAPHY

W.E. Bradford, et al. The Paraguayan Chaco (the U.S. Operations Mission to Paraguay, Asuncion, 1955).

De Leuw, Cather and Company of Canada, "Feasibility Report on the Ruta-Trans-Chaco," Consultant report presented to Exemo Senor Ministro, Gral. de Div. Marcial Samaniego, Ministerio de Obras Publicas y Comunicaciones, Asuncion, Paraguay on 21 March 1969 (Ottawa: De Leuw, Cather and Company of Canada, 1969).

J.W. Fretz, Immigrant Group Settlements in Paraguay (North Newton, Kansas: Bethel College, 1962).

\_\_\_\_\_, Pilgrims in Paraguay, (Scottsdale, Pa.: Herald, 1953).

A. Hecht, "The Agricultural Economy of the Mennonite Settlers in Paraguay," Growth and Change, Vol. 6, No. 4, (1975), pp. 14-23.

A.M. Krause, Mennonite Settlement in the Paraguayan Chaco (Chicago: Department of Geography, Research Paper, No. 25, 1952).

Mennoblatt, 16 January, 1977, p. 4.

J. Pincus, The Economy of Paraguay, (New York: Praeger, 1969).

E.W. Shannahan, South America, (New York: Methuen, 1927).

R.H. Unruh, "Experimental Farm Report", (Filadelfia, Fernheim Colony, Chaco, Paraguay. January, 1973).

WORKING PAPERS

- Hecht, Alfred. Changes in Agricultural Activities of the Mennonites in the Chaco Region of Paraguay: The results of the Ruta Trans-Chaco Road. Working Paper No. 1.
- Hecht, Alfred. The Agricultural Impact of the Paraguayan Trans-Chaco Highway. Working Paper No. 2.
- Hecht, Alfred and Bert Duncan. Residence and Work Locations of Manufacturing Workers: An Annotated Bibliography. Working Paper No. 3.
- Hecht, Alfred. An Index of Organizations and Agencies which Collect Statistical Data on The Kitchener-Waterloo Area, Ontario, Canada. Working Paper No. 4.